NATURAL GAS
Meeting the Challenges of the Nation's Growing Natural Gas Demand

Volume I
SUMMARY REPORT

A Report of the National Petroleum Council
December 1999

Obtained and made public by the Natural Resources Defense Council, March/April 2002
December 15, 1999

Dear Mr. Secretary,

On behalf of the members of the National Petroleum Council, I am pleased to submit to you the results of the 1999 study on natural gas, entitled Meeting the Challenges of the Nation’s Growing Natural Gas Demand. The objective for the study was to provide the requested advice on the potential contribution of natural gas in meeting the nation's future economic, energy, and environmental goals.

The Council is pleased to report that natural gas can make an important contribution to the nation's energy portfolio well into the twenty-first century. Demand for natural gas will continue to increase as economic growth, environmental concerns, and the restructuring of the electricity markets encourage the use of natural gas. More than 14 million new customers will be connected to natural gas supply by 2015 and many more will find their growing electricity needs met by gas-fired generators.

The estimated natural gas resource base is adequate to meet this increasing demand for many decades, and technological advances continue to make more of those resources technically and economically available. However, realizing the full potential for natural gas use in the United States will require focus and action on certain critical factors. These factors include:

- Access to resources and rights-of-way
- Continued technological advancements
- Financial requirements for developing new supply and infrastructure
- Availability of skilled workers
- Expansion of the U.S. drilling fleet
- Lead times for development
- Changing customer needs.

Each of these factors can be positively influenced, but government, industry, and other stakeholders must act quickly, cooperatively, and purposefully to ensure the availability of competitively priced natural gas.

The National Petroleum Council stands ready to work with government to further discuss the results of this report and to implement the recommendations in order to meet the nation’s growing gas demand.

Respectfully submitted,

[Signature]

Joe B. Foster
NPC Chair

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The National Petroleum Council is pleased to report to the Secretary of Energy that, given immediate focus on key issues, natural gas can make an important contribution to the nation's increasing energy needs and its environmental goals through 2015 and beyond. The natural gas industry has evolved into a competitive industry offering its expanding and reliable services on a national basis. Between 1990—the reference point for the 1992 NPC report—and 1998, total U.S. gas consumption grew from 19.3 trillion cubic feet (TCF) to an estimated 22 TCF and continues to represent approximately a quarter of the nation's fuel needs. Using the study methods described in this report, the Council concludes that gas demand is likely to increase to 29 TCF in 2010 and could increase beyond 31 TCF in 2015. Further, the resource base exists to support the indicated levels of future demand and adequate gas supplies can potentially be produced to meet that market. The additional supply required can be brought to market at competitive prices through an expanded network of pipeline, storage, and distribution facilities. However, the Council recognizes that meeting the significant challenges that accompany such vigorous market growth will require strenuous effort by the industry and substantial support on key issues by the government.

The initial impetus for the current study (hereinafter referred to as “the 1999 Study”) came from a letter dated May 6, 1998, in which then-U.S. Energy Secretary Federico Peña requested the National Petroleum Council to:

Reassess its 1992 report [Potential for Natural Gas in the United States] taking into account the past five years' experience and evolving market conditions that will affect the potential for natural gas in the United States to 2020 and beyond. Of particular interest is the Council’s advice on areas of Government policy and action that would enable natural gas to realize its potential contribution toward our shared economic, energy, and environmental goals.

In making his request, the Secretary noted that “at least two major forces ... are beginning to take shape which will profoundly affect energy choices in the future – the restructuring of electricity markets and growing concerns about the potentially adverse consequences that using higher carbon-content fuels may have on global climate change and regional air quality.” Further, the Secretary stated that “For a secure energy future, Government and private sector decision makers need to be confident that industry has the capability to meet potentially significant increases in future natural gas demand.” (See Appendix A for this letter and
Secretary Bill Richardson’s follow-up letter expressing his interest in receiving the Council’s advice on these matters.

To respond to this request, the Council established a Committee on Natural Gas under the Chairmanship of Peter I. Bijur, Chairman of the Board and Chief Executive Officer, Texaco Inc. T. J. Glauthier, Deputy Secretary of Energy, served as the Committee’s Government Cochair, with H. Leighton Steward, Vice Chairman of the Board, Burlington Resources, Inc., and William A. Wise, President and Chief Executive Officer, El Paso Energy Corp., serving as Vice Chairs for Supply and for Transmission & Distribution, respectively. The Committee was assisted by a Coordinating Subcommittee, chaired by Rebecca B. Roberts, Strategic Partner, Global Alignment, Texaco Inc., with Robert S. Kripowicz, Principal Deputy Assistant Secretary, Fossil Energy, U.S. Department of Energy, serving as Government Cochair. (Appendix B contains the Committee roster along with the rosters of its Coordinating Subcommittee and three Task Groups on Demand, Supply, and Transmission & Distribution.)

Key Differences from 1992

The Secretary was correct in noting that the U.S. energy markets have changed significantly since the 1992 NPC study on natural gas (hereinafter referred to as “the 1992 Study”). The U.S. economy is growing more rapidly than was anticipated in 1992, and with that growth has come a higher natural gas demand than was expected. Environmental regulations that favor natural gas consumption are more firmly in place than in 1992 and environmental restrictions on fossil fuel-burning facilities are increasingly stringent. In fact, gas demand has grown at a rate that exceeds even the most robust scenario projected in the 1992 Study. Continued economic growth as well as concerns about air quality and climate change favor the continued expansion of natural gas demand.

Since 1992, the gas industry has undergone a significant restructuring. The primary impetus came from Federal Energy Regulatory Commission (FERC) regulations, which over time have converted interstate pipelines from sellers and transporters of natural gas to solely transporters. State regulators and local distribution companies (LDCs) are moving toward a similar result in many jurisdictions. This restructuring has driven changes in roles and risks for industry participants because a number of market functions and obligations formerly managed under the auspices of the LDCs and pipelines must now be accepted and carried out by other market participants. Since the 1992 Study, new market structures—market hubs/centers, futures trading for natural gas, and a capacity release market (a secondary pipeline capacity market)—have either developed or matured. Other financial tools have been developed to reduce the risk of price change to buyers and sellers over extended time periods. In short, the gas market has become highly efficient and sophisticated, with numerous participants ensuring competitive prices. Increased confidence in the functionality of the gas market and in competitive gas prices has played a significant role in increasing gas demand.

The industry has benefited from remarkable progress in technology in areas that were not fully anticipated in 1992. For example, three-dimensional (3D) imaging now allows scientists to virtually “see” underground rock formations in graphic detail and to reduce drilling risk by more accurately predicting locations for hydrocarbon deposits. Progress in 3D and 4D seismic technology, in conjunction with imaging technology, has allowed producers to spot small hydrocarbon accumulations. Improved drilling techniques enable production companies to more precisely hit drilling targets and accomplish difficult maneuvers such as drilling a vertical well, turning a corner, and then drilling horizontally over five miles. New technology now allows producers to access supply in ocean waters that are more than a mile deep. These improvements, along with many more, have resulted in significant reserve additions and prospects of new production in areas that were once considered physically or economically unreachable.

Technological progress has also been evident in the transmission and distribution segments of the industry and has contributed to a steady and significant decline in transmission and distribution charges since the mid-1980s. Technological advances have taken place in areas such as gas measurement, pipeline mon-
While these issues are significant, the Council wishes to emphasize that the industry has successfully met difficult challenges in the past and has proved to be resilient and resourceful. Each of the challenges identified in this study can be met if immediate, cooperative, and focused actions are taken by the industry and the government.

**Approach to the 1999 Study**

In conducting the 1999 Study, the NPC Committee on Natural Gas and its Coordinating Subcommittee and three Task Groups developed projections for gas demand, gas supply, and transmission and distribution. The primary focus of the 1999 Study was to test supply and delivery systems against significantly increased demand. As in the case of the 1992 Study, the Committee on Natural Gas selected Energy and Environmental Analysis, Inc. (EEA) to run econometric models for the analysis. The Coordinating Subcommittee and its Task Groups provided data and assumptions to EEA for inclusion in the development of a Reference Case for the focus period of 1999 to 2010. The assumptions used in the Reference Case represent a plausible view of the future and were selected with full understanding that, in reality, each could vary significantly. Each of the Task Groups developed sensitivity analyses to test the Reference Case through 2010 and to develop an extended view through 2015. The results of the Reference Case and the sensitivity analyses form a framework for better understanding the factors that influence supply and demand balances. This approach was particularly useful in exploring the potential range of outcomes beyond 2010, a point at which uncertainties in assumptions begin to escalate. Throughout this report, data are reported for the focus period of 1999 to 2010, with an extended view for the more uncertain period of 2011 through 2015. While the study did not attempt to model supply and demand beyond 2015, the issue of long-term sustainability is addressed.

The study participants focused on the broader industry implications and dynamics indicated by the data rather than attempt to forecast specific end results. Issues such as new regulations for climate change were not examined in detail, but other factors that
increase demand were specifically analyzed and some correlations can be made. Changes that are occurring in the areas of electricity generation, such as distributed generation, were not studied, but the overall impact of increases in gas demand due to electricity generation was examined.

Results of the 1999 Study are presented in a three-volume report as follows:

- Volume I, Summary Report, provides conclusions and recommendations on the potential contribution of natural gas in meeting the nation’s growing demand for energy in the residential, commercial, industrial, and electric power generation sectors. Also included are summaries of key findings from the study’s three Task Groups: Demand, Supply, and Transmission & Distribution. Volume I can be viewed and downloaded from the NPC website, http://www.npc.org.

- Volume II, Task Group Reports, contains the results of the analyses conducted by the three Task Groups and provides further supporting details for the conclusions, recommendations, and findings presented in Volume I.

- Volume III, Appendices, includes output of the study’s computer modeling activities as well as various source and reference materials developed for or utilized by the Task Groups in the course of their analyses. The Council believes that these materials will be of interest to the readers of the report and will help them better understand the results. The members of the National Petroleum Council were not asked to endorse or approve all of the statements and conclusions contained in Volume III but, rather, to approve the publication of these materials as working papers of the study.

Enclosed with Volume III is a CD-ROM containing further model output on a regional basis. The CD also contains digitized maps, which were used in assessing a key critical factor—access to resources and rights-of-way. These maps provide a comprehensive inventory of acreage by land-use categories associated with related USGS gas plays for the several key Rocky Mountain resource areas analyzed in the 1999 NPC Study.

An outline of the full report and a form for ordering additional copies can be found in the back of this volume.

The National Petroleum Council believes that the results of the 1999 Study are amply supported by the rigorous analyses conducted by the Committee on Natural Gas and its subgroups. Further, the Council wishes to emphasize that the significant growth in demand that is projected in this study is based on long-term trends and should not be interpreted as a “goal” of the industry. However, as natural gas demand continues to expand, the natural gas industry stands ready to work with all stakeholders to economically develop the natural gas resources and infrastructure necessary for continuing the nation’s economic growth and meeting its environmental goals.
Conclusions

The emphasis on natural gas is good news for the economy, the environment, and society as a whole. In recent years, the United States has enjoyed a thriving economy, which has been driven in part by the ready availability of energy at competitive prices. Natural gas has played a vital role in meeting those energy requirements and today provides almost a quarter of the nation's energy portfolio (Figure 1). As this study demonstrates, natural gas can be a growing source of energy to power our economy for many years to come.

Actual U.S. gas demand has outpaced the 1992 Study High Reference Case projection by more than 1 TCF over the period from 1990 through 1998 (Figure 2). The 1999 Study projects that U.S. gas demand will grow from 22 TCF (including net storage fill) in 1998 to approximately 29 TCF in 2010 and could rise beyond 31 TCF in 2015. Each key consumption sector—residential, commercial, industrial, and electricity generation—will increase (Figure 3a). However, the electricity generation sector alone will account for almost 50% of the increase through 2010 (Figure 3b). Over 110 gigawatts of new gas-fired generation capacity is projected to be in service by 2010, and a total of 140 gigawatts by 2015. Natural gas is now the preferred fuel for new electricity generation facilities, with 98% of the nearly 250 recently announced new generation projects planning to burn natural gas. This dramatic shift to natural gas is driven by improved efficiencies, lower capital costs, reduced construction time, more expeditious permitting of natural gas-burning facilities, and environmental compliance advantages. However, the service requirements and price sensitivity of this additional load present many challenges to suppliers and transporters of natural gas.

Growth in gas demand will remain subject to changes in such key variables as growth in the economy, price of competing fuels, nuclear retirements, and the capacity utilization of coal-fired electricity generation plants. For example, if 30 gigawatts of nuclear capacity are retired rather than the 15 gigawatts assumed in the Reference Case, demand could increase another 0.7 TCF. If coal capacity utilization remains at current levels instead of increasing from 64% to 75% as assumed in the Reference Case, demand could rise as much as 1.7 TCF. New environmental regulations, beyond those that are currently scheduled for implementation, have not been factored into this analysis and could also further increase natural gas demand. While this study did not attempt to quantify the impacts of additional environmental regulations on demand, incremental increases from Kyoto-related regulation were estimated in independent studies at 2-12% by the Energy Information Administration and 10-22% by the Edison Electric Institute beyond their respective reference cases.
Figure 1. Total U.S. Energy Consumption by Primary Energy Source, 1998

7.9% Nuclear

24.1% Natural Gas

40.7% Petroleum

3.8% Hydro

0.2% Other

23.3% Coal


The role that natural gas plays in improving the nation's environment has been widely recognized. A recent Minerals Management Service (MMS) report, OCS Resource Management and Sustainable Development (September 1999), pointed out the benefits of natural gas:

Natural gas is the least polluting fossil fuel. It is thought by many, including the present administration, to be the fuel of the early part of the next century that will power our economy into the sustainable fuels of the later decades and beyond. Even in the short run, conversion of more of our fuel burning facilities to natural gas will greatly diminish air pollution and improve the long run sustainability of forests, waters, and farmlands now being negatively affected by acid deposition.

The MMS report also noted the following regarding income from offshore resources:

...royalties and taxes enable government to carry on programs which are beneficial to the oil and gas industry as well as society as a whole. For example, an average of 60 percent of the collections from Federal offshore sources [$126 billion since offshore leasing began in 1953] went into the U.S. Treasury General Fund. Among other expenditures the Government uses a portion of these funds to invest in social infrastructure, which helps make the U.S. economy one of the most productive in the world. One of the
areas in which some of this money is invested is in renewable energy, including many forms of energy conservation.

In onshore areas, federal, state, and local governments receive royalty income and colo-
taxes from natural gas production. The revenues that are collected from these sources allow these entities to provide essential services expected by their citizens, such as fund-
ing for education.

This study estimates the U.S. natural gas resource base, excluding Alaska, to be 1,466

Figure 2. U.S. Natural Gas Demand
Comparison of 1992 and 1999 NPC Study Results

Source of historical data: DOE/EIA, Natural Gas Monthly, September 1999.
Figure 3a. U.S. Natural Gas Demand by Sector

Figure 3b. Growth in Reference Case Demand, 1998–2010
(Distribution of 7 TCF Increase by Sector)

Industrial 23%
Electricity Generation 47%
Commercial 11%
Residential 19%

* Historical data include all gas use for industrial cogeneration and independent power producers; all gas for new power plants except cogeneration is included in the electricity generation sector.


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TCF (Figure 4). This total represents a net increase of 171 TCF over the 1,295 TCF estimated in the 1992 Study. Taking into account the 124 TCF that has been produced in the lower-48 states since then, the estimate of the resource base has increased 23% since the last study. The increase is largely due to technology breakthroughs that have opened new frontiers such as the deepwater Gulf of Mexico and have provided improved information and better tools for evaluating—and more fully recovering—resources.

U.S. gas demand will be filled with U.S. production, along with increasing volumes from Canada and a small, but growing, contribution from liquefied natural gas (LNG).
imports (Figure 5a). Two regions—deepwater Gulf of Mexico and the Rockies—will contribute most significantly to the new supply (Figure 5b). U.S. production is projected to increase from 19 TCF in 1998 to 25 TCF in 2010, and could approach 27 TCF in 2015. Deeper wells, deeper water, and nonconventional sources will be key to future supply. For example, deepwater production (water depths greater than 200 meters), which in 1998 provided 0.8 TCF annually, will increase to over 4.5 TCF in 2010 (Figure 6). Onshore production from nonconventional formations is projected to increase by 50% from 4.4 TCF in 1998 to almost 7 TCF in 2010, with much of it coming from the Rocky Mountain region. By 2015, nonconventional gas production could be approaching 9 TCF. Production is likely to decrease in more traditional areas such as the Gulf of Mexico shelf and onshore Louisiana, each dropping by roughly one-third by 2015. It is important to note that approximately 14% of current natural gas supply is “associated,” meaning that it is produced from oil wells. This associated gas will continue to be an important component of the overall supply, particularly in deepwater Gulf of Mexico.

Imports from Canada are projected to increase from 3 TCF in 1998 to almost 4 TCF by 2010, continuing to represent 13–14% of U.S. demand. Canada’s remaining resource base is estimated at approximately 670 TCF in this study, down from 740 TCF in 1992. The decrease in the estimated Canadian resource base is due to depletion and reassessment of the nonconventional resources. Challenges similar to those confronting the U.S. industry will be faced by the Canadian producers, compounded by the fact that much of this gas is in frontier areas such as the Mackenzie Delta in far northwest Canada. Reaching this frontier will require significant capital expenditures as well as considerable lead times. Continued cooperation between the United States and Canada will be essential to ensure the timely availability of Canadian gas.

LNG imports are projected to reach a maximum of approximately 0.9 TCF, based on a 75% average capacity utilization rate for existing facilities. The assumption was made that no additional LNG import facilities would be built in the 1999–2015 period. Also, the assumption was made that exports to Mexico would reach a maximum of 0.4 TCF to serve Mexico’s gas demand near the U.S. border.

The infrastructure required to deliver gas to market must be optimized and expanded to accommodate the increase in demand as well as the changing logistics of getting new supply to new customers. Future needs include new pipelines to reach supplies in the frontier regions, expansion of existing pipeline systems, new laterals to serve electricity plants, and expansion and construction of storage facilities to meet seasonal and peak-day requirements. By 2015, more than 14 million new customers will be added to the natural gas delivery system. To serve this growing market through 2015, over 38,000 miles of new transmission line are projected to be needed as well as 263,000 miles of distribution mains and almost 0.8 TCF of new working gas storage capacity.

The current delivery system (transmission, distribution, and storage) was built and optimized over decades to meet the design peak-day requirements of firm service customers that were primarily residential, commercial, and to a lesser extent, industrial customers. The anticipated growth in electricity generation demand for natural gas will require the delivery system to be re-optimized to meet larger off-peak swing loads as well as peak-day requirements that will increase from 111 BCF per day in 1997 to over 152 BCF per day in 2015. Meeting requirements of the electricity generators on a significantly larger scale will entail changes in operational procedures, communications, tariffs, and contracting. Further, these changes must be accomplished without degrading the historically reliable service to the residential, commercial, and industrial markets.

The Council believes that an unprecedented and cooperative effort among industry, government, and other stakeholders will be required to develop production from new and existing fields and build infrastructure at sufficient rates to meet the high level of demand indicated in this study. The ability to meet the anticipated demand hinges on addressing the following critical factors: access, technology, financial requirements, skilled workers, drilling rigs, lead times, and changes in customer requirements.
Figure 5a. U.S. Natural Gas Supply by Source

Figure 5b. Growth in Reference Case Supply, 1998-2010
(Distribution of 7 TCF Increase by Source)

Critical Factors

Access

Much of the nation's resource base resides on federal lands or in federal waters, yet a large portion of this resource base is not open to either assessment or development (Figure 7). Two of the most promising regions for future gas production, the Rocky Mountains and the Gulf of Mexico, currently have significant access restrictions. For example, an estimated 40%—or 137 TCF—of potential gas resource in the Rockies is on federal
land that is either closed to exploration or is open under restrictive provisions. Another 76 TCF of resources are estimated for restricted offshore areas in the eastern Gulf of Mexico, the Atlantic, and the Pacific. The eastern Gulf of Mexico is largely closed to exploration and the limited areas that are now open are the subject of political debate. The proposed MMS Lease Sale 181 scheduled for December 2001 in the eastern Gulf of Mexico is the first such sale in this area since the late 1980s, yet only covers a small portion of the entire area. The East Coast of the United States is completely closed to development while Canada is pursuing its East Coast gas resources, as demonstrated by the recent Sable Island development off the coast of Nova Scotia. In addition, drilling on the West Coast of the United States also faces strong restrictions, while offshore British Columbia is opening up to greater exploration and production.

This study assumes that planned lease sales for areas in the Outer Continental Shelf (OCS) will continue on schedule and that further restrictions will not be applied to those lands currently open to development. These assumptions may be optimistic in light of recent statements by some public officials. Further restrictions would increase the challenge of meeting the projected gas demand with cost-competitive supply. Conversely, opening hydrocarbon-rich areas for development would greatly improve the industry's potential to respond to market needs.

**Figure 7. Lower-48 Natural Gas Resources Subject to Access Restrictions**

* Approximately 29 TCF of the Rockies gas resources are closed to development and 108 TCF are available with restrictions.*

- These areas are close in land to grow the population center.
Access is also an issue for the transmission and distribution sectors of the industry as they seek rights-of-way for pipeline facilities. The permitting and construction processes have become more complex over time. Restrictions for wetlands, wildlife refuges, and other sensitive federal and state lands impact the routing and construction of pipelines throughout the United States, not just the frontier areas. Other issues arise from the encroachment of urban development on existing rights-of-way, heightened community awareness of and resistance to pipeline construction, and increasingly restrictive government policies and regulations. Resolution of these issues—which must be addressed for each pipeline addition—is costly and time-consuming and often results in project delays or abandonment of projects.

Most of the access restrictions are due to environmental concerns or multiple-use conflicts even though industry has made tremendous improvements in reducing the “footprint” of exploration, production, and transportation activities, and in maintaining clean, safe operations. As stated in a recent Department of Energy report, “Resources underlying arctic regions, coastal and deep offshore waters, sensitive wetlands and wildlife habitats, public lands, and even cities and airports can now be contacted and produced without disrupting surface features above them.” An excellent example of the dramatic improvements in environmental footprints can be found in Alaska where significant efforts have been made to minimize the impact of drilling operations on the tundra. A report to the Secretary of the Interior in 1997 by the Alaska Oil and Gas Association stated that in the 1970s, pads for drilling operations took up about 65 acres whereas the pads for recent operations are now less than 10 acres. The report further explained that cluster drilling and extended reach drilling enable producers to access hydrocarbon deposits 3-4 miles away from the pad, thus greatly reducing the number of drilling locations and associated roads and pipelines. Lateral extensions of 18,000 feet are common on the Alaskan North Slope today. More recent efforts in other parts of the world have extended the drilling reach to 5-6 miles. This has the same effect as setting up drilling operations on the White House lawn and extracting hydrocarbons from beneath most of Washington, D.C., and into its suburbs (Figure 8).

Equally impressive improvements in environmental impacts have been demonstrated offshore, where much of the natural gas production is associated with oil production. As reported to President Clinton by the Cabinet in Turning to the Sea: America’s Ocean Future (September 1999), “Advances in technology have made offshore oil and gas production cleaner and safer than ever. Since 1980, 6.9 billion barrels of Outer Continental Shelf oil have been produced with a spillage rate of less than 0.001%. Despite these advances, however, environmental concerns have led to congressional and executive moratoria since 1981, and many of our coastal areas are now closed to new leasing through the year 2012.”

This study has determined that access issues, and associated environmental concerns, must be addressed. Access to some portion of the federal gas resource base currently closed or significantly restricted to appraisal or development, as well as acquisition of rights-of-way, is essential to meeting the projected demand with cost-competitive gas supply.

Technology

Even though the estimated resource base is adequate to last many decades, technological challenges and the degree of difficulty in reaching, evaluating, and producing the resource base continue to escalate. The previously referenced report by the Office of Fossil Energy of the U.S. Department of Energy highlights the importance of research and development to the oil and gas industry:

In the past three decades, the petroleum business has transformed itself into a high-technology industry. Dramatic advances in technology for exploration, drilling and completion, production, and

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site restoration have enabled the industry to keep up with the ever-increasing demand for reliable supplies of oil and natural gas at reasonable prices. The productivity gains and cost reductions attributable to these advances have been widely described and broadly recognized. Looking forward, the domestic oil and gas industry will be challenged to continue extending the frontiers of technology. Ongoing advances in E&P productivity are essential if producers are to keep pace with steadily growing demand for oil and gas, both in the United States and worldwide. Continuing innovation will also be needed to sustain the industry’s leadership in the intensely competitive international arena, and to retain high-paying oil and gas industry jobs at home. Progressively cleaner, less intrusive, and more efficient technology will be instrumental in enhancing environmental protection in the future.

Technology improvements are particularly important given the more difficult conditions accompanying new resources. Deeper wells encounter extreme temperatures and pressures and increased potential for intensely corrosive environments. These conditions require high-strength materials and advanced drilling methods. Current deepwater endeavors involve exploration wells in over 8,000 feet of water and complex production projects in more than 5,000 feet of water. Subsea pipelines must be built to withstand powerful currents, shifting ocean floors and external pressures that are greater than those inside the pipe. Innovative

Figure 8. Reducing Environmental Impact with Extended-Reach Drilling

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design, fabrication, and installation techniques must emerge to enable these new resources to reach existing markets at attractive prices.

Technology improvements are also needed for expanding and managing the delivery system and improving efficiency at the burner-tip. The increased challenges of serving a growing market and changing load must not jeopardize the historical reliability and favorable economics of the transmission and distribution system. Pipelines and LDCs will continue to rely on technology for reducing operation and maintenance expenses and minimizing environmental impacts of facilities construction. Information and communications technology will play an ever-increasing role in safe and efficient operations as well as in supply management and customer service enhancements.

Technology advances are essential in all industry segments for improving operational efficiencies, reducing resource development time, increasing production, developing frontier areas, controlling costs, and minimizing environmental impact. This study assumes that technology improvements will continue at an aggressive pace. However, recent industry trends in research and development spending have raised concerns regarding this assumption. Industry restructuring, consolidations, and spending cuts have resulted in reductions in research budgets. Producers are turning to the service sectors to develop new technology for specific applications. Industry consortia have been formed to address critical technology challenges such as deepwater development. While many of these changes improve the efficiency with which research and development dollars are spent, concerns have been widely expressed that basic and long-term research are not being adequately addressed.

Financial Requirements

Adequate financial performance must be demonstrated in order to compete for and attract the investments required to meet the growing demand. Companies will need to balance short-term performance demands with long-term planning to achieve the needed growth. Almost $1.5 trillion ($1998) will be required to fund the industry through 2015. This amount includes over $700 billion for operating expenses and an estimated $781 billion for capital investments. Approximately $658 billion of capital is projected to be spent for oil and gas supply development and about $123 billion for transmission, storage, and distribution infrastructure expansion (Figure 9). This equates to an average annual increase in capital expenditures from $34 billion per year between 1990 and 1998 to $46 billion between 1999 and 2015. Many of these expenditures will involve higher risk projects—such as large deepwater projects or pipelines to new frontiers—each of which can easily exceed $1 billion.

While much of the required capital will come from reinvested cash flow, capital from outside the industry is essential to continued growth. To achieve this level of capital investment, industry must be able to compete with other investment opportunities. This poses a challenge to all sectors of the industry, many of which have historically delivered returns lower than the average reported for Standard and Poors 500 companies.

The transmission and distribution sectors of the industry also face challenges in attracting investments to future projects. Expanding the infrastructure of the delivery system to accommodate increased demand and changing requirements of new customers will involve changes in financial risks. For example, expiring long-term LDC contracts for pipeline capacity, which historically provided the financial backing for pipeline expansions, will be replaced by shorter term contracts with new non-utility customers. Uncertainty exists with future rate structures and obligations to serve, as electricity and gas restructuring continues. Industry participants and regulators must work together to find an appropriate balance for these risks so that the needed infrastructure expansions can be accomplished.

Skilled Workers

A significant concern of the industry is the future availability of skilled workers at all levels to produce the increased supply and construct the necessary infrastructure. Company consolidations and volatile fluctuations in oil prices have resulted in cuts in exploration and production budgets, leading to layoffs at all levels in exploration and pro-
Figure 9. Capital Required for Expansion

![Graph showing capital required for expansion from 1990 to 2015.](image)

* Because "associated" natural gas is produced with oil, expenditures for oil and gas have not been separated.

- Substantial increase in capital expenditures will be required.
- Total capital expenditures for 2007-2015 will be $785 billion.

Source of historical data: American Gas Association, 1998 Gas Facts; and estimates from EIA, Inc.

...duction companies and in service/supply companies. Approximately 900,000 jobs have been eliminated from the industry since the early 1980s, with over 40,000 job cuts occurring in the producing sector alone in the past year. Simultaneous reduction in industry hiring rates in the last 20 years has resulted in a disproportionate percentage of the workforce reaching retirement age in the next decade—an average of 43% in a sampling of major producers. Furthermore, the next generation of workers is not choosing to enter the industry, as indicated by the significant decrease in enrollment in some energy-related college curricula.
since the mid-1980s. The oilfield service/supply sector faces a similar situation as many laborers and supervisory personnel have left the industry in search of more stable work. Higher wage scales are likely to be required to attract workers back into the industry.

Drilling Rigs

The U.S. drilling fleet must expand to undertake the dramatic increase in activity that will be required over the next decade to produce the additional supply. The total number of oil and gas wells drilled per year (including dry holes) will have to double, from approximately 24,000 in 1998 to over 48,000 by 2015. Even taking into account anticipated improvements in drilling efficiencies, approximately 2,300 active rigs (over 2,100 land rigs and 180 offshore) would be needed to achieve this level of drilling. This

Figure 10. Onshore Drilling Rig Fleet

Source of historical data: "Reed Rig Census," 1997-1998 (published in World Oil); and estimates from EIA, Inc.
Figure 11. Offshore Drilling Rig Fleet

Source of historical data: Offshore Data Services, Rig Locator, September 24, 1999.

represents an 80% increase over the 1,250 average active rig count estimated for 1999.

Rig availability, which is crucial to exploration and development, will be a challenge for the industry. The oilfield supply and service sectors have been hit particularly hard by the boom and bust cycles. Very few new onshore drilling rigs have been built since the mid-1980s. If the 5% per year historical attrition rate were to continue, most of the existing 1,700 onshore rigs would be retired by 2015 and a total of almost 1,900 onshore rigs would have to be built (Figure 10). Additions to the offshore rig fleet will also be needed and are projected to include 10 deepwater drilling rigs, 32 platform rigs, and 35 jack-up rigs and barges (Figure 11). Although the number of

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new offshore rigs is smaller, the average cost per rig is significantly higher than that of onshore rigs. The drilling sector and the manufacturers of drilling equipment are not currently positioned to undertake this level of expansion.

Lead Times

Reduction of development lead times—from lease acquisition and prospect identification, to the beginning of exploration, to pipeline construction for delivery to the burner tip—is critical to meeting the gas demand projected in this study. For example, as many as 10 years—or two-thirds of the time period of this study—may elapse between the time a block in the offshore is leased until production flows to market. Industry and government are working diligently to reduce development time by streamlining processes and applying new technology. However, access limitations and cumbersome permitting and approval processes often negate those improvements. For example, increases in time required to perform studies previously conducted by government agencies, and obtain multi-agency permits have resulted in production project delays of up to two years on federal lands in the Rocky Mountain region. While the MMS has improved the approval process for offshore development by serving as the facilitator for the process, production and pipeline projects on land still require extensive interactions with multiple levels and agencies of federal, state, and local governments. For example, the recently constructed Portland Natural Gas Transmission System involved the acquisition of over 150 permits and/or approvals from federal, state, and municipal government agencies. Most of the agencies involved in these processes have different data requirements, forms, and processes. Additional improvements are needed immediately in order to impact the development in the outer years of this study.

Changing Customer Needs

The ongoing regulatory restructuring of the natural gas and electricity markets changes the roles and responsibilities of all industry participants. As restructuring continues to unfold at the state level, the roles and obligations of LDCs and electric utilities will be changing. Other energy market participants may accept some aspects of the former roles of the LDCs and electric utilities as services are unbundled. These other participants, such as producers, generators, marketers, energy service providers, and end-users will contract for and use capacity differently than the LDCs and traditional electric utilities. In addition, new flexible services will be required to meet the anticipated increase in gas demand for electricity generation as projected in this study. For example, natural gas-fueled turbines (simple and combined cycle) have unique operating requirements in terms of inlet pressures and operations. Since electricity cannot be stored, the electricity generation systems must be constantly monitored and adjusted to change output instantaneously as electricity demand changes. Thus corresponding changes in natural gas demand occur constantly throughout the day. These changes in roles, services, and customer requirements will cause all sectors of both the natural gas and electricity industries to manage their assets differently.

Sensitivity Analyses

As discussed earlier in this report, sensitivity analyses provided some important information regarding the importance of the critical factors (see Figure 12a). Demand, for example, can increase by 0.6 TCF in 2010 if gross domestic product (GDP) grows by 3.0% annually instead of 2.5%. Conversely, GDP growth of 2.0% could result in a decrease in demand of 0.9 TCF by 2010. If crude oil price averaged $22.00 rather than $18.50 as assumed in the Reference Case, demand could increase by 0.7 TCF in 2010. However, demand would be 1.0 TCF lower if crude oil price averaged $15.00.

The model’s output on price also served as a gauge for quantifying the impact of certain assumptions (Figures 12b and 13). While the model projects an average production weighted U.S. wellhead gas price through 2010 of approximately $2.74 per million British thermal units (MMBtu), prices in the sensitivity analyses change significantly. For example, the model projects that gas prices could be as much as $0.32 per MMBtu lower in 2010 if technology improvements are significantly better than assumed in the Reference
Figure 12a. Influence of Key Assumptions on Natural Gas Demand

Figure 12b. Influence of Key Assumptions on Natural Gas Price

NOTE: See Figures 14a and 14b for more details on resource base and access cases.
Figure 13. Historical and Projected U.S. Natural Gas Prices*
Lower-48 Weighted Average Wellhead Price

*Prices are NOT intended to be a forecast. Seasonal factors such as abnormal weather and demand fluctuation
have not been taken into account.

Case. Conversely, a slower pace of technology improvements could drive the price up by $0.27 per MMBtu.

The single most significant assumption in the Reference Case is the size of the resource base. The model projects that the price of gas could be lowered by as much as $0.96 per MMBtu in 2010 if the economically recoverable resource base were found to be 250 TCF larger than assumed in the Reference Case. In this case, demand increases by 1.9 TCF and U.S. production increases by 1.5 TCF. A second sensitivity run was to examine the impact of a smaller resource base, although it should be noted that the resource base estimates have always increased over time. If estimates of the resource base are lowered by 250 TCF, prices could be as much as $0.56 per MMBtu higher, demand would be 1.5 TCF lower, and U.S. production would be 1.6 TCF lower. While this sensitivity was run to evaluate the impact of learning more about the resource base, it also provides some insight to the impact of access restrictions. Access is an important factor because it removes potential supply from the available resource base. Access restrictions also limit the opportunity to better assess the resource size in those areas.

To better quantify the impact of access restrictions, two additional sensitivity cases were developed. The first case tightened access restrictions in the Rocky Mountain region and eliminated the planned MMS Lease Sale 181. In this reduced access case, price increased $0.16 per MMBtu in 2010 and demand decreased by 0.4 TCF. U.S. production decreased by 0.5 TCF. The second sensitivity case relaxed access restrictions in the Rockies and made currently restricted offshore regions available for leasing in 2004. This increased access case resulted in an increase in U.S. production of 0.5 TCF in 2010, an increase in demand of 0.4 TCF and a corresponding decrease in price of $0.21 per MMBtu. More importantly, a dramatic shift occurred in the Extended View period of the increased access case with an increase in demand of 1.5 TCF in 2015, a corresponding increase in U.S. production of 1.6 TCF (primarily from the Rockies and the eastern Gulf of Mexico), and a corresponding decrease in price of $0.45 per MMBtu (Figures 14a and 14b).

The most important conclusion derived from these sensitivity analyses is that the future availability and cost of natural gas can be influenced. While some variables cannot be controlled, factors such as the rate of technology development, knowledge of the resource base, and access to the resource base can be impacted—either positively or negatively—by the actions of the industry and the government.

The Council wishes to emphasize that the price output of the model is not to be used as a forecast, but rather as an indicator of the relative influence of the critical factors and assumptions. Seasonal factors that affect price, such as abnormal weather and demand fluctuations, have not been taken into account. The market will ultimately determine the price of natural gas. However, actions can be taken by industry and government to ensure that adequate supply is available, that it can be delivered to the market, and that the ultimate price is competitive through the study period and beyond.

In summary, affordable energy is necessary to sustain continued growth of the nation's economy and quality of life. Natural gas will play an important role, particularly as it helps the nation meet its environmental goals. By 2015, more than 14 million new customers will be connected to natural gas supply through over 300,000 miles of new transmission pipelines and distribution mains. Many more customers will use electricity that is fueled by natural gas as over 140 gigawatts of new electricity generation capacity—almost entirely gas-burning units—go into service. These new customers, as well as the existing customer base, are counting on long-term availability of reliable, competitively priced natural gas to meet their energy needs and to support the nation's environmental goals. Industry, government, and other stakeholders must act quickly, cooperatively, and purposefully to meet those expectations.
Figure 14a. Impact of Size of Resource Base and Access on U.S. Natural Gas Production

Figure 14b. Impact of Size of Resource Base and Access on U.S. Natural Gas Price
Recommendations

The Council wishes to emphasize that gas supply, and the associated infrastructure, can be expanded to meet growing demand if the critical factors are adequately addressed. The following recommendations are made by the Council to ensure that the mutual goals of government, industry, and consumers are met. While recommendations are made to the government for specific actions, the Council does not advocate regulations or legislation that artificially alter market signals. Instead, the Council encourages changes that remove impediments which hinder the development of supply and infrastructure to meet market needs.

Recommendation 1:
Government and industry must take a leadership position in establishing—at the highest level—a strategy for natural gas in the nation's energy portfolio: An Interagency Work Group on Natural Gas should be established to work with industry and other stakeholders to formulate the strategy and resolve issues.

The government can help to overcome the barriers to meeting future natural gas demand by establishing a national strategy for natural gas. This strategy should include the areas of supply, demand, and transmission/distribution and should address the issues of access to the resource base, technology development, environmental regulation, education of the future workforce, and financial incentives. It should also affirm and describe the role of natural gas in balancing the national objectives of economic growth, environmental protection, and energy security. The strategy must provide a proper balance between conflicting environmental and land-use interests, yet reflect a sense of urgency about developing natural gas supply and the delivery infrastructure given the long lead times required.

The Council recommends that an Interagency Work Group on Natural Gas be established within the National Economic Council to formulate this comprehensive natural gas strategy and identify and aggressively resolve the issues associated with the development of natural gas supply and supporting delivery systems. This Interagency Work Group should be analogous to, but distinct from, the Interagency Working Group on Energy that has been set up under the National Economic Council to address oil industry issues. This new Work Group should oversee the implementation of government-related recommendations contained in this report. It should also monitor, on a biennial basis, trends for the assumptions used in this study and progress on the identified critical factors in order to anticipate changes in the supply/demand equation.
All federal agencies that have a role in natural gas policy, technology, and resource assessments should be members. The Work Group should make every effort to include input from industry and other stakeholder groups, including states with natural gas production or potential for production, in its strategy-setting process. This solicitation of stakeholder views should be as interactive as possible.

The industry must also step up to the leadership challenge and work with government and other stakeholders to identify and understand their issues associated with developing supply and delivery systems and to seek practical solutions. Industry must work with customers to understand future supply and delivery needs and work with government to shape appropriate strategy and policies so that the required services can be provided in the most cost-effective manner while ensuring safety and reliability. Industry councils and trade associations can play an integral role in this effort.

**Recommendation 2:**

Establish a balanced, long-term approach for responsibly developing the nation’s natural gas resource base.

As seen in the analysis of critical factors in this report, the estimated size of the resource base is the single most important factor in projecting availability of competitively priced natural gas. While the ultimate size of the resource base cannot be changed and cannot be precisely known, industry can continue to improve its knowledge of the size and characteristics of the resource base, thus improving the likelihood of locating and producing new supply. However, access to a significant portion of this resource base for either assessment or development is subject to restrictions due to environmental and land-use concerns. These concerns are appropriate for consideration in granting access to potential supply areas, but significant improvements in the industry’s environmental footprints warrant a new look at these restrictions.

Given the compelling need for developing economic natural gas supply, the following actions are recommended:

- **Government agencies and industry representatives should continue the work begun with this study to inventory existing information on the resource base in the Rocky Mountain region and analyze the impact of access restrictions.** A significant portion of work associated with this study included a first-time assessment of resource impacts associated with land access restrictions and related environmental stipulations in six areas in the Rockies. The results were then extrapolated to the entire region. This involved a cooperative effort between members of the Supply Task Group and representatives from the federal government, including the U.S. Department of Energy, the Bureau of Land Management, and the U.S. Forest Service. Representatives from state and local governments, as well as other stakeholders, also participated. This analysis, and the cooperative approach, should be continued and expanded beyond this study to increase understanding of the impact of access restrictions in the Rockies.

- **Industry should work with the government to prioritize restricted areas on the basis of resource potential as well as environmental sensitivity.** Certain restricted areas should be more fully assessed to determine the potential for gas supply. Those with higher potential and lower sensitivity should be opened for additional geological assessment. Industry should work with the government to identify methods and technologies that could be practically applied to minimize the environmental impact of the assessment.

- **A comprehensive approach should then be established for developing gas supply in selected restricted areas.** Existing moratoria should be reviewed and modified as appropriate. Industry should continue to develop practical techniques that minimize environmental impact, particularly for these sensitive areas. Once a long-term development plan is in place, the affected agencies should work together to coordinate their roles in assisting that development. A template for long-term planning
and coordination among multiple agencies can be found in the MMS and their management of the offshore region.

- Long-term sustainability of natural gas supply should be addressed. The current study finds that, with focused effort, the gas demand through 2015 and well beyond can be met with sustainable gas supplies from U.S. and Canadian resources. The life of the resource base can be further extended by encouraging efficiency at the burner tip. However, the Council also recognizes that at some point in the future—though probably not within the timeframe contemplated by this report—the United States will need to develop resources in what are now regarded as far frontiers. Such sources might include Alaska, large-scale LNG imports from a variety of foreign sources, and possibly gas transported by pipeline from the Caribbean and Latin America.

Gas hydrates—frozen crystals of methane and water found both below the ocean floor and in Arctic regions—could also be a potential source of natural gas. In Turning to the Sea: America's Ocean Future (September 1999), the Secretaries of Commerce and Navy recommend the acceleration of scientific research on ocean hydrates. In addition, the Department of Energy’s Office of Fossil Energy issued a document, A Strategy for Methane Hydrates Research & Development (August 1998), that provides for a comprehensive national research program that includes both marine and Arctic hydrate resources.

Projects to reach the far frontiers will be very expensive and will have extremely long lead times. At some point during the study period, government and industry must begin a cooperative, public planning process to lay the groundwork for far frontier projects.

The recommended Interagency Work Group could play a very important role in addressing access issues and the long-term sustainability of natural gas supply. The Work Group should be assigned the following responsibilities:

- Establish a set of principles that would guide federal land management policy. These principles should balance the national goals of economic growth, environmental protection, and energy security and should recognize the unique role of natural gas in meeting national objectives in the areas of clean air, climate change, electricity industry deregulation, and domestic energy supply. The guiding principles should also emphasize the need for multiple use of public land. Recognizing that it is the primary responsibility of the Secretaries of the Interior and Agriculture to establish land management policies within their jurisdictions, the guiding principles should help put those policies and priorities in a national policy context with respect to natural gas. The principles should be used by the appropriate land management and regulatory agencies to establish policies that promote domestic production of natural gas in order to meet national goals.

- Address the barriers that restrict access to natural gas resources in the Outer Continental Shelf and on onshore federal lands, particularly in the Rocky Mountain region where the majority of the onshore public gas resource is found. The goal of this effort should be to maximize the amount of economic natural gas resource available for development (consistent with effective environmental protection), reduce delays in natural gas exploration, production, and transportation, and improve consistency among federal and state agencies. The Work Group should oversee the continuing effort to inventory the impact of access restrictions on natural gas resources as discussed above. It should also evaluate the process by which access to the natural gas resource base and pipeline rights-of-way has been restricted in the past and may be further restricted in the future. The Work Group should look at the following categories of barriers:

  - Land withdrawals that put natural gas resources off limits
  - Regulatory and policy decisions that make natural gas resources effectively off limits or impractical to recover, such as:
    - “no surface occupancy” designations
use of stipulations more restrictive than needed to protect environmental resources

- old access restrictions that don't account for the effect of technology improvements that might allow development of natural gas in environmentally sensitive areas

- air quality issues that threaten to delay or limit natural gas exploration and production.

- Decisions and applications of regulations and policies that increase the cost of or impose unnecessary delays in natural gas recovery and transportation, such as:
  
  - "combined hydrocarbon" leasing that imposes unnecessary costs on producers
  
  - a cumbersome Coastal Zone Management process that imposes delays on CCS leasing.

Recommendation 3: Efforts for Research and Technology Development at a Rapid Rate

Technology is another highly critical factor affecting both supply availability and price. Accelerating the development of technology is in the best interest of all stakeholders. The following industry and government actions are recommended:

- Industry participants must aggressively build on past successes in advancing technologies by investing in research and supporting additional industry consortia.

Transmission and distribution companies should continue to invest in improving the efficiency of the delivery systems. All industry segments should explore additional applications that advanced information and communication technology can provide. Industry must continue to fund basic research, both independently and through grants to universities.

Industry must also continue to invest in the development of technologies that reduce the environmental impact of exploration, production, and construction of infrastructure. Industry and consumers should continue to develop more efficient gas consumption equipment, thereby improving energy efficiency and yielding lower costs to consumers.

- The government should continue investing in research and development through collaborations with industry, state organizations, national laboratories, and universities. Efforts should be made to define key research and development priorities to support increased reserve growth in existing fields and new field discoveries in areas with the largest potential resource and to support expansion of the delivery infrastructure. Examples of specific research that government might sponsor include:

  - Reservoir detection and characterization technology targeted at exploration and field development

  - Technologies to reduce the cost of environmental compliance

  - Innovative geologic and engineering concepts based on novel technologies such as 3D and 4D seismic and horizontal drilling

  - Technologies to further ensure the reliability, security, and integrity of the delivery system.

Particular consideration should be given to long-term technology needs for ultra-deep water, low permeability, and non-conventional reservoirs that will contribute more of the nation’s gas supply in the future. Policy issues that affect technological developments should also be addressed.

- The government should promote high-efficiency gas technologies such as fuel cells, gas cooling, and high-efficiency turbines. Due to the inherent environmental advantages of natural gas and the high
efficiencies offered by new gas equipment, the use of gas in place of other fossil energy forms promotes both energy conservation and environmental improvement (e.g., in areas such as acid rain, ozone formation, particulate emissions, and solid waste disposal). All energy efficiency evaluations and standards should be based on a “total energy efficiency” concept, that is, energy efficiency measurements should include energy used or lost from the point of production through consumption.

The recommended Interagency Work Group on Natural Gas can play a significant role in overseeing technology investments made by the government. Industry and state agencies should be actively involved with the Work Group in directing these efforts.

**Recommendation 4:**
Plan for capital, infrastructure, and human resource needs.

The long-term demand growth projected in this study translates to long-term opportunities for the industry and the government. The increase in demand provides the opportunity for industry participants to expand their markets and to increase their service offerings. Benefits to the government extend beyond meeting environmental goals and include increases in revenues from royalties, rentals, and bonuses from the leasing of federal lands and development of the resources. For example, income generated by the Offshore Mineral Management Program alone generates about $4 billion annually. However, taking full advantage of these opportunities will require long-term resource planning on the part of industry and government. The following areas should be specifically addressed:

- **Industry must immediately address concerns regarding the future availability of skilled workers.** Several years are required to train highly skilled workers to perform their jobs knowledgeably, efficiently, and safely. Given the projected increase in activity and the impending increase in retirements, aggressive action must be taken to attract, train, and retain qualified workers at all levels. Industry must also undertake initiatives to attract high school students with strong math and science skills to replenish college enrollments in petroleum, geotechnical, and other energy-related disciplines. Government funding of energy-related studies in universities can also help to populate these disciplines.

- **Producers, drilling companies, and equipment manufacturers should form a joint industry task force, headed by the International Association of Drilling Contractors, to gather additional information on infrastructure needs.** Of particular concern is the projected need to increase the number of wells drilled per year and increase the drilling rigs and equipment required to accomplish that task. The task force can begin its study by collecting data, such as drilling success rates in deeper formations and drilling rates for deep vertical wells, that are needed for assessing future needs. The task force should include rig builders and shipyard operators as well as industry groups such as the Petroleum Equipment Suppliers Association.

- **Government should examine possible new financial incentives, such as limited-duration tax and royalty incentives, that would accelerate the development of high-risk, high-cost natural gas resources onshore and offshore.** Past support from the government, such as tax credits and deepwater royalty relief, has promoted development activity. The MMS, in their January 1999 publication on deepwater development facts, states “The Deepwater Royalty Relief Act, passed in 1995, has contributed significantly to the increase in deepwater activity by providing the opportunity to lease new prospects in deepwater.” The MMS reports that Gulf of Mexico OCS bids for leases in water greater than 800 meters increased from 49 in 1994 to 1,138 in 1997 and 817 in 1998. Other types of incentives should also be explored with input from industry advisors. These
incentives, if properly targeted, can convert non-economic resources into economic supply.

Once a high level policy is established, all agencies involved in the development of supply and delivery systems should review and align existing policy to eliminate conflicting directives and remove obstructions. Processes that affect development must be streamlined to eliminate duplicative efforts, follow more predictable time-lines, and eliminate unnecessary costs to the industry, government, and, ultimately, consumers. Approval processes involving multiple levels of government and agencies should be coordinated in order to resolve conflicts in a timely manner.

The Council recommends that the following areas be evaluated:

- Updating of resource management plans for federal lands
- Potential for sharing land management and environmental assessment resources, such as data bases and personnel, among agencies
- Designation of sufficient budgets for required land-management planning and studies
- Adequacy of legislation for land-management policy and procedures
- Opportunities for coordinating permitting/approval processes among agencies.

In response to the ongoing restructuring of the natural gas and electricity markets, all industry participants must offer new or reconfigured services specifically designed to meet changing customer needs. For example, individual pipelines and many LDCs are implementing new services to meet customer needs through filings for services such as parking, loaning, balancing, peaking, and hourly firm transportation. While industry-wide changes may take some time to implement, individual pipeline changes can be developed and approved in far less time. When new services are offered to gas customers, maximum choice should be ensured by allowing all parties to compete for the provision of those services in a non-discriminatory manner.

The members of the National Petroleum Council stand ready to further discuss and implement the recommendations made in this report. Members will assist the Interagency Work Group in identifying impediments and solutions to the mutual goals of government, industry, and consumers for increased availability of competitively priced, environmentally desirable natural gas.