



**Department of Energy**  
Washington, DC 20585

February 1999

To Our Readers:

This document is the second edition of the Department of Energy's *Oil and Gas RD&D Programs*, and describes the major program components of the Office of Natural Gas and Petroleum Technology. Some issues identified in the first edition remain the same; however, the challenges now facing the domestic oil and gas industry are dramatically changed. The domestic oil and gas industry is now facing one of its biggest challenges to date: survival through persistent low oil prices and declining gas prices. One of the consequences of low prices and ever increasing competition is reduction in or elimination of research and development (R&D) activities. It is critical that technology innovation continue, both in the private and Federal sectors, through joint collaborations and partnerships that will share costs and leverage resources.

Oil and gas provide 63 percent of our Nation's energy supply. The U.S. now imports over half of the oil it consumes, posing a national security threat in the event of a supply disruption. According to Energy Information Administration projections, oil imports will account for 70 percent of oil supply by 2020. Because major integrated companies are focusing their activities in overseas markets, the role of independent producers will become more critical to maintaining our domestic oil and gas supplies. Independent producers are vital to our Nation. The 7,000 independent producers drill 85 percent of all new oil and gas wells in the U.S., including almost 60 percent of offshore wells. They produce 66 percent of the Nation's natural gas and 40 percent of its crude oil. Most importantly, estimated demand for natural gas in the U.S. is forecast to increase 47 percent by 2020, tripling the use of gas in electricity generation. The future of independent producers depends largely on access to new and better technologies.

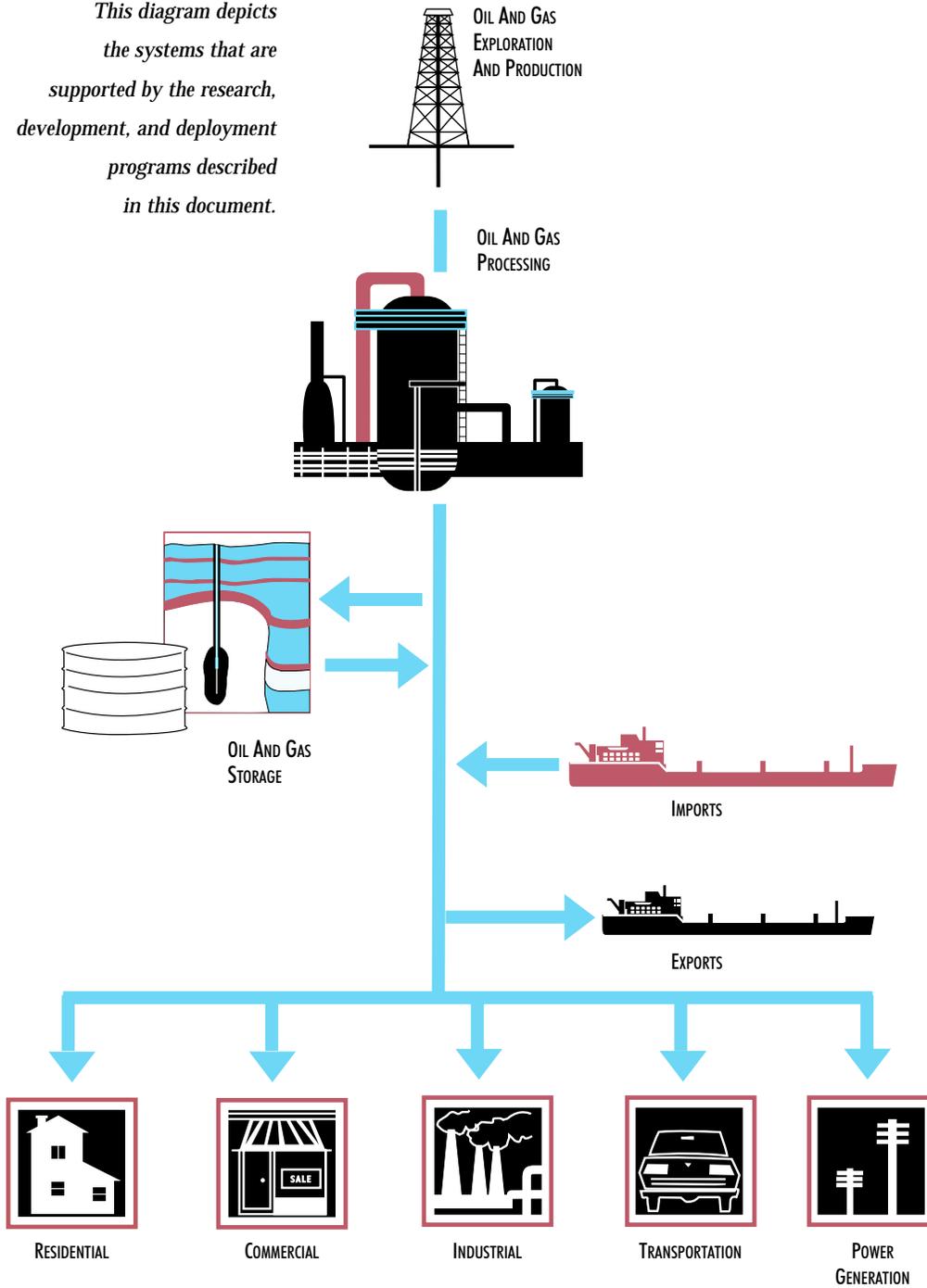
The Department's oil and gas supply Research, Development, and Deployment (RD&D) programs are being driven by the needs of independent producers. Government has been a valuable partner in bringing unique technologies, some adapted from a half century of investment in defense technology, to locate difficult-to-find resources; to improve natural gas storage and retrieval; to extend the life of domestic energy resources; and to reduce well abandonments - all technologies that are essential to maximizing the production of domestic resources while protecting our environment.

The Office of Natural Gas and Petroleum Technology has been working with industry, universities, and States to ensure that we continue to develop, enhance and deploy these technologies. We have focused our RD&D to help provide industry with these tools through the programs described in this document. The purpose and focus of these programs are outlined in our Strategic Plan section.

We invite your comments and questions regarding this document and the programs described. A list of program contacts is provided on the inside back cover for more information.

Office of Natural Gas and Petroleum Technology

*This diagram depicts the systems that are supported by the research, development, and deployment programs described in this document.*



# TABLE OF CONTENTS

<b>INTRODUCTION</b>	<b>i-5</b>	
<b>STRATEGIC PLAN</b>	<b>i-15</b>	
<b>Program Plans</b>		
Advanced Drilling, Completion & Stimulation Systems	1-1	
Advanced Diagnostics & Imaging Systems	2-1	
Reservoir Efficiency Processes	3-1	
Reservoir Life Extension	4-1	
Gas Storage Program	5-1	
Oil & Gas Environmental Research and Analysis	6-1	
Oil Processing Program	7-1	
Gas Processing Program	8-1	
Oil & Gas Modeling and Analysis	9-1	
Crosscutting Programs	10-1	
<b>APPENDICES</b>		
Acronyms & Abbreviations	A-2	
DOE Oil and Gas RD&D Program Offices	A-5	
Internet Sites for Oil & Gas Program Information	A-6	
Program Contacts	<b>Inside Back Cover</b>	



## Government Role

Competitively priced energy is essential to U.S. strength in the global marketplace to enable the Nation's industries to compete effectively. Domestic oil and gas production helps stabilize energy markets, and also slows the need for oil imports, which currently account for 56 percent of U.S. crude oil supply. According to the Energy Information Administration (EIA), the share of imports could rise to over 70 percent by 2020.

The Federal Government has responsibilities that necessitate the following roles relating to oil and gas:

- Maximize public benefit of oil and gas resources;
- Provide stewardship of Federal lands;
- Promote effective environmental protection;
- Ensure energy security;
- Foster strategic alliances;
- Enhance U.S. global competitiveness; and
- Protect critical infrastructure.

Because reliable domestic energy supplies are vital to our economy, the Department of Energy (DOE) conducts a range of programs designed to enhance the efficiency and environmental quality of domestic oil and gas production and utilization.

These research, development, and deployment (RD&D) programs are conducted in partnership with universities, State and local governments, industry, and other stakeholders. In cooperation with these partners, DOE supports research and development of promising new technologies in areas identified as priorities by the domestic oil and gas industry. DOE programs combine the RD&D resources of government and industry, including the unique strengths of the National Laboratories, which focus on technology developments where long-term, high-risk payoffs are likely to prevent companies from investing adequately on their own. By providing science-based information and analysis for legislative and regulatory decisionmaking, DOE programs contribute to policies that encourage increased domestic supplies of oil and gas.

The Natural Gas and Petroleum Technology Program is developing advanced technologies that are: increasing the cost effective recovery of domestic oil and gas; improving recovery from geologically-complex, deeper reservoirs; developing long-term research projects; and cost-effectively meeting environmental regulatory compliance standards.

## Oil and Gas RD&D Programs: An Introduction

The United States economy runs on fossil fuels. In 1997, 85 percent of U.S. energy consumption was provided by fossil fuels. Oil and gas accounted for about 63 percent.

**T**he Natural Gas and Petroleum Technology Program (Oil and Gas Program) operates under a single overriding goal: to ensure the availability of competitively-priced oil and natural gas supplies to support a strong U.S. economy. In pursuing this goal, DOE does not have a direct role in finding and producing hydrocarbons, but rather supports the development and transfer of technology to domestic oil and gas operators and the service industry.

The Program's RD&D activities focus on enhancing the efficiency and environmental quality of domestic oil and natural gas exploration, recovery, processing, transport, and storage operations. Improved technologies and information are required to boost production of natural gas, a clean and abundant domestic fossil fuel that is an increasingly important component of our Nation's energy portfolio, and to extend the life of domestic oil reservoirs. Program efforts are also directed to making environmental regulation cost-effective, compliance feasible,

and reasonably economic, while assuring economic access to and recovery of domestic oil and gas resources consistent with effective environmental protection.

The Energy Information Administration's *Annual Energy Outlook 1999 (AEO 99)* projects that natural gas demand will increase from 22 trillion cubic feet (Tcf) in 1997 to 32 Tcf by 2020. Petroleum demand is projected to increase from 18 million barrels (Bbls) per day in 1997 to over 24 million barrels per day by 2020. Oil and gas will provide 68 percent of U.S. energy in 2020.

Although remaining U.S. oil and gas reserves are substantial, they are becoming more difficult and expensive to discover and produce. Past technology has recovered only an estimated one-third of the oil-in-place, leaving two-thirds of the U.S. oil resource base – about 350 billion barrels – still in the ground. Increasing operating costs are resulting in the abandonment of 15,000 to 22,000 U.S. wells each year.



*The oil and gas extraction industry employs nearly 326,000 people in the U.S., and the industry accounts for 1.4 million domestic jobs. Oil and gas production activities contributed more than \$125 billion to the domestic economy in 1997. U.S. companies export about 40 percent of the world's petroleum equipment and services, achieving sales of \$5.9 billion in 1997.*

With the rising costs of environmental compliance, U.S. oil and gas producers and processors can face competitive disadvantages relative to operators in other areas of the world. These competitive disadvantages contribute to the fact that many major companies are concentrating their new exploration, production, and processing investments overseas.

Low oil prices worldwide, in late 1998, threatened the economic viability of many U.S. oil and gas production operations, particularly the independent producers. There are currently about 7,000 U.S. independent producers who are drilling 85 percent of all domestic wells and producing 66 percent of the natural gas and 40 percent of the crude oil. Advanced technologies can help reduce costs of domestic oil and gas production and help maintain reliable domestic supplies of these vital fuels at competitive prices – a goal of strategic importance to our Nation.

## **Impact of Technology**

Historical data demonstrate that technology advances are key to keeping energy prices low for consumers and maintaining the profitability and long-term survival of the domestic oil and gas industry. Since the 1980s, due to three-dimensional (3-D) seismic imaging, advanced drilling systems, and fracturing technologies, our Nation has seen a 14 percent increase in its gas production despite a 50 percent decline in wellhead prices. Higher gas production in 1994 was achieved with fewer than 9,000 well completions, compared to 14,250 completions in 1985. Further, success rates of exploratory oil and gas wells have increased from 29 percent to 38 percent since the 1980s, while costs have substantially decreased.

In the future, technology advances can further the trend toward more cost-effective recovery of domestic oil and gas, particularly from geologically-complex, deeper reservoirs. Such advances will allow domestic producers to continue exploring for and recovering oil and gas from reservoirs that would otherwise be economically unviable. Other new technologies can enable processors to continue refining oil domestically while complying with environmental requirements, and can support pipeline companies in cost-effectively moving fuel supplies to consumer markets.

## Importance of RD&D

The Energy Information Administration's *AEO 99* forecasts show an increase in domestic gas production and a decrease in annual domestic oil production for the period of 1999 to 2020. This forecast can be realized only if the assumed technology development and deployment increases are achieved.

The Nation's historical dominance in developing and using oil and gas technologies may be lost as industry reduces its funding for long-term RD&D activities. In the last three years alone, major oil and gas companies have reduced overall RD&D spending by 22 percent. Today, of the approximately \$1.5 billion invested annually for exploration and production RD&D by these companies, only \$450 million is allocated to basic and applied RD&D. The remainder is spent for near-term product development and technical services, areas where major companies have focused efforts to solve today's operational problems. Longer-term research has been curtailed, reflecting the inability of the companies to capture economic benefits of such investments and their targeting of "next quarter" financials.

Compounding the crisis in private RD&D investment, Federal government RD&D also has been declining significantly. In the oil and gas supply and processing area specifically, RD&D spending was reduced by 32 percent in the period from 1995 to 1999.

## DOE's Oil and Gas Program

DOE's oil and gas RD&D program is managed by the Office of Natural Gas and Petroleum Technology (ONGPT). At \$75 million, DOE's 1999 oil and gas RD&D budget is about 17 percent of the \$450 million invested annually by the oil and gas industry for basic and applied RD&D. Although DOE's program represents a relatively small percentage of the total RD&D, it brings a unique national perspective to technology development that is independent of company-specific or State-specific interests.

The DOE program uses EIA technology assumptions, translating them into a balanced portfolio of technology projects that will contribute to product volumes forecast by EIA models. For example, in partnership with industry, DOE is developing technologies required for increasing gas production from more difficult formations. Increased production from these formations – including onshore deep gas reservoirs (greater than 15,000 feet), offshore Gulf of Mexico, and remote North Slope of Alaska – will be essential in satisfying the 45 percent increase in gas demand forecast for 2020. Accordingly, industry and government will target RD&D on technologies aimed at improving recovery efficiency and lowering costs from deeper and more complex reservoirs, while increasing economic recovery from conventional reservoirs.

## Issues & Drivers

U.S. economic strength depends on a secure supply of reasonably priced energy.

Oil and gas provide two-thirds of U.S. energy consumption and 97 percent of transportation fuels.

- Oil and gas consumption will increase by 2020, despite energy efficiency improvements and use of renewables.

Growing energy demand is increasing U.S. dependence on oil and gas imports.

- Imports now supply 56 percent of crude oil supply and are forecast to reach 70 percent in 2020.

Advanced technologies are essential to maximizing domestic resource production while preserving the environment.

- Advanced technologies are needed to slow declining oil production and increase gas production and deliverability.

U.S. is a mature oil producing region; domestic production is more difficult and costly than overseas production.

- Remaining oil and gas resources are in deep, complex reservoirs or environmentally sensitive areas.
- High costs of operations and environmental compliance place U.S. producers at a competitive disadvantage.

Low prices and global competition are curtailing industry research, development, and deployment.

- Overall industry RD&D spending fell about 30 percent from 1994 to 1998.

## ONGPT Roles in Oil and Gas RD&D

To support national goals to:

- Enhance the efficiency and environmental quality of domestic oil and natural gas exploration, recovery, processing, transport, and storage operations;
- Focus on high-risk technology that private companies alone will not undertake;
- Provide scientific and technological information and analysis to assist policymakers in their decision-making; and
- Contribute to science-based improvements in regulations to reduce uncertainties and costs, while achieving optimal environmental protection.

## RD&D Program Areas

**Advanced Drilling, Completion & Stimulation Systems:** To increase recovery through wellbore improvements.

**Advanced Diagnostics and Imaging Systems:** To improve technologies to locate and measure oil and gas within reservoirs.

**Reservoir Efficiency Processes:** To improve technologies for enhanced oil recovery processes.

**Reservoir Life Extension:** To extend the life of mature oil and gas fields and reduce well abandonments.

**Gas Storage:** To improve natural gas storage for peak usage and protect the gas transportation infrastructure.

**Oil and Gas Environmental Research and Analysis:** To minimize potential environmental damage from oil and gas operations.

**Oil Processing:** To advance technologies for refining lower quality crude and reduce process related emissions.

**Gas Processing:** To upgrade low quality gas and convert remote and offshore gas-to-liquid transportation fuels.

**Oil and Gas Modeling and Analysis:** To estimate potential economic recovery of domestic oil and gas through a range of technologies, economic criteria, and legislative and regulatory scenarios.

## Oil & Gas RD&D Programs

### Partnership Approach

- RD&D in partnership with universities, State and local governments, industry, and other stakeholders.
- Combined resources of government and industry, including the unique capabilities of National Laboratories.
- Support for cooperative efforts on promising technologies in priority areas identified by key stakeholders.
- Technology transfer through cooperative efforts of DOE, State, and industry organizations including the Petroleum Technology Transfer Council (PTTC).



Areas of emphasis for the DOE oil and gas RD&D program are:

- Drilling, completion, and stimulation to increase recovery through wellbore improvement;
- Reservoir characterization and modeling to define reservoirs and characterize their potential;
- Recovery technologies to increase recovery from known oil and gas resources;
- Resource- and reserve-base expansion to find and exploit new resources;
- Gas storage to improve natural gas storage and retrieval for peak usage and protection of critical infrastructure;
- Environmental technology to minimize any potential environmental damage through oil and gas operations and to improve general understanding and industry cooperation in environmental compliance; and
- Processing to reduce environmental emissions, to increase refinery efficiencies, and to bring remote gas to market.

Each of these program areas is designed to reduce risks and costs, improve efficiencies, and protect the environment while contributing to the overall goal of maximizing production.

## Payoffs from DOE's Investment in RD&D Programs

Metrics that quantify the benefits of DOE's oil and gas RD&D program have been developed through modeling and analysis, and they indicate that the impacts of these programs are substantial. For example, by 2020, potential benefits to our Nation will include:

- Over 8 billion barrels of additional oil production and 56 Tcf of gas;
- \$26 billion in public sector tax revenues;
- Savings of \$36 billion in environmental compliance costs (produced water, remediation, and air emissions control); and
- Reduction of over 20 million tons of carbon dioxide emissions, while providing approximately 500,000 barrels/day of additional refined products from heavy oil.

DOE's oil and gas RD&D program has already shown a significant return on the taxpayer's investment. For example, DOE has received favorable reactions from industry to the polycrystalline diamond drill bit developed in the 1980s, and the Reservoir Class Demonstration Program implemented in the 1990s. Total DOE investment in the Reservoir Class Program, which consists of three classes of reservoirs containing 32 projects and 102 participants, was \$115 million.

The return from the Inland Resources project alone (with DOE funding of \$1.8 million) will be \$160 million in Federal royalties and taxes – a sum larger than the entire cost of the Reservoir Class Program. Because this project covers only 13 percent of the field, widespread application of demonstrated technology could double or triple the reserves, resulting in about \$500 million in Federal revenues.

DOE has also received favorable responses from industry to its coalbed methane recovery RD&D from the 1980s. This resource shifted from the nonconventional category to conventional by the 1990s, and reserves have doubled since 1990 to 10 Tcf. The combined DOE-Gas Research Institute (GRI) investment totaled \$100 million, but industry revenues are now \$150 million per year.

After six years, the Secondary Gas Recovery Program, initiated in 1988, has also covered DOE's investment of \$11 million. The actual value of this program, based on trends of production in 1993 and 1994, could reach hundreds of millions of dollars in revenues.

DOE is working with the Underground Injection Practices Research Foundation and agencies in more than a dozen States to develop alternatives to Area of Review (AOR) variance systems for an entire region. The current Safe Drinking Water Act requires an AOR for each well.

This approach is expected to relieve the burden of regulatory compliance, where appropriate, while maintaining environmental protection. As a result of the use of the AOR variance methodology in a single East Texas field, the Texas Railroad Commission approved a variance for the field, saving the industry an estimated \$86 million. Program partners and performers are working with agencies in oil-producing States to develop similar AOR variance systems. DOE estimated that exemption from maximum AOR costs for pre-1982 wells in all States could save the industry \$340 million; variances for newly drilled wells could save more than \$200 million.

In addition to the above examples, other success stories are provided in the program plans that follow the Introduction and Strategic Plan.



## DOE Oil & Gas Programs

The oil and gas program plans contained in this document represent the RD&D programs that are managed by the Office of Natural Gas and Petroleum Technology, a major component of the Office of Fossil Energy (FE). Within the DOE organization, the Office of Fossil Energy is a part of the Energy Science and Technology Programs. The location of oil and gas technology programs is shown in the flowchart on page i-13.

The Department's RD&D Portfolio was developed to align with and directly support the goals and objectives of the Comprehensive National Energy Strategy (CNES), which was developed by the Department of Energy, other Federal agencies, and major stakeholders.

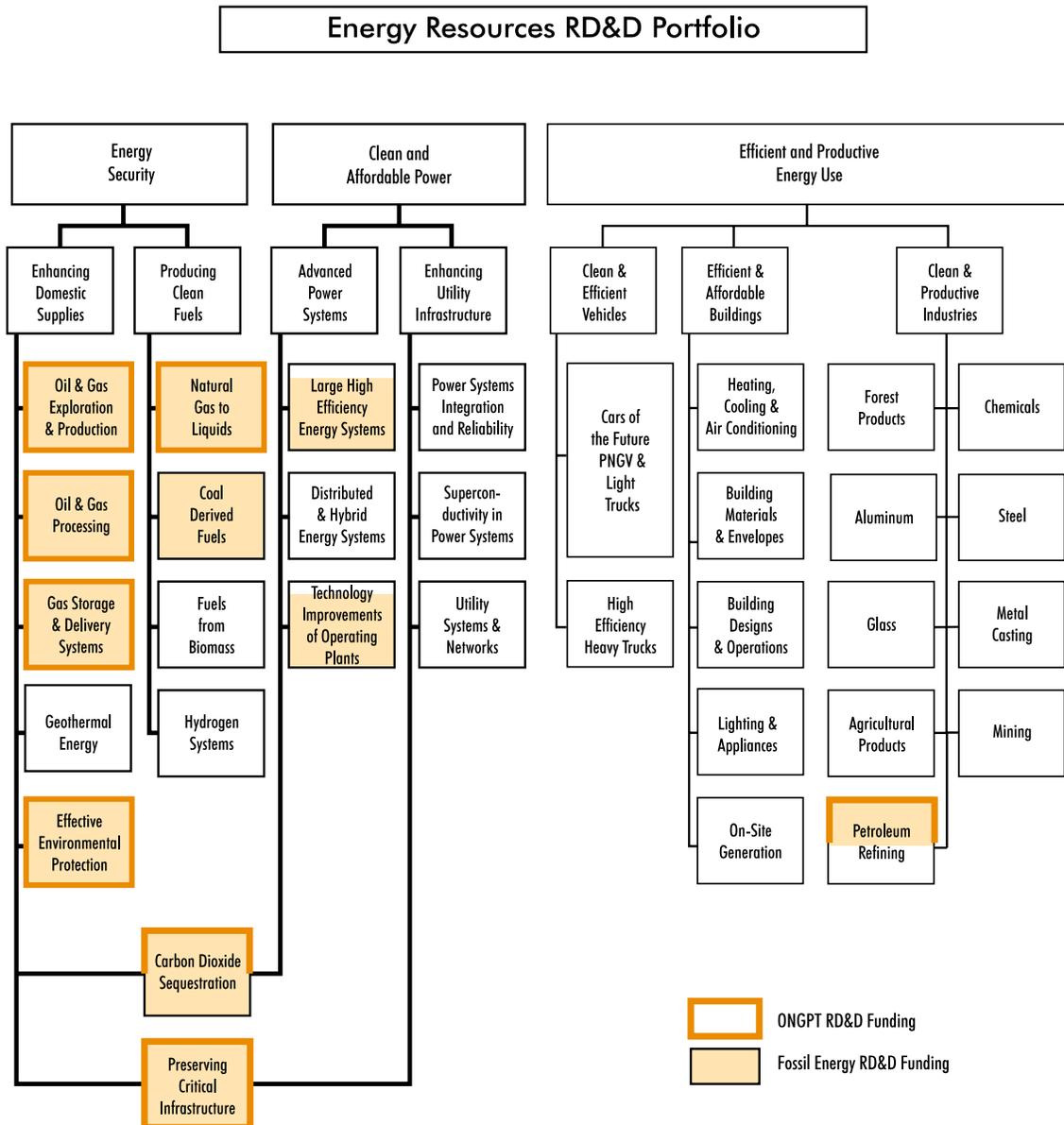
The Energy RD&D Portfolio needed to accomplish these goals and objectives is managed by three principal organizations: the Office of Energy Efficiency and Renewable Energy; the Office of Fossil Energy; and the Office of Nuclear Energy, Science, and Technology.

Their combined RD&D portfolio is centered on developing the technologies to ensure the following three energy RD&D goals and objectives: energy security, clean and affordable power, and efficient and productive energy use.

The programs described in this publication are commonly referred to collectively as the "Oil and Gas Program."

Program plans contained herein provide a single source of information describing the details of the individual technology program components. The strategic plan and individual program plans reflect the current status of developments in a planning cycle that began in 1996. These plans are dynamic and are updated on a regular basis. Budget charts shown in the individual program plans represent the activities of the programs described therein. Numbers may vary from the Congressional Budget Appropriations due to the sorting of activities among programs.

## Where Oil and Gas RD&D Programs Fit within DOE Energy Science & Technology Programs



**Key Program Drivers for Oil and Gas RD&D Program****Comprehensive National Energy Strategy**

When the Department of Energy was created in 1977, the law required that a “National Energy Policy Plan” be regularly submitted to Congress. Moreover, statutory requirement of regular submissions of national energy policy plans ensures that this framework can be modified to reflect evolving conditions, such as better knowledge of our surroundings, changes in energy markets, and advances in technology.

In the context of pursuing a market based energy policy, the Comprehensive National Energy Strategy, published in April 1998, sets forth five common sense goals for national energy policy. Taken together, the goals, objectives, and strategies form a blueprint for the specific programs, projects, initiatives, investments, and other actions that will be developed and undertaken by the Federal Government. A common thread running through our national response to these goals is development and deployment of new technology, achieved through basic scientific and engineering advances. Goals, objectives, and strategies applicable to ONGPT’s oil and gas RD&D program are highlighted in the Strategic Plan.

**The President’s Committee of Advisors on Science and Technology (PCAST)**

PCAST was established by Executive Order 12882 to serve as the highest level private sector science and technology advisory group for the President and the National Science and Technology Council. Committee members are distinguished individuals appointed by the President, and are drawn from industry, education and research institutions, and other non-governmental organizations. In November 1995, the Committee published its report, “Federal Energy Research and Development for the Challenges of the Twenty-First Century.”

PCAST recommendations for oil and gas production and processing include development of a strategic research and development (R&D) plan for natural gas as the transition fuel of the twenty-first century; increased R&D investment for gas production and processing technologies; development of a research program to understand the potential of methane hydrates worldwide; and continuing support of technology transfer and cost-effective demonstrations to maintain production from mature and marginal regions.

---

# STRATEGIC PLAN

## Oil and Gas RD&D Programs

---

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



---

**OIL AND GAS RD&D PROGRAMS**

### **Mission**

**I**n concert with customers, promote activities and policies to enhance the efficiency and environmental quality of domestic oil and natural gas exploration, recovery, processing, transport, and storage.

Success of these programs will help our Nation maintain reliable and economic oil and gas supplies and enhance U.S. technology leadership worldwide, while protecting the environment.

### **Vision**

**D**OE oil and natural gas research has identified new technology concepts that significantly reduce greenhouse gas emissions, contribute to energy security, and ensure the availability of affordable energy into the mid-twenty-first century and beyond.

The United States remains the world leader in the development and deployment of oil and gas technologies, and advanced U.S. technologies are exported and used worldwide.

A customer-driven, cost-shared/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.

## Strategic Plan – Oil and Gas RD&D Programs

The Natural Gas and Petroleum Technology Program has one overriding goal – to ensure that competitively priced oil and gas supplies are available to support a strong U.S. economy.

**T**he United States depends on oil and gas for approximately 63 percent of the energy it consumes. The Energy Information Administration, in its *AEO 99*, projects increasing demand for oil and gas to 2020. Others also forecast continuing dependence on these energy sources well into the next century.

Availability of affordable energy is essential to our Nation's economic strength in the coming decades, and oil and gas will be dominant energy sources for the foreseeable future. Although Americans want to continue to enjoy the economic benefits of lower-cost energy, they also want reliable energy supplies that do not harm the environment. DOE, in partnership with the private sector, supports the development of economically viable and environmentally safe oil and gas technologies that would emerge far more slowly without DOE support. This support focuses on areas where there are large potential public sector benefits, and where rewards, given the

risks, are not adequate to attract high levels of private sector investment.

In pursuing energy security, DOE does not have a direct role in finding and producing hydrocarbons, but rather supports cost-shared fundamental science and technology programs that ultimately develop and transfer technology to domestic operators and the service industry. DOE also provides scientific information and analysis to assist policymakers with decisions affecting domestic oil and gas resources.

This strategic plan has been developed to help achieve goals that support projected oil and gas demand through DOE's Oil Technology, Natural Gas Research, related Environmental Research, and DOE's Import and Export Activities Programs. This plan evaluates the key challenges facing our Nation whose economic strength relies on oil and gas as a major energy source. It describes the strategies being pursued by the Office of Natural Gas and Petroleum Technology.





## Federal Roles and Responsibilities

Federal roles and responsibilities in natural gas and oil technology research are to:

- Maximize the public benefit of oil and gas resources;
- Provide stewardship of U.S. oil and gas resources;
- Protect the environment;
- Ensure energy security;
- Foster strategic alliances;
- Enhance U.S. global competitiveness; and
- Protect critical infrastructure.

ONGPT's role in oil and gas RD&D is to support national goals to:

- Enhance the efficiency and environmental quality of domestic oil and gas exploration, recovery, processing, transport, and storage operations;
- Focus on high-risk technology that private companies will not undertake alone;
- Provide scientific and technological information and analysis to assist policymakers in their decisionmaking; and
- Contribute to science-based improvements in regulations to reduce uncertainties and costs, while achieving optimal environmental protection.

## Current Situation and Outlook

The Reference Case in the Energy Information Administration's *1999 Annual Energy Outlook* represents a consumer-friendly scenario, where energy prices in the year 2020 are marginally different from today's, and in some cases are lower. The *AEO 99* does not assume any incentives to reduce carbon emissions, and reflects an optimistic view of U.S. gas and world oil supplies, which is currently shared by a number of other major forecasters. This is in sharp contrast to projections several years ago. For example, year 2010 projected prices for world oil and lower-48 wellhead gas were 83 percent and 118 percent higher, respectively, in EIA's *1992 Annual Energy Outlook* than those of *AEO 99*.

These low prices strongly impact EIA forecasts. According to EIA, projected market share for most fuels changes little through 2020. The fossil fuel share of the domestic energy market increases from 85 percent in 1995 to 90 percent in 2020. With total energy consumption increasing by over 30 percent during this period, energy-related carbon dioxide emissions, the most pervasive greenhouse gas, increase nearly 39 percent.

## Federal Lands and Stewardship of Oil and Gas Resources

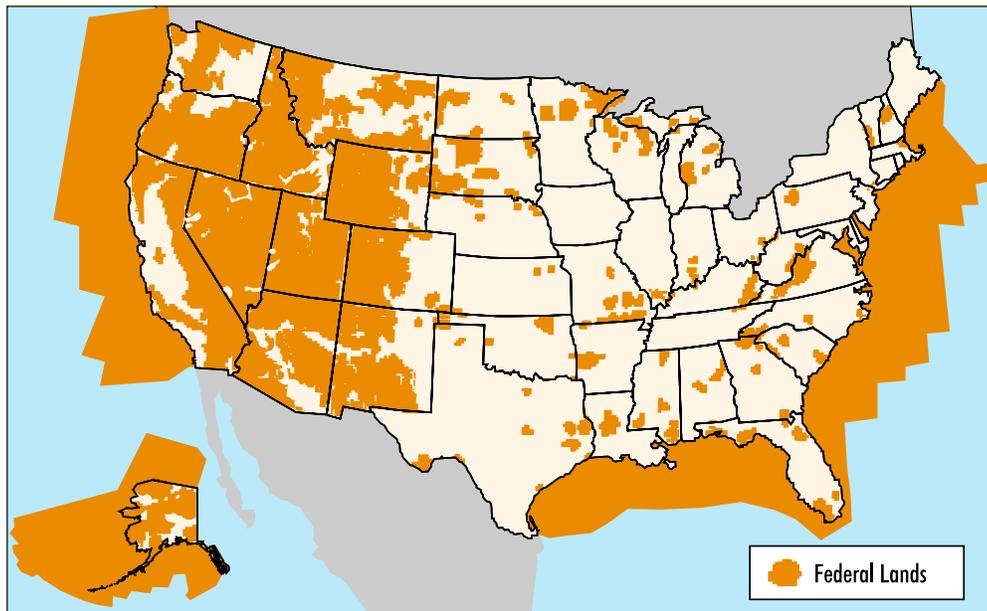
Federal lands, both onshore and offshore, are critical sources of our Nation's oil and gas supply. In fact, Federal offshore lands currently account for the Nation's 19 percent of oil and 27 percent of gas production. Onshore Federal lands provide five percent of oil and ten percent of gas production in the U.S. This production comes from less than five percent of onshore Federal lands.

Oil produced on Federal lands currently supplies 24 percent of total U.S. production. Similarly, gas produced from Federal lands has grown to 37

percent of the U.S. total today. Approximately three-quarters of this oil and gas come from offshore Federal lands. In addition, royalties, rents, and bonuses from Federal and Indian oil and gas leases provided almost \$60 billion in revenues to the U.S. Treasury during the period of 1982 to 1997.

According to the latest estimates, half of the Nation's remaining, untapped technically and economically recoverable oil and gas resources are located on Federal lands, and more than 80 percent of these resources are located offshore.

Therefore, it is important to maintain access to these Federal lands with a resources potential and where multiple use is acceptable after proper environmental and scientific analysis. According to a recent report, access to Federal lands in eight western States has declined by more than 60 percent since 1983. About 32.5 million acres, or less than 17 percent of the total Federal mineral acreage, is under lease today, compared to 114 million acres, or 72 percent, in the eight western States.



Low oil prices lead to steadily increasing consumption in the U.S. and worldwide. Low natural gas prices, through 2020, result in gas becoming the fuel of choice for electricity generation, delaying significant penetration by renewable and advanced coal technologies. While no new nuclear electricity generation is assumed, nuclear capacity does not decline significantly until after 2010. However, early nuclear plant shutdowns and/or retirements could add 1.5 Tcf of gas demand.

### Oil Technology

The United States imports more than one-half of the crude oil that the country uses. Seventy-four percent of this imported crude oil comes from politically unstable regions. Two-thirds of the known U.S. oil resource remains unrecovered after conventional production – a significant target for advanced technologies. The well abandonment rate is high – 15,172 oil wells and 4,914 gas wells in 1997 – and much of the U.S. oil resource is prematurely and permanently lost. It is estimated that as much as 80 percent of the remaining U.S. oil resource could be abandoned by 2020 without advanced recovery technologies and cost-effective environmental regulations. Environmental compliance expenditures are also causing refinery closures, which could result in a loss of refining capacity – over 10 percent of 15 million barrels per day in less than 5 years.

### Natural Gas Research

Natural gas consumption in the United States is projected to reach or exceed 32 Tcf per year by 2020, up from 22 Tcf in 1997 (projections of EIA, Gas Research Institute (GRI), and Enron Corporation). Reduced emissions targets for greenhouse gases call for a potential 40 Tcf gas market by 2010. Gas will play a key role in the 21st century transition to a post-oil economy for transportation fuels. The domestic gas resource base is not yet fully known (“immature”), and is located in such areas as: deep formations, gas-bearing shales, below basalt formations, methane hydrates, deep water, remote areas (Gulf of Mexico and Alaska), coalbed methane, and landfill gas. However, the resource base is expanding with geologic knowledge and advanced exploration and recovery technology. Underinvestment in research could cause scarcity in gas supplies.

## Planning Assumptions

### Key Issues and Uncertainties

Forecasts by EIA and others assume a business-as-usual environment, where there are no major policy shifts, no new energy-related legislation, and no crises to significantly alter the status quo. Many believe that this is not the only scenario that should be considered when determining national energy policy and RD&D priorities, because there is a host of outcomes that could alter energy trends. Issues and uncertainties that could have far-reaching effects on domestic energy use are outlined below.

**Current low oil prices** at the end of 1998 are having a significant impact on U.S. oil and gas producers, both majors and independents. The Asian economic crisis has reduced oil and gas demand with an attendant impact on world oil prices, which have fallen to all-time lows. EIA and other experts are projecting that world oil prices will remain low for the next two years or longer, thus threatening the economic viability of U.S. oil and gas operations. Many small independent operators are shutting-in wells and abandoning production and some are being forced out of business.

**Oil and gas security**

remains a prominent issue despite the relative tranquility in the market in recent years. Our economy is almost totally dependent on oil for its transportation needs. By 2015, it is projected that: (1) demand for petroleum in non-industrialized countries will nearly double; (2) the U.S. will be importing almost 70 percent of its oil and 15 percent of gas; and (3) the Middle East will control nearly 70 percent of the world petroleum export market. There will be great crude oil price uncertainty in international markets. This concentration of export market control will be greater than that which existed in the 1970s and early 1980s, when supply disruptions caused severe economic dislocations and fundamentally reordered U.S. and International Energy Agency (IEA) member nations' energy security priorities.

**Declining RD&D budgets** have become a reality throughout the domestic energy industry. The oil and gas industry also has significantly reduced RD&D projects applicable to domestic prospects, in response to both increased global competition and greater emphasis on overseas opportunities. Deficit reduction has placed increasing pressure on DOE-supported RD&D, which has decreased in real terms by about one-third since 1990. Domestic energy RD&D budget declines come at a time when environmental



and energy security threats are becoming more real, and there is a great need to adapt technologies to a changing industry. Governments of our main global competitors are continuing to strongly support energy RD&D in strategically important technology areas of oil and gas exploration, production, processing, transport, and maintenance of a critical infrastructure for the Nation.

Traditional industry RD&D through organizations such as GRI is being reduced. Continuing research is expected to be minimal and focused on near-term operational issues. Unless there is legislative relief, there could be a major adverse affect on industry investment in longer-term RD&D.

**Environmental regulations** can significantly affect energy choices and costs. Compliance with regulations will become more difficult if energy prices remain moderate and fossil fuel demand increases as anticipated. There are a host of potential regulatory actions that could require major

additional reductions in energy-related emissions during the next decade. Some of these reductions are expected to be very expensive if compliance must depend on current technology and approaches. Examples include: Clean Air Act requirements for pollutants, such as methane gas, ozone, small particulates, and air toxics; and regulations affecting land use and water quality/rights. New regulatory approaches and transfer of regulatory authorities to States will also affect energy choices and costs.

**Electric utility restructuring** has brought competition to the wholesale market under existing Federal authority, and there is considerable support for bringing competition to retail markets as well. It is not clear what the restructured industry ultimately will look like, but there will be a transition period that could last a decade or more, where the emphasis will be on profit and competitive survival.

**Global trade competition** has become a major factor in the post-cold war era, as countries increasingly rely on exports in pursuit of prosperity. The energy infrastructure requirements for developing nations will require trillions of dollars over the coming decades, and significant amounts of goods and services will be imported from industrialized countries. In many cases, trade barriers still exist. For example, in some countries, trade is impeded by lack of a legal and financial framework. Where governments still exercise decisionmaking control, industries may need to work through government-to-government contacts. Some countries may be disadvantaged because competing governments provide significant assistance to their industries.

**Climate change** – The rise in greenhouse gas emissions from fossil fuel combustion and industrial and agricultural activities has caused domestic and international concern about the possible impacts on our climate. With the signing of the *International Framework Convention* in 1992, the U.S. Congress recognized the threat of global warming and committed the United States to reduce its carbon emissions over time.

The impacts of any climate change strategy will lead to profound changes in the energy mix. The EIA forecasts that, by 2020, a strategy to stabilize carbon emissions at 1990 levels will lead to a 35.8 Quadrillion Btu (Quad) market for natural gas, versus a 32.7 Quad market under the Reference Case. Likewise, the market for petroleum products, being higher carbon energy sources, are forecast to shrink over the same timeframe, decreasing from 46.9 Quads in the reference case to 43.8 Quads to stabilize emissions at 1990 levels. These forecasts, based upon assumptions and strategies, suggest the potential impact of climate change legislation on the oil and gas industry.

### **Goals, Objectives, Strategies, and Success Measures**

The Strategic Plan for Oil, Natural Gas, and Related Environmental Technology RD&D Programs pursues its mission and vision through two goals, which fall under the broad categories of energy security and environment. These goals, associated objectives and strategies are summarized in Table 1, along with success measures that help determine progress toward meeting goals and objectives.

## Table 1: Goals, Objectives, Strategies, and Success Measures for Oil, Natural Gas, and Related Environmental Technology RD&D

**GOAL I: Security – Help protect the U.S. economy from external threat of interrupted supplies or infrastructure failure.**

**OBJECTIVE 1.**  
Help stabilize domestic production of liquid fuels throughout the 2005 to 2010 period.

**Strategy 1.** Develop higher-resolution imaging and diagnostic tools for complex or fractured reservoirs that permit wells to be designed for higher productivity and increased ultimate recovery.

- By 2010, add cumulative oil production of 1.1 billion barrels through program activities, such as demonstrating tools and analytical techniques for electromagnetic crosswell seismic reservoir imaging in steel-cased wellbores, and allowing monitoring of injected fluid movement in several hundred U.S. projects.

**Strategy 2.** Make available new and more efficient processes to increase recovery.

- By 2010, add cumulative domestic oil production of 850 million barrels through the development of enhanced oil production processes.

**Strategy 3.** Extend the productive life of currently producing fields with improved reservoir management and advanced secondary and tertiary recovery technologies.

- By 2010, add cumulative domestic oil production of 55 million barrels through program activities such as completing the demonstration and transfer of seven advanced secondary and tertiary technologies.

**Strategy 4.** Develop economical processes for producing liquid fuels from remote natural gas resources.

- By 2010, produce 200,000 barrels per day of high quality liquid transportation fuel from the Alaska North Slope gas resources.

**OBJECTIVE 2.**  
Ensure energy system reliability, flexibility, and emergency response capability of oil and gas transportation and storage.

**Strategy 1.** Develop improved energy measurement technologies and advanced gas storage facilities to ensure system reliability and protect critical energy infrastructure.

- By 2010, through improved modeling of salt cavern design and integrity research, increase working gas capacity from salt caverns by 10 percent and reduce the need for the development of six salt cavern storage facilities to meet peak demand.
- In 2000, conduct formal industry-wide consequence-based risk assessment for the protection of critical energy infrastructure.

*Continues on next page*

**GOAL II: Environment – Promote oil and gas production and use in ways that respect health and environmental values.**

---

**OBJECTIVE 1.**  
Support RD&D and policies to allow domestic natural gas production to grow by as much as 6 Tcf by 2010, and to provide a viable option if additional supplies are needed in the longer-term to achieve national environmental goals.

**Strategy 1.** Develop drilling and completion technologies tailored to difficult geologic settings that can reduce drilling and production costs, improve production, and reduce formation damage.

- In Fiscal Year 1999, complete demonstration of an advanced drilling and completion technology system that, along with other systems under development, could ultimately contribute to an additional six Tcf of domestic gas reserves.

**Strategy 2.** Develop technologies to convert unmarketable or low quality natural gas to marketable fuels.

- By 2010, expand domestic natural gas production potential by more than 150 billion cubic feet (Bcf) per year, resulting from advanced techniques for removal of nitrogen and hydrogen sulfide/carbon dioxide from low quality gas.

**Strategy 3.** Develop diagnostic and imaging technologies to locate productive parts of complex gas reservoirs and quantify unconventional gas resources.

- By 2010, add 3.6 Tcf of cumulative gas production through projects such as demonstrating cost-effective horizontal well, and advanced exploration and stimulation technologies in low permeability formations, to increase recovery of the over 5,000 Tcf gas resources in the Green River and Wind River basins.

**Strategy 4.** Expand long-term natural gas options, including the production of gas from methane hydrates and deep gas formations.

- By 2015, methane hydrates will contribute to the 25 Tcf per year of gas produced as an outgrowth of DOE RD&D.

**OBJECTIVE 2.**  
Increase domestic oil and gas production with less environmental impact.

**Strategy 1.** Reduce the cost of effective environmental protection in oil and gas production and processing.

- By 2010, decrease cumulative industry environmental compliance cost by \$16 billion in exploration and production.

**Strategy 2.** Develop cost-effective and environmentally acceptable heavy oil and residual upgrading and refining technologies that will maximize the output of transportation fuels, while minimizing output of low value products and waste streams.

- By 2010, reduce imports by 50,000 barrels per day by developing new technologies and chemical data, which will increase refinery efficiencies by 2 to 3 percent and lower the environmental impact and waste fraction percentages in a barrel of crude, such as reductions in air emissions (carbon dioxide, sulfur, nitrogen, and ammonia) and solid waste management (coke reduction by 2.5 percent).

## Environmental Benefits of Advanced E&P Technology

Our Nation has come to expect both the benefits of fossil fuels and products and a clean environment. The oil and gas industry has consistently responded to meet these expectations. A report issued by DOE, *Environmental Benefits of Advanced Oil and Gas Exploration and Production Technology* (February 1999), documents the innovations being applied by the oil and gas industry to increase the efficiency and productivity of its exploration and production (E&P) operations. These innovations are also improving the environmental performance of the E&P industry in significant ways. The report summarizes key E&P trends of the past three decades, as well as the challenges facing the industry in the future.

In the past three decades, the petroleum industry has transformed itself into a high-technology industry. Dramatic technological advances have been made in exploration, drilling, and completion, production, site restoration, and operations in sensitive environments, enabling the industry to keep up with the ever-increasing demand for reliable supplies of oil and natural gas at reasonable prices. The productivity gains attributed to these advances have been widely recognized, but awareness of the impressive environmental benefits from new E&P technology remains limited. Across the E&P spectrum, new technology is delivering:

- **More efficient recovery of oil and gas resources:** Continuing improvements in recovery efficiency per well means more reserve additions for a given level
- of effort, which translates into fewer wells (and less impact from drilling operations) to achieve the same level of reserves. For example, technology advances have boosted productivity so successfully that 1985-level production from two wells can be achieved today with only one well.
- **Smaller footprints:** Smaller, lighter rigs made possible by advanced drilling technology shrink the footprint of oil and gas operations and reduce surface disturbance. Advances in directional and extended reach drilling enable extraction of valuable resources without disturbing sensitive habitats and cultural resources. For example, using slimhole drilling, operators can produce the same volume of resources with a rig up to 75 percent smaller and lighter than a standard rig, reducing impacts on surface environments.
- **Cleaner, safer operations:** More energy-efficient drilling and production methods cut emissions of hazardous air pollutants, nitrogen oxides, particulates, and greenhouse gases associated with electricity and fuel use. For example, volumes of produced water can be drastically reduced by 90 percent in wells where downhole separation is applicable. Better wellbore control translates into enhanced worker safety, lower risk of blowouts, and better protection of groundwater resources.

DRILLING & COMPLETION
DIAGNOSTICS & IMAGING
RESERVOIR EFFICIENCY
RESERVOIR LIFE
GAS STORAGE
ENVIRONMENTAL
OIL PROCESSING
GAS PROCESSING
MODELING & ANALYSIS

**Program Plans**

Advanced Drilling, Completion & Stimulation Systems	1-1
Advanced Diagnostics & Imaging Systems	2-1
Reservoir Efficiency Processes	3-1
Reservoir Life Extension	4-1
Gas Storage Program	5-1
Oil & Gas Environmental Research and Analysis	6-1
Oil Processing Program	7-1
Gas Processing Program	8-1
Oil & Gas Modeling and Analysis	9-1
Crosscutting Programs	10-1