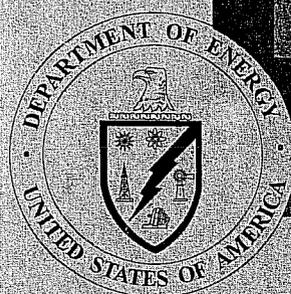
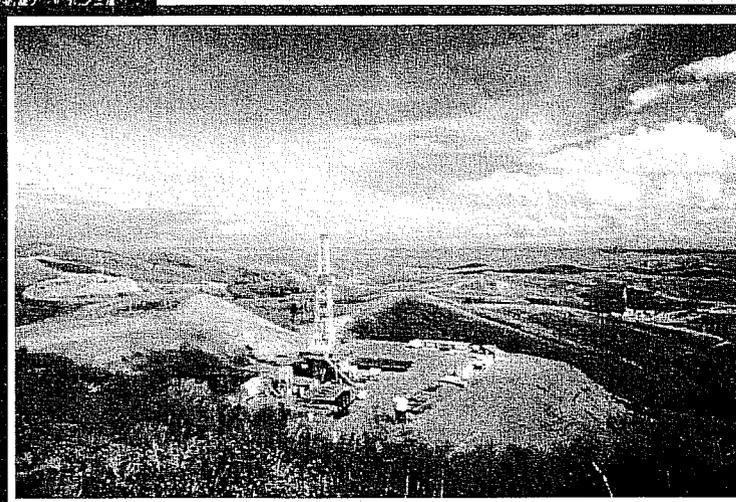
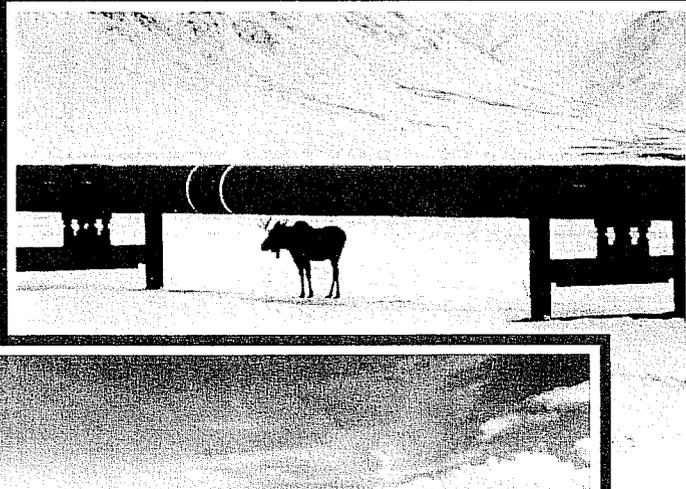
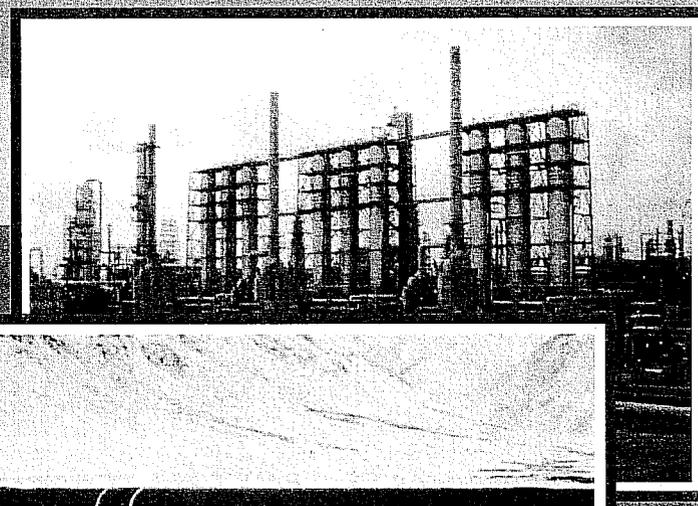
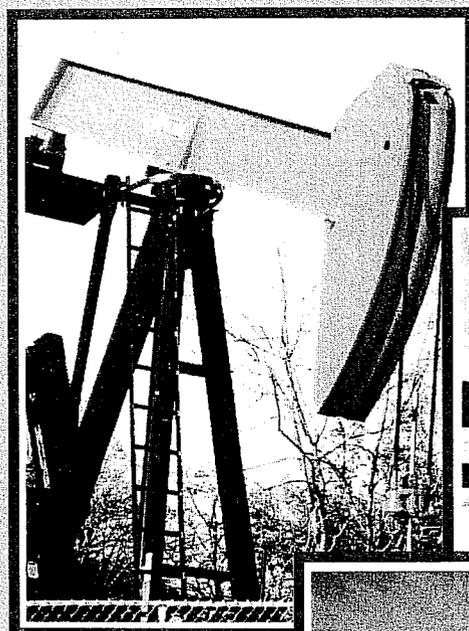


COORDINATED STRATEGIC PLAN FOR THE OIL, NATURAL GAS, AND RELATED ENVIRONMENTAL TECHNOLOGY RD&D PROGRAMS



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**Coordinated Strategic
Plan for the Oil, Natural
Gas, and Related
Environmental
Technology
RD&D Programs**



**U.S. Department of Energy
Washington, DC 20585**

August 1996

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INTRODUCTION

The United States depends on oil and gas for approximately 63 percent of the energy it consumes. Many forecasts project that relatively low oil and gas prices and high U.S. dependency on these fuels will continue well into the next century. The economic benefits of having strong oil and gas industries that create export-related jobs supports the competitive economy required for global market competition in the twenty-first century and simultaneously provides low-priced domestic oil and gas fuels. A coordinated strategy has been developed to help achieve the Department of Energy's Oil Technology, Natural Gas Research, and related Environmental Research, Development, and Demonstration (RD&D) Program goals that support projected demand. Further, because of tightening budgets and generally reduced implementation resources, the strategy was formed to help attain the goals and attendant economic benefits using minimum resources and without unacceptable environmental costs or national security risks.

This is a coordinated plan for all oil technology, natural gas supply, and related environmental RD&D program activities. Stakeholder recommendations contained in the following documents were considered: the National Petroleum Council (NPC) studies, "RD&D Needs of the Oil and Gas Industry" and "Future Issues — A View of U.S. Oil and Natural Gas to 2020;" the Petroleum Technology Transfer Council's "Technology and Related Needs of U.S. Oil and Natural Gas Producers;" the report of the Yergin Task Force on Strategic Energy Research and Development; and relevant information from other sources.

Program drivers stem from defined Federal Government roles to maintain reliable domestic energy supplies at reasonable costs; increase the value of Federal lands and U.S. Treasury revenues by maximizing production; provide science and technology leadership; enhance global market opportunities for U.S. energy technologies; and serve as a catalyst for industry, State, and other Federal agency partnerships. Program activities are consistent with the scope of research needs analyzed by NPC in its RD&D Needs report, and encompasses the entire "systems approach" from natural resource identification to refinery and gas processing facility output.

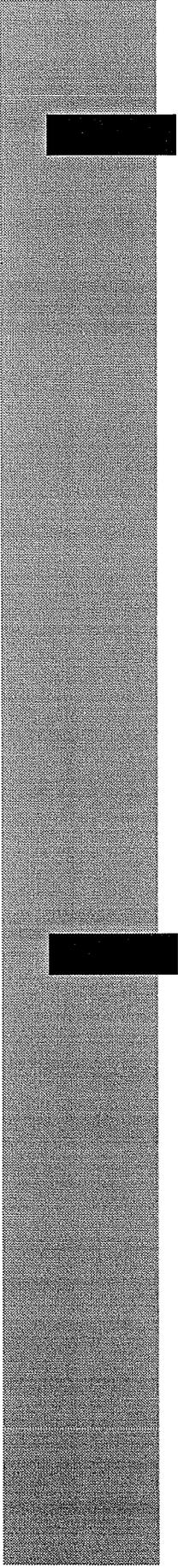
The Oil Technology Program's supply portion includes RD&D in four program areas as outlined in the fiscal year 1996 budget:

- Exploration and Production Supporting Research
- Recovery Field Demonstrations
- Exploration and Production Environmental Research
- Processing Research and Downstream Operations

INTRODUCTION

The Natural Gas Research Program's supply portion covered in this plan include:

- Exploration and Production (formerly Resource and Extraction)
- Storage
- Natural Gas Processing (comprised of Natural Gas-to-Liquids and Upgrading)
- Environmental Research/Regulatory Impact Analysis

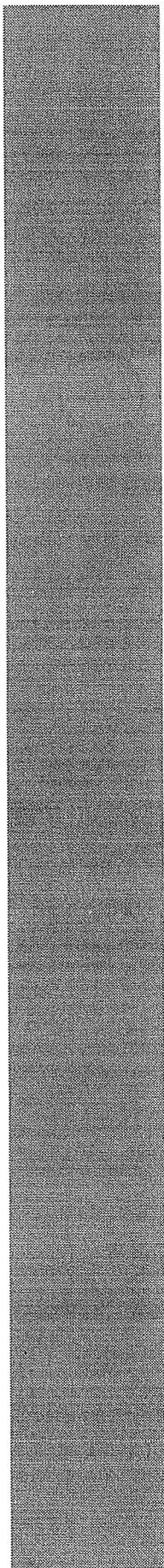


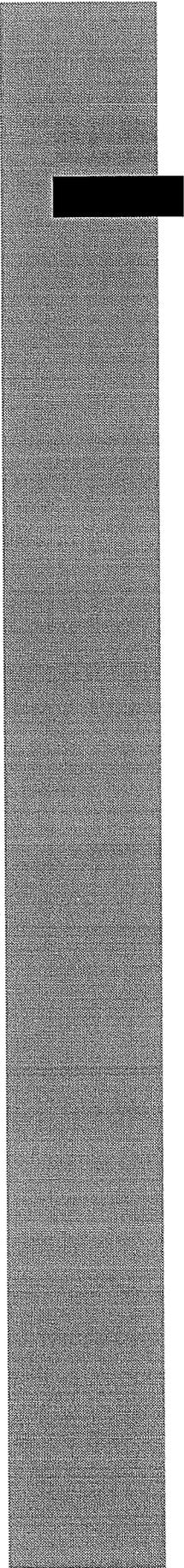
MISSION

The U.S. Department of Energy's (DOE) Office of Fossil Energy, in concert with customers, undertakes and promotes activities and policies through its oil technology and natural gas supply programs to enhance the efficiency and environmental quality of domestic oil and natural gas exploration, recovery, processing, transport, and storage. The success of these programs will help our Nation achieve a reliable and economic oil and natural gas supply and enhance U.S. technology leadership while protecting the environment.

VISION 2020

Oil and natural gas reach their full potential in contributing to the Nation's national security, economic growth, and environmental quality. The United States remains the world leader in oil and natural gas technologies; advanced U.S. technologies are sold and used worldwide. A customer-driven, public-private partnership is recognized as a key contributor to the development of technologies, regulatory streamlining, and policies that support increased supplies of oil and gas.





CUSTOMERS

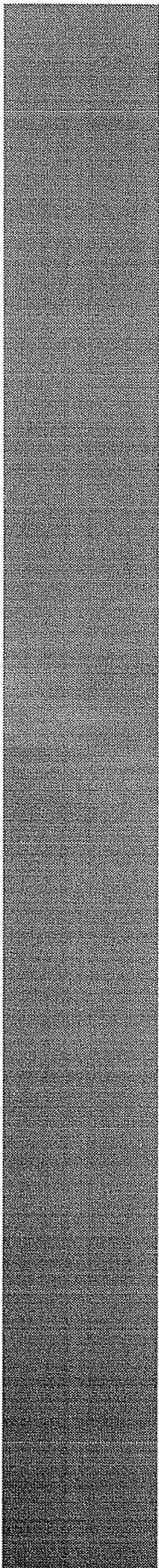
DOE's first-line customers -- those directly involved -- include:

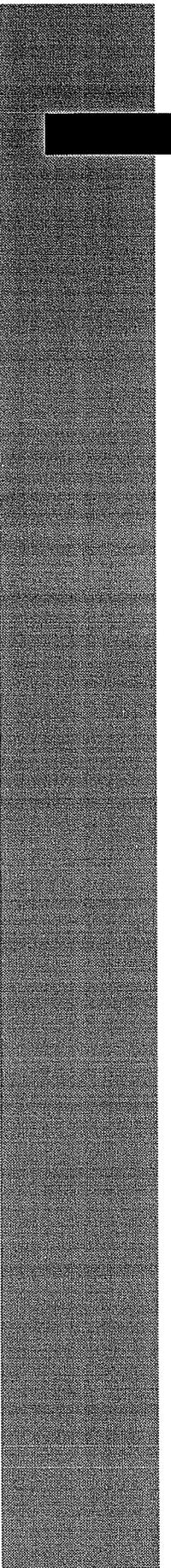
- Oil and gas producers
- Service companies
- Energy marketers
- State and Federal agencies
- Universities
- Private research organizations
- Refiners
- Gas processors
- Pipeline companies
- Gas distributors
- Power generators
- Industry/producer associations
- Congress
- Native American Nations
- Oil and gas marketers
- Financial community
- Trade associations

DOE recognizes that the ultimate customer is the consumer. First-line customers serve ultimate consumers in the following market sectors:

- Transportation
- Residential
- Agriculture
- Industrial
- Commercial
- Electricity Generation

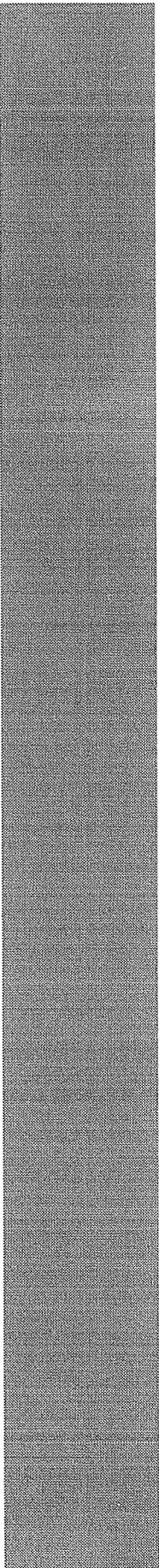
DOE's work with customers reflect the Government Performance and Results Act of 1993 and the Department's Outreach Strategy.





GOVERNMENT PERFORMANCE AND RESULTS ACT OF 1993

Extensive stakeholder involvement in the development and ongoing assessment of coordinated oil and gas programs will be consistent with requirements of the Government Performance and Results Act (GPRA) of 1993. The purpose of this Act is to reduce waste and inefficiency and increase customer satisfaction in Federal programs. The GPRA calls for development of strategic plans which cover 5 fiscal years (to be updated every 3 years); a comprehensive mission statement linked to ongoing operations; general goals and objectives and how they will be achieved; a description of key external factors that could affect achievement of the goals; and annual program evaluations to be used in establishing or revising general goals and objectives. GPRA also requires consideration of the views and suggestions of those entities potentially affected by or interested in the program.



OUTREACH STRATEGY

A primary purpose of DOE's outreach program is to build strong relationships and frequent dialogue with industry. Departmental outreach efforts will enable industry and other stakeholders to: (1) provide input concerning needs and priorities; (2) identify areas for effective customer-driven, public-private partnerships; and (3) better utilize results of DOE-supported work.

Outreach activities establish vital relationships and two-way communications between a program's managers, implementers, and customers. In 1996, DOE developed a national and regional outreach network, involving teams composed of managers and staff from Headquarter's Oil and Gas Program and Policy offices and product and project managers from the Field. The network will serve as a framework for facilitating and coordinating outreach efforts in a cost-effective manner.

DOE's outreach teams parallel the structure established by the Petroleum Technology Transfer Council (PTTC) in 10 producing regions. There are also two non-PTTC regions (consuming only), and one overall national coordination activity. Each regional outreach team is responsible for understanding the region; knowing the industry and other key players; understanding regional resources, challenges, and needs; and marshalling DOE's resources. These team members combine expertise in technology, policy and regulatory analysis, and information and economic analysis.

A number of approaches will be used to establish relationships and develop the communications desired from outreach activities. These approaches include:

- Meeting with and listening to a variety of industry organizations such as technical associations, the Gas Research Institute, American Petroleum Institute, National Petroleum Refiners Association, American Gas Association, Petroleum Environmental Research Forum, and others;
- Working with the PTTC in using its regional centers, producer networks, and problem identification activities;
- Participating in national and regional conferences and workshops where research and other industry needs are discussed; and
- Coordinating with other Federal Government agencies having related interests such as the U.S. Geological Survey, Minerals Management Service, Bureau of Land Management, and the Environmental Protection Agency, as well as State and local agencies.

OUTREACH STRATEGY

Information exchanged through these efforts will be used to develop coordinated strategic and implementation plans and budgets for the Oil Technology, Natural Gas Research, and related Environmental RD&D Programs. The dissemination of results (technology transfer) will emphasize delivering user-friendly information and products that meet the needs identified by the outreach program. In serving as a resource for industry and others on oil and gas matters, the coordinated programs will become the preferred points-of-contact for information and assistance in dealing with the Federal Government in areas such as the availability of research funds, environmental concerns, and royalty or tax matters. These information exchange activities will strengthen partnerships between DOE and its customers. Pursuing this approach to outreach will build and expand on industry-identified priorities by:

- Finding solutions to industry-identified problems and implementing them through proactive partnerships among industry and Federal, State, and local governments;
- Using cost-benefit analyses and risk-based solutions in the regulatory decision-making process; and
- Better coordinating policy development and regulatory activities with industry and Federal, State, and local agencies.

CURRENT SITUATION

For more than a century, oil and gas industries have been essential to the economic growth, high standards of living, and national security of the United States. The U.S. leads the world in petroleum production and processing technologies, which provide high-paying jobs for Americans both domestically and abroad. In 1995, oil and gas accounted for two-thirds of total U.S. energy consumption.

Technology has changed the U.S. resource base over the last decade. Oil and gas resource estimates have increased, and at the same time, the cost of converting the resource base to producible reserves has decreased to less than \$5/barrel today compared to \$8 to \$9/barrel in 1987. Several technological developments contributed to lowering the cost of augmenting natural gas and oil reserves. Advances in three-dimensional (3-D) seismic techniques enabled geologists to discover hydrocarbons beneath salt domes in the Gulf of Mexico and improvements in platform design reduced the cost of developing deep-water resources. These technological innovations resulted in cost-effective development of U.S. offshore reserves and led to a significant increase in exploratory activity in the Outer Continental Shelf (OCS) during 1994 and 1995. The 3-D seismic techniques also greatly improved the success rate for onshore drilling, reducing the cost per barrel of recovery.

Today, the United States is considered a mature oil province where oil, which is easily found and produced, is rapidly being depleted. Domestic oil production is at its lowest level in 40 years, but substantial natural gas and oil resources, remaining and undiscovered, can be recovered with advanced technology. U.S. oil and gas reserves represent about a 9-year supply of domestic production. However, according to the NPC's recently updated estimates, U.S. reserve extensions and "undiscovered recoverable" resources are equivalent to a 35-year supply of oil and a 59-year supply of gas at current production rates.

Natural gas, a clean-burning and domestically abundant fossil fuel, is an increasingly important component of the Nation's energy portfolio. Natural gas is now recognized by many as the fuel of choice in the long-term transition to a sustainable energy future. Proved reserves of dry natural gas are 164 trillion cubic feet (Tcf), a slight increase from the previous year. Large offshore discoveries, several in deep-water, contributed to this increase and to maintaining the reserve base. According to the Energy Information Administration's (EIA) Annual Energy Outlook 1996 (AEO-96), economically recoverable Lower-48 natural gas resources are estimated at 1,040 Tcf with 1990 technology and 1,696 Tcf with advanced technology in 2015.

In the 1980s and 1990s, the natural gas industry has moved from a heavily regulated utility service to a more competitive commodity supplier and has become increasingly more responsive to competitive market dynamics. Changes in Federal and State public policy are recognizing the benefits of increased gas use and energy competition. Before industry restructuring, producers

CURRENT SITUATION

sold gas mainly to interstate pipeline companies. Now, producers sell significant amounts of gas to marketers or directly to end users, and consequently, significantly less to pipeline companies.

In 1995, total dry natural gas production was 18.9 Tcf and consumption was 21.7 Tcf, both increased 4 percent from 1994. Imports totaled 2.8 Tcf, almost all from Canada. Compared to a year ago, gas consumption increased in all end-use sectors, with the highest gain in the utility sector. Natural gas prices have been relatively flat during the first quarter of 1996 and remain well above the unusually low level of the first quarter of 1995. The average wellhead price in March 1996 was \$2.04 per thousand cubic feet (Mcf), compared to \$1.54 for 1995.

Crude oil continues to be the primary source for transportation fuels. The United States is experiencing declining domestic reserves and production, and increasing imports. Proven U.S. oil reserves are estimated at 22.5 billion barrels, about 0.5 billion barrels less than last year. Revisions and large discoveries occurred in 1995 for the Gulf of Mexico; the 0.7 billion-barrel Mars field was the largest deep-water discovery in the Gulf in 25 years. According to EIA/AEO-96, economically recoverable Lower-48 oil resources are estimated at 106 billion barrels with 1990 technology and 142 billion barrels with advanced technology in 2015.

The Gulf of Mexico is one of the most exciting areas in terms of exploration and

drilling. Increasing prospects and new discoveries in the Gulf have brought major producers back to domestic exploration, which has been primarily dominated by independents. In May 1996, total footage drilled for oil and gas was almost 11 million feet, up 45 percent from May 1995.

Domestic oil production in 1995 was 2.4 billion barrels, as the declining production trend continued. Alaska accounted for a quarter of U.S. oil production despite a 73,000 barrel/day decrease compared to 1994. Industry estimates that in 1995, Gulf of Mexico oil production was increased by 100,000 barrels/day, more than enough to offset the Alaskan decrease but not enough to offset the lower-48 onshore oil production decline. In 1995, domestic consumption, in terms of petroleum products supplied, was 6.5 billion barrels, almost the same as 1994. Oil imports totaled 2.6 billion barrels during 1995 and are projected to continue increasing. This volume represents 52 percent of U.S. crude oil usage.

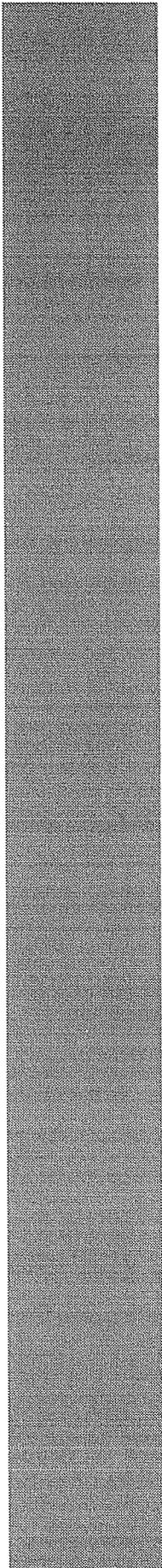
The average composite crude oil price (refiner acquisition cost) in 1995 was \$17.24/barrel, compared to \$15.59/barrel in 1994. The average price in April 1996 was \$21.61/barrel.

Higher oil prices have resulted in increased domestic activity. The number of drilling rigs operating in the United States in the first half of 1996 was almost 10 percent higher compared to the previous year.

PLANNING ASSUMPTIONS

The following assumptions, based on information contained in EIA publications, "Annual Energy Review 1995" and AEO-96, were considered in developing the goals and strategies of the coordinated Oil Technology, Natural Gas Research, and related Environmental Technology Programs. These assumptions are consistent with the outlook through 2015 presented as EIA's Base Case in the AEO-96, specifically with respect to supply, price, and technology development for oil, gas, and competitive fuels. A revolutionary change in any of these variables would alter this strategic plan.

- U.S. oil and gas consumption, in absolute terms, will continue to increase despite energy efficiency improvements. Demand for transportation fuels will rise as a larger vehicle population and increased travel more than offset anticipated improvements in average fleet efficiency.
- Between 1980 and 1993, as gas supplies became more certain and regulations on end uses were removed, natural gas markets expanded — a trend that is expected to continue.
- Historically, technological progress has expanded the economically recoverable oil and natural gas resource base and reduced effective exploration and development costs. The extent to which this trend is likely to continue is uncertain and will depend on future rates of technology development and deployment.
- The prices of both oil and gas are expected to rise, but remain relatively low, through 2015. Oil prices are projected to average \$25.43 per barrel in 2015 (1994\$). The natural gas wellhead price is projected to be \$2.57 per thousand cubic feet in 2015 (1994\$).



PROGRAM DRIVERS

The following plans were used to provide information for this coordinated plan:

DOE Strategic Plan — “Fueling A Competitive Economy”

National Energy Policy Plan

Natural Gas Strategic Plan

Draft Oil Strategic Plan

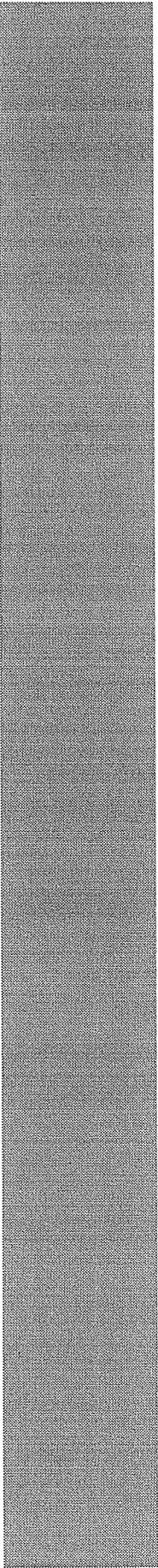
Draft Update Natural Gas Multi-Year Plan

Oil Multi-Year Plan

International Strategic Plan

New Outreach Strategy

This coordinated strategic plan also considers recommendations from the following reports: NPC’s studies, “RD&D Needs of the Oil and Gas Industry” (1995), “Future Issues—A View of U.S. Oil and Natural Gas to 2020” (1995), and “The Potential for Natural Gas in the United States” (1992); the Yergin Task Force Study on Strategic Energy Research and Development (1995); the Petroleum Technology Transfer Council survey, “Technology and Related Needs of U.S. Oil and Natural Gas Producers” (1996); the Gas Research Institute’s annual baseline projection of U.S. energy supply and demand (1996), and its annual 5-year research and development plan (1996). Summaries of these reports and studies are contained in Appendix A.



STRATEGIC ISSUES

Strategic issues have been defined to represent the key barriers or obstacles that must be overcome to realize DOE's vision for its oil and gas, and related environmental RD&D programs.

NATIONAL SECURITY

- The growing demand for oil products will increase U.S. dependence on petroleum imports.
- The United States is a mature oil producing region, but it is more difficult and more costly to produce domestic oil than imported oil.
- The world's oil supply is concentrated in politically unstable regions, which poses a national security threat.

TECHNOLOGY

- Available funding limits industry and government RD&D and the commercialization of advanced oil and natural gas exploration, recovery, refining, gas processing, storage, transmission, utilization, and environmental technologies.
- The widely varying characteristics of reservoirs and associated exploration, production, and processing methods result in the need to consider many diverse problems. The cost of technologies that address these problems must be reduced to ensure economic supply.
- Advances in exploration and production technologies to enhance cost competitiveness of natural gas are needed to maintain increased use of gas in a competitive energy price environment.
- Sufficiently accurate and timely information is necessary to support well-informed oil and gas supply decisions.

ENVIRONMENTAL CONSTRAINTS

- Environmental protection is vital to national and global prosperity.
- A reduction in the environmental impact of oil and natural gas exploration, production, and processing is essential to allow development of environmentally sensitive areas with high resource potential.
- Environmental constraints increase the cost of operations.

ECONOMIC STRENGTH

- Future economics of oil and natural gas supplies may limit capital investments, new or expanded markets, infrastructure maintenance and development, and new technology development.
- The oil and gas industry has shifted its spending emphasis from basic and applied R&D to technical services.
- The involvement of major integrated oil and gas companies in domestic production (especially oil production) has been declining, leaving a less technology-oriented industry responsible for meeting domestic oil and gas needs.
- Without access to international markets, the U.S. petroleum industry may not be able to maintain its position as a leader in and exporter of technology and knowledge services.

POLICY/REGULATORY

- Restructuring in natural gas and electricity industries increases the need for coordinating Federal, State, and local policies affecting natural gas from reservoir to end use.
- Natural gas can significantly increase its role in the domestic energy resources portfolio with new policies and regulatory reforms at the Federal, State, and local government levels.
- Environmental regulations often do not reflect a sound scientific assessment of risk and an economic analysis of costs and benefits.
- Legal and other related problems in leasing new prospects will hamper resource development.

PROGRAM GOALS AND STRATEGIES

For the purpose of strategic coordination of the component programs, goals and strategies have been grouped into major technology groupings: reservoir life extension; advanced drilling, completion, and stimulation systems; advanced diagnostic and imaging systems; effective environmental protection; emerging processing technology applications; and crosscutting program areas. Appendix B contains a table which cross references these technology groupings to current program budget categories.

RESERVOIR LIFE EXTENSION

Reservoir Life Extension focuses on coordinating the Oil Technology and the Natural Gas Supply Programs' activities in research, development, and demonstration of advanced technology for extraction of hydrocarbons from known (discovered) oil and gas reservoirs and for improving natural gas storage. These activities provide improved technology and/or more efficient methods to recover more of the 150 billion barrels of discovered but unproduced domestic oil resource and the more than 500 Tcf of discovered natural gas, and for balancing the storage system that provides up to 30 percent of gas supply during peak months.

GOALS

- Conduct research to develop and demonstrate tools and methodologies that permit oil and gas operators to recover hydrocarbons from known reservoirs not producible by current technology;
- Assist the storage industry to increase deliverability and capacity and to develop more accurate and timely gas measurement;
- Conduct, with industry, pilot-scale and field-scale demonstrations of proven laboratory technologies;
- Support university research on extraction technologies and recovery-process modeling to ensure a supply of well-trained workers while developing the scientific basis for promoting major technology breakthroughs applicable to oil, gas, and other industries; and
- Increase recovery of oil and gas from Federal lands.

STRATEGIES

In partnership with stakeholders, DOE seeks to:

- Develop, demonstrate, and transfer to industry new, improved, and cost-effective advanced oil and gas recovery technologies and methodologies evolving from reservoir class projects and secondary gas recovery projects;
- Develop, demonstrate, and transfer to industry advanced reservoir management techniques and technologies to enhance production from economically marginal wells;
- Develop, demonstrate, and transfer reservoir characterization methodologies and technologies to enhance the operation and improve the development of gas storage in depleted oil and gas reservoirs;
- Work with industry associations to provide focused technology workshops, information resource centers, and computer-based information for oil and gas producers and storage operators; and
- Revisit the Oil Reservoir Class Program and include natural gas resources.

PERFORMANCE INDICATORS

The Oil Technology and Natural Gas Supply Programs will evaluate performance upon completion of the following:

In the Near-Term, by 2000

- Development of novel chemical technology for water shut-off and improved injectant sweep;
- Demonstration of reservoir management technologies in economically marginal fields in the Midwest, Eastern Gulf of Mexico, and North Midcontinent regions of the United States;
- Demonstration and transferal to industry of advanced technologies to increase production from fluvial-dominated deltaic reservoirs, shallow shelf carbonate reservoirs, and slope and basin clastic reservoirs;
- Complete establishment of a regional network of PTTC resource centers so they are fully industry supported;
- Complete integration of a national network of geoscience data repositories, assuring industry access to more than 2 million record sets of information and wellbore samples that would otherwise be lost;

- Demonstration of modeling capability and complete data requirements to show the impact of price and policy changes on the entire oil and gas system from reservoir to end use;
 - Demonstration of fracture stimulation technology and improved remedial treatment technology to restore long-term deliverability from conventional underground gas storage reservoirs;
 - Establishment of increased gas reserves through advanced technologies and methodologies demonstrated in secondary gas recovery projects; and
 - Identification of market needs for natural gas storage in growing market areas.
-
- Demonstration and transferal to industry of remote sensing technology, (high resolution aeromagnetics and 3-D magnetic intensity projection) for predicting and detecting fracture locations in low permeability gas reservoirs;
 - Demonstration and transferal to industry of a computer model to predict fluid flow in heterogenous gas reservoirs;
 - Demonstration of ultrasonic meter performance to improve gas measurement and reduce operational costs;
 - Development of shear wave technology to determine the seismic signature and properties of fractured gas reservoirs; and
 - Demonstration and transferal to industry of directional drilling technology for low permeability gas reservoirs in the Greater Green River Basin.

In the Mid-Term, by 2005

- Demonstration and transferal to industry of technology for carbon dioxide (CO₂) flooding of fractured shale reservoirs;
- Development and transferal to industry of computer programs for improved extraction project design, including enhanced UTCHEM, microbial enhanced oil recovery simulator, and a streamlined simulator for miscible processes;

In the Long-Term, by 2010

- Development and demonstration of thermal technologies to produce the currently uneconomic heavy oil resources in the onshore Gulf of Mexico area;

- Development and testing of novel chemical and gas injection technology for recovery of the immobile oil resource that is not producible using current technology;
- Technology workshops provided to more than 90,000 independent producers through PTTC;
- Demonstration and transferal to industry of remote sensing technology for predicting and detecting the location of fractures in oil and gas reservoirs; and
- Demonstration and transferal to industry of directional drilling technology for low permeability gas reservoirs development in other Western basins.

ADVANCED DRILLING, COMPLETION, AND STIMULATION SYSTEMS

Advanced Drilling, Completion, and Stimulation (DCS) Systems focus on research, development, and demonstration of technologies that increase the net present value of produced oil and gas over the life-cycle of the producing well. DCS, a major program driver, can account for 30 to 70 percent of the initial capital cost of exploration wells, and advanced technologies can have a major impact on drilling operation economics.

GOALS

This program area focuses on developing tools and techniques to drill, complete, and stimulate oil and gas wells required to produce the over 400 Tcf of natural gas and the more than 40 billion barrels of oil EIA's AEO-96 estimates will be produced domestically by the year 2015. Program goals are to:

- Assist industry with developing a balanced portfolio of DCS technologies that will match diverse geologic settings under development;
- Assist the drilling industry in developing new technology products that reduce costs, increase exploration success, minimize formation damage, and improve the producibility of wells;
- Develop, demonstrate, and deploy new technologies that will enhance general industry acceptance and use of technologies designed to reduce cost and improve productivity of oil and gas wells; and

- Coordinate with Gas Research Institute's (GRI) drilling program and other collaborative DCS groups such as the Drilling Engineering Association, the Completion Engineering Association, Natural Gas and Oil Technology Partnership, and other industry RD&D groups.
- Participate in Drilling Engineering Association and Completion Engineering Association projects that will contribute to program efforts; and
- Develop revolutionary drilling systems in partnership with other government and industry groups.

STRATEGIES

The overall strategy is to conceive, develop, demonstrate, and deploy advanced drilling, completion, and stimulation products through laboratory confirmation and field testing in diverse high-potential geologic settings. Technology products and techniques being developed must provide higher net present value over the life cycle of the producing well. To achieve its goals, the Oil Technology Program and the Natural Gas Supply Program will:

- Design, fabricate, and test innovative drilling surface and subsurface instrumentation, hardware, software, and drilling fluids;
- Develop advanced hydraulic fracture technology to reduce damage and/or improve productivity of wells;
- Design, fabricate, and test innovative completion hardware, perforation techniques, and cementing processes;

PERFORMANCE INDICATORS

For Advanced Drilling, Completion, and Stimulation Systems, DOE will evaluate performance upon completion of the following:

In the Near-Term, by 2000

- Use of tool-hardened near-bit sensors for real-time drilling and reservoir information in difficult drilling environments having a "meantime-between-failure" rate of greater than 100 hours;
- Demonstration of slimhole, coiled-tubing products for drilling and completing wells with a minimum of a 25 percent cost savings over conventional methods;
- Commercialization of steerable air percussion measurement-while-drilling (MWD) systems in priority basins;

GOALS & STRATEGIES

- Commercialization of a coiled-tubing and steerable air percussion drilling systems;
 - Completion of at least three technology demonstrations of integrated underbalanced motor MWD systems in priority basins;
 - Demonstrations of cost effective domestic drilling rig retrofit components or systems;
 - Development and commercialization of light weight mud for underbalanced drilling;
 - Promotion of industry use and funding of the Fracturing Fluid Characterization Facility designed to test new hydraulic fracturing systems;
 - Development, testing, and demonstration of high efficiency, non-damaging hydraulic fracture fluids and stimulation technologies for reservoirs up to 25,000 feet in depth;
 - Commercialization of CO₂ sand fracturing in reservoirs representing 10 percent of the fracturing market;
 - Development of an axial force transfer model for coiled-tubing drilling;
 - Development of a performance model of positive displacement motors;
 - Development of a model to predict and mitigate fatigue failure in top-drive rigs;
 - Development of ways to predict and mitigate casing damage induced by reservoir compaction;
 - Development and field testing of a novel Fast-Neutron Monitor; and
 - Development of Electro-Osmosis technology to improve bit penetration rates in formations with clay problems.
-
- In the Mid-Term, by 2005***
-
- Completion of a feasibility demonstration project of an advanced drilling concept resulting in a greater than 50 percent improvement in drilling efficiency;
 - An increase in domestic use of underbalanced drilling technology from 15 percent to 50 percent of the market;
 - Development and commercialization of new DCS products that reduce cost and improve efficiency sufficiently to compete in the energy marketplace; and

- Successful commercialization of high efficiency, non-damaging stimulation technologies in priority basin deployment supply demonstrations.

In the Long-Term, by 2010

- Complete development of revolutionary drilling systems through collaborative efforts with GRI.

ADVANCED DIAGNOSTIC AND IMAGING SYSTEMS

Advanced Diagnostic and Imaging Systems focus on finding undiscovered oil and gas resources by using remote imaging, advanced instrumentation, and computational technology. This area also focuses on developing new ways to measure reservoir properties, increasing the accuracy of currently measurable properties, and developing tools and interpretive techniques to measure currently unmeasurable properties. Advanced diagnostic and imaging systems will be increasingly used for defining when to drill in discovered resources rather than for finding undiscovered resources. Likewise, independent operators will be using these technologies for making development decisions.

GOALS

Advanced Diagnostic and Imaging Systems seek to develop technology that will improve the success rates and cost efficiencies of finding new fields and developing producing fields. These technologies are required to ensure a longer-term economic supply of domestic oil and gas needed to meet projections of EIA's AEO-96, which are over 400 Tcf of natural gas and more than 40 billion barrels of oil by the year 2015. The activities in this area are important to finding and economically developing the U.S. Geological Survey and Mineral Management Service resource estimates of 600 to 1,200 Tcf of undiscovered natural gas and 60 to 100 billion barrels of undiscovered oil in the United States. Program goals are to:

- Conduct research to develop technologies needed for deeper and higher temperature reservoirs, providing U.S. technology leadership worldwide in geoscientific diagnostics and imaging systems, thereby, increasing technology exports that contribute to high-paying U.S. jobs;
- Conduct research to develop and deploy technologies that can provide a picture of underground resources and their environment, resulting in fewer dry holes, better usage of natural phenomena (such as fractures) to increase well productivity, and development of more effective well patterns, which can reduce the overall amount of required drilling fluids, thereby protecting the environment; and

GOALS & STRATEGIES

- Enhance oil and gas production, including that from Federal lands, by developing technologies that will continue to provide technical, environmental, and economic justification for exploiting these resources.

STRATEGIES

In partnership with stakeholders, DOE seeks to:

- Develop technologies and tools to measure important rock properties that are currently not measurable, and increase accuracy of measurement technologies;
- Develop technologies that increase resolution and applicability of rock pore-scale to geologic basin-scale imaging;
- Develop user-friendly exploration technologies for independent producers;
- Apply existing state-of-the-art computational technologies to advance seismic imaging and reservoir and production modeling; and
- Maintain an analysis and planning program (a crosscutting, integrated network of reservoir performance models and reservoir and project databases), which support program planning, analysis, and quality assurance.

PERFORMANCE INDICATORS

The success of Advanced Diagnostics and Imaging Systems will be gauged through the following tangible measures:

In the Near-Term, by 2000

- Complete development and transfer of risk-based exploration decision-making software;
- Complete development of advanced seismic acquisition and processing technology to improve resolution of complex subsalt reservoirs; and
- Complete development of advanced data processing and simulation methods for applying advanced computing technology.

In the Mid-Term, by 2005

- Development of technologies for single-well seismic acquisition and processing;
- Development and demonstration of cross-well seismic technologies for use in both consolidated and unconsolidated formations;
- Development of models of fractured reservoirs for improved recovery design; and

- Development and transferal to industry of improved scale-up techniques to accommodate pore-to core-scale heterogeneities in fast, large-grid simulators.
 - Development and transferal to industry of well logging and geological modeling techniques for in-situ permeability determination; and
 - Development and transferal to industry of improved rock-mechanics measurement and modeling technology.
-
- In the Long-Term, by 2010***
-
- Development and transferal to industry of exploration analyses for high-priority basins;

EFFECTIVE ENVIRONMENTAL PROTECTION

Effective Environmental Protection focuses on technologies and practices that reduce the threat to the environment and decrease the cost of effective environmental protection and compliance. The activities in this area fall under four program elements: risk assessment, regulatory streamlining, technology development, and program planning and analysis.

Risk Assessment: The activities in this element, the largest in terms of budget, address the industry priority of providing sound scientific information to support risk-based regulation. These activities assess and mitigate environmental risks posed by oil and gas exploration and production. DOE serves as a source of credible data that has been successful in influencing the development of regulation based on environmental risk, and cost and energy impacts. This has resulted in considerable cost savings for industry.

Regulatory Streamlining: This element supports the industry priority of reducing unreasonable and unnecessary compliance and reporting requirements, as well as the goals of the Vice President's National Performance Review. Such streamlining can reduce costs to oil and gas operators as well as to government agencies. It is accomplished through interagency cooperation, partnerships and dialogue among industry, States, Tribes, the public, and other affected parties, and a willingness to try innovative approaches. This activity includes outreach to stakeholders both to educate them on environmental issues and to assess their needs as a basis for determining program priorities.

Environmental Technology Development: This element includes the research, development, demonstration, and transfer of environmental compliance technologies and practices to oil and gas operators to improve environmental performance and lower costs for producers. Activities are aimed at demonstrating methods and technologies related to drilling and production waste management, including air emissions detection and control, produced water treatment and disposal, management of solid wastes and wastes containing naturally occurring radioactive materials, as well as remediation of contaminated sites. Technologies are often regional in nature, addressing specific technical needs in such areas as the Rocky Mountains, the Gulf of Mexico, Appalachia, and California. Technology transfer is an integral part of this activity, in both individual project efforts, and wider, coordinated networks such as the PTTC. The program also works cooperatively with the other oil and gas R&D programs to encourage development of environmentally sound technologies and leverage the efforts of the environmental program with relevant research in other areas.

Program Planning and Analysis: This element both develops information on industry and environmental trends for program planning purposes and conducts cooperative efforts with industry, States, and Federal agencies to promote environmentally sound gas and oil resource recovery. Many of these activities are regional in nature to address environmental constraints that exist in particular parts of the country. A large part of this effort supports the continuous review and improvement of existing and proposed environmental legislation, regulation, and policies that may affect natural gas and oil supply.

GOALS

The Effective Environmental Protection activity area seeks to maximize industry recovery of U.S. oil and gas resources by reducing the cost of effective environmental protection. In doing so, the program addresses all four of the previously identified national level goals of the oil and gas RD&D programs. In addition, the environmental program's specific goals are to:

- Enable industry to reduce compliance costs and improve environmental performance;
- Expand the capabilities of State and Federal governments to make more cost-effective, risk-based regulatory decisions—promoting sound science and common sense; and

online survey

- Improve communication and technology transfer among industry, government, Tribes, and the public toward balancing national energy, economic, and environmental objectives.

- Work cooperatively with States, Federal agencies, and industry to leverage efforts to accelerate progress toward reducing the costs of effective environmental protection.

STRATEGIES

In partnership with stakeholders, DOE seeks to:

- Promote dialogue, education, collaboration, and innovative problem solving;
- Work with States and Federal agencies to streamline regulations;
- Develop credible scientific and technical information to serve as the basis for risk-based regulation and compliance, including economic and energy impact analyses and tools for regulators to make risk-based decisions;
- Develop new, lower-cost environmental compliance technologies;
- Promote sound environmental practices through outreach and assistance to industry; and

work w/ env. groups establish liaisons
Workshops
IOGCC
NPC driven
build image
National labs
DOEB political

PERFORMANCE INDICATORS

The success of the Effective Environmental Protection program will be gauged through the following tangible measures:

- Adoption and implementation of program products by industry, Tribes, States, and Federal agencies;
- Reduction in costs of environmental compliance, both for specific technologies and for the industry as a whole;
- Initiation of specific efforts that use dialogue, collaboration, and consensus in regulatory decision-making; and
- Changes in State and Federal regulations and policies that reduce duplication and overlap, simplify compliance, and eliminate unnecessary requirements.

EMERGING PROCESSING TECHNOLOGY APPLICATIONS

The Emerging Processing Technology Applications activity area encompasses two program elements. Natural Gas includes Low Quality Gas Upgrading, Coal Mine Methane Technology (demonstration of capture and utilization methods), and Gas-to-Liquids Conversion; Oil Technology includes Processing (pollution prevention, environmental compliance, and upgrading technology development).

GOALS

The Emerging Processing Technology Applications activity area, through the Oil Technology and Natural Gas Supply Programs, seeks to enhance a diverse, secure domestic supply of oil and natural gas fuels by improving oil refinery efficiency and gas technologies that convert uneconomic or low quality gas to valuable commercial products. The specific program goals are to:

- Develop cost-effective technologies for upgrading contaminated natural gas to pipeline quality or direct use and for converting natural gas to higher hydrocarbon liquid fuels or chemical precursors;
- Develop technologies to effectively capture gas from coal mines, increase productivity and mine safety, and reduce the escape of gas into the atmosphere; and
- Contribute to energy security by continuously generating and transferring to the refining industry new technologies and thermodynamic data that will lead

to a streamlined regulatory framework, and at the same time lower the environmental impact and waste fraction percentages in a barrel of crude oil and increase efficiencies by 2 to 3 percent by 2000.

STRATEGIES

In partnership with industry, research, develop, and implement technologies and approaches and processes for upgrading uneconomic heavy oil and gas, which include: novel polymeric or ceramic membranes; novel adsorbents; heavy oil and residual upgrading; refinery processes that maximize transportation fuels; and hybrid technologies.

In partnership with stakeholders, DOE seeks to:

- Develop and transfer to industry, gas-to-liquids conversion technologies based on research on catalytic and noncatalytic processes;

- Develop technologies to enhance the cost effectiveness of collecting and using gas released in coal mining;
- Work with industry to develop improved, cost-effective, and environmentally acceptable heavy oil and residual upgrading and processing technologies to maximize the output of transportation fuels;
- Develop advanced measurement instrumentation for collecting emissions data and collect data for developing risk-based regulations;
- Develop thermodynamic and chemical data about crude oils, especially heavy crudes, to improve refinery efficiencies; and
- Assure U.S. leadership regarding natural gas upgrading, coal mine methane recovery, and gas conversion technologies for products, information, and methodologies.

PERFORMANCE INDICATORS

The success of Emerging Processing Technology Applications will be gauged by the following tangible measures:

In the Near-Term, by 2000

- Development of heavy oil and residuum upgrading technology that reduces coke formation;
- Development of technology for improved acid-gas removal from natural gas at 25 percent lower cost than current technology; and
- Complete pilot-plant testing of breakthrough gas-to-liquids technology to convert unmarketable Alaskan and other remote natural gas to high quality transportation fuels.

In the Mid-Term, by 2005

- Development of improved analytical methodology for analysis of heavy oils; and
- Development of advanced measurement instrumentation to improve environmental data on emissions and wastes.

In the Long-Term, by 2015

- Development of new catalysts with improved selection and yields for processing crude oil fractions;

- Application of advanced natural gas-to-liquids conversion technology in Alaska to provide increased liquid fuels necessary to keep the Alaska pipeline volume at required levels;
- Development of technology for improved nitrogen removal from natural gas at 25 percent lower cost than current technology;
- Development of bioremediation technologies for heavy crudes;
- Deployment of cost-effective technologies for coal mine methane to recover and utilize one-third of the resource from longwall mining operations; and
- Transferal of environmental technologies for reducing air emissions (16 million tons of CO₂ and 1,250 tons of ammonia) and solid waste management (coke reduction by 2.5 percent) to the refining industry to improve operating conditions and to prevent closure of smaller refineries.

CROSSCUTTING PROGRAM AREAS

Crosscutting Program Areas encompass the following program elements: Outreach, Planning and Analysis, and International. These activities support all other program areas to assure that programs are responsive to industry and other stakeholder needs and are targeting research areas that will most benefit the Nation, and assuring that U.S. technology continues to be internationally competitive.

GOALS

The crosscutting program areas support the other program areas by assuring that:

- A strong and continuous dialogue exists with industry and other stakeholders, providing guidance for program planning and evaluation of program results;
- Program planning is based on accurate data on the oil and gas resource, supply and utilization trends, industry activity, and R&D needs;
- Legislative, regulatory, and policy initiatives in oil and gas supply are based on the best available information;
- The domestic industry has access to research conducted in other countries; and
- Increased international marketing opportunities are available for U.S. oil and natural gas supply technology.

STRATEGIES

The crosscutting areas use the following approaches to support the Oil Technology, Natural Gas Supply, and related Environmental Technology Programs:

- Regional outreach teams and Headquarters and Field representatives with technical expertise across all program areas created to encourage stakeholder communication through coordination with PTTC; the Interstate Oil and Gas Compact Commission (IOGCC); GRI, and other government, industry, and technical organizations, with related interests, and participate in national and regional technical meetings (information exchanged through these efforts will be used in the development of program plans and budgets);
- Work with industry organizations and regulators to improve understanding of the energy and environmental situation and foster improved regulatory and policy decision making;
- Reservoir-level databases and exploration models of production technology impacts, including: Total Oil Recovery Information System (TORIS), Gas Information System (GASIS), Crude Oil Policy Model (COPM), and Gas Systems Analysis Model (GSAM),

developed and maintained to identify, characterize, quantify, and model the most attractive resource targets and measure technology impacts and to support program planning and policy development; and

- Activities to promote international awareness of U.S. capabilities and interests, foster international partnerships, and create opportunities for U.S. industry to market services and equipment by sponsoring international conferences and establishing bilateral and multilateral agreements for exchange of data and technology, and by supporting international efforts of other parts of the DOE and other Federal agencies.

PERFORMANCE INDICATORS

The success of Crosscutting Program Areas will be gauged through the following tangible measures:

In the Near-Term, by 2000

- Synchronization of oil and natural gas computer models to assure consistent national resource assessments;

GOALS & STRATEGIES

- Complete development of the Appalachian Basin and offshore Gulf of Mexico atlases of reservoir properties and make these and other previously developed atlases available to industry; and
- An increase in the number of persons and organizations using Oil Technology and Natural Gas Supply RD&D Program products and other resources.

In the Mid-Term, by 2005

- Update of process performance computer models capable of simulating advanced technologies; and

- Complete research exchanges with Western Hemisphere Nations that have expertise in improved heavy oil recovery.

In the Long-Term, by 2010

- U.S. and worldwide commercialization of technologies developed through oil and gas RD&D programs; and
- An increase in the number of international partnerships dedicated to supply research and technology development.

APPENDIX A

NATIONAL PETROLEUM COUNCIL, "RD&D NEEDS OF THE OIL AND GAS INDUSTRY" (1995)

The report contains the following recommendations for DOE:

- Use the study in the realignment, program development, spending priorities, and budgeting activities;
- Focus research on areas of technology needs that cannot be effectively conducted in the private sector;
- Analyze expenditures to match industry's needs to the unique capabilities of the National Laboratories;
- Provide continuity for logical, cost-effective completion of ongoing, short-term projects;
- Place greater emphasis on prioritizing DOE programs based on industry's needs and participation. Improved processes and mechanisms for participation are also needed;
- Develop a project definition system, which uses broadly based industry input to prioritize and recommend RD&D;
- Remove barriers to collaboration; e.g., DOE needs to simplify administrative procedures, reduce paperwork, and accelerate turnaround time to bring technology to application; and
- Do not allow government laboratories to become technical services organizations competing with industry.

The theme of these recommendations is to establish a process that embodies the new paradigm of user-driven technology development in oil and gas RD&D.

The report contains a survey of NPC members that identifies their high priority technology needs based on potential impact of these technologies on company performance in terms of cost reduction and gains in domestic production and efficiency. NPC member survey results were used as a starting point to re-examine existing program emphasis and direction and to establish an ongoing dialogue with industry to redirect the oil and gas supply program.

In response to the NPC study, the Department analyzed its oil and gas programs and projects to determine if they address industry's priority technology needs as identified in the NPC study.

Of 176 technology areas surveyed, NPC identified 36 as high priority. Analysis indicated that DOE's fiscal year 1995 oil and gas programs addressed 22 of the 36 high priority areas. Fourteen high priority areas were not addressed by the Department's oil and gas programs. Nine of these are in Deepwater Offshore and Arctic areas. Forty percent of the Department-wide and 49 percent of Fossil Energy oil and gas fiscal year 1995 research, development, and demonstration funds were spent on the NPC's identified high priority areas. The Department uses this information and other inputs as the basis for ongoing discussions with industry to plan and evaluate oil and gas programs with the goal of addressing priority industry needs consistent with national interests.

NATIONAL PETROLEUM COUNCIL, "FUTURE ISSUES—A VIEW OF U.S. OIL AND NATURAL GAS TO 2020" (1995)

This report recommends that industry and government:

- Encourage responsible development of domestic resources;
- Encourage development of as wide a range as possible of foreign import sources;
- Use sound science, cost-benefit analyses, and goal-oriented mechanisms for regulating industry;
- Encourage science, economics, and energy education;
- Improve and expand communication with stakeholders to more effectively resolve issues; and
- Improve coordination of policies.

These recommendations were also used as a starting point in re-examining existing program emphasis and direction and in establishing an ongoing dialogue with industry to redirect the oil technology and gas supply programs.

NATIONAL PETROLEUM COUNCIL, "THE POTENTIAL FOR NATURAL GAS IN THE UNITED STATES" (1992)

The 1992 NPC Study, "The Potential for Natural Gas in the United States," has been an integral and important element in the planning and prioritization of both the DOE and GRI gas supply programs. A key finding of this study is that the abundant domestic natural gas resources can be produced and delivered at prices that allow market expansion and continued resource development. This finding depends on development of advanced supply technologies to reduce costs, as an increasing fraction of gas is supplied from more

complex resource areas. Advancements in drilling technologies needed to continue the historic 3 percent per year decline in drilling costs is an essential element of the advanced technologies development.

YERGIN TASK FORCE STUDY ON STRATEGIC ENERGY RESEARCH AND DEVELOPMENT (1995)

The Task Force recommended that DOE:

- Identify opportunities for streamlining R&D management and for eliminating overlapping management contracts, duplicative laboratory programs, marginal and overlapping research projects and facilities, and programs not directly related to strategic DOE R&D missions;
- Benchmark R&D management practices against “best practices” in the private sector and elsewhere in government and adopt these practices where practicable;
- Develop an integrated strategic plan and process for energy R&D, and use this process to determine funding priorities and manage a diverse energy R&D portfolio, through:
 - A balance of basic research and applied R&D (including industry co-funded demonstrations); and
 - Near and long-term R&D to provide continuing return on investment and to contribute to the health and vitality of domestic energy industries;
- Assure that Federal energy-related R&D investments serve to promote strategic goals, including U.S. economic strength, energy security, environmental quality, and science and technology leadership;
- Base and prioritize Federal R&D programs on the systematic application of measurable cost-benefit criteria tied to strategic national goals;
- Evaluate more widespread use of peer-reviewed competitions as a basis for awarding support in more applied strategic energy R&D programs;
- Make leveraging dollars through shared co-funding with industry the norm for near- to mid-term energy R&D programs;
- Continue to invest in energy-related research at universities, recognizing the strategic value of the research and its contribution to development of scientific and technological human resources for the future; and
- Consolidate energy RD&D programs to avoid duplication of effort and scattered management objectives.

**PETROLEUM TECHNOLOGY TRANSFER COUNCIL,
"TECHNOLOGY AND RELATED NEEDS OF U.S. OIL
AND GAS PRODUCERS" (1996)**

This report underscores a fundamental message that current technology transfer mechanisms have not been able to increase the awareness, use, and adaptation of cost-effective technologies by most of the oil and gas producing industry, especially independent producers. The report's key message is that the mission of technology transfer efforts must be to accelerate and expand producers' awareness, understanding, access to, and acceptance of current and emerging, cost-effective technologies. Broad problems and needs identified include:

- Inadequate well and reservoir level geologic and production data, case studies, and analogs to enable effective analysis and implementation of existing and emerging technologies;
- Insufficient producer access to or awareness of regulations and requirements for environmental compliance and associated financial liabilities;
- Insufficient availability of or awareness of tools, technologies, and approaches for cost-effective environmental protection and regulatory compliance;
- Inadequate producer awareness, understanding of, and access to advanced seismic and remote sensing technologies for exploration and reservoir development;
- Insufficient awareness of availability, performance, and economics of improved drilling and completion technologies such as horizontal drilling, coiled-tubing, slimhole, air drilling, and extended-reach drilling;
- Need for cost-effective, environmentally-safe technologies to manage water channeling; reduce water cut; increase recovery; and address related corrosion, scale, and other problems;
- Inadequate education in and understanding of applications of reservoir management, logging, simulation, and characterization tools;
- Inadequate awareness, applications, performance, and economics of currently available technologies and operating approaches to remediate wells; reduce operating costs; and improve or sustain economic production; including primary, secondary, and improved oil and natural gas recovery technologies; and

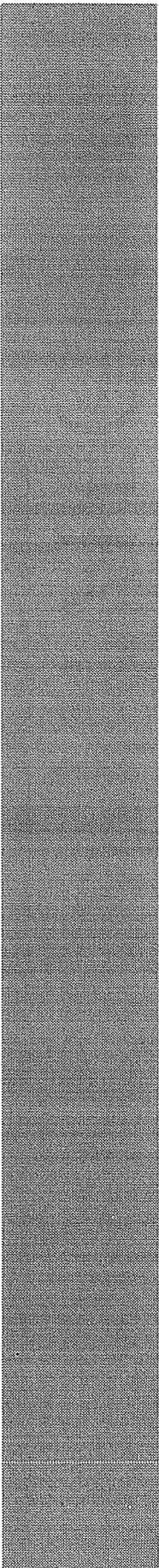
- Need for improved technology transfer mechanisms to inform producers objectively about the availability, application, history, potential costs and benefits, and potential performance of technologies that address their priority problems and needs.

ANNUAL GAS RESEARCH INSTITUTE BASELINE PROJECTION OF U.S. ENERGY SUPPLY AND DEMAND (1996)

This report presents GRI's summary analysis of gas supply, distribution, and utilization, which highlights the results of the prior decade and key factors that impact future projections. GRI's assessment of the impact of advanced supply technology developments are included in the document. The key point of this report is that gas demand will grow significantly in the next 20 years but wellhead prices will remain low — lower than prior year projections. This places greater emphasis on the development of advanced technologies that reduce production costs.

ANNUAL GAS RESEARCH INSTITUTE 5-YEAR RESEARCH AND DEVELOPMENT PLAN (1996)

This plan presents a summary of the current and future GRI programs and budgets for supply, operations, and end use technologies. This information provides an opportunity for assuring that GRI and DOE gas supply and gas utilization programs are complementary and avoid duplication. The document also ensures that appropriate support is given to essential technology areas.



APPENDIX B

RELATIONSHIP OF NEW TECHNOLOGY GROUPINGS TO CURRENT BUDGET CATEGORIES

New Technology Group	Oil Program Current Budget Category	Gas Program Current Budget Category
Reservoir Life Extension	<ul style="list-style-type: none"> • Extraction • Field Demonstration • Technology Transfer 	<ul style="list-style-type: none"> • Secondary Gas Recovery • Storage Technology
Advanced Drilling, Completion, and Stimulation	<ul style="list-style-type: none"> • Drilling 	<ul style="list-style-type: none"> • Drilling, Completion, and Stimulation
Advanced Diagnostics and Imaging Systems	<ul style="list-style-type: none"> • Reservoir Characterization • Exploration • Natural Gas and Oil Technology Partnership 	<ul style="list-style-type: none"> • Resources / Reserves Assessment • Low-Permeability Formations
Effective Environmental Protection	<ul style="list-style-type: none"> • Environmental and Regulatory 	<ul style="list-style-type: none"> • Environmental and Regulatory
Emerging Processing Technology Applications	<ul style="list-style-type: none"> • Oil Processing / Downstream Operations 	<ul style="list-style-type: none"> • Low-Quality Gas Upgrading • Gas-to-Liquids Conversion • Coal-Mine Methane Technology
Crosscutting Program Areas	<ul style="list-style-type: none"> • Planning and Analysis 	N/A

