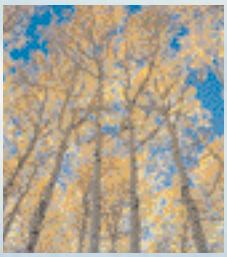
Sustainable Development of North America's Oil and Natural Gas

Ensuring Plentiful Energy and a Clean Environment





More Efficient, More Effective, More Protective of the Environment

White House photo by Eric Draper

America must have an energy policy that plans for the future, but meets the needs of today. I believe we can develop our natural resources and protect our environment.[1]

— President George W. Bush

America's energy strength

As the President's National Energy Policy states, "America's energy strength lies in the abundance and diversity of its energy resources, and in its technological leadership in developing and efficiently using these resources." These abundant domestic resources include oil and natural gas, which will remain a vital part of our nation's energy portfolio for many decades to come, playing a key role in meeting escalating energy demand.

Today, oil and gas are produced in over 30 states, in settings as diverse as rural Appalachia, coastal wetlands of Louisiana, tall grass prairies in the Midwest, urban landscapes in California, and the tundra of Alaska. However, producing domestic resources in the future will be increasingly challenging. Much of the lower-cost oil and natural gas in the United States has already been recovered, and remaining resources are located in geologically complex reservoirs and in difficult-to-reach locations. Also, many resources are in environmentally sensitive areas that will require use of less intrusive technologies.

Increasing supplies of energy from such domestic sources, while protecting our environment, is one of the primary challenges addressed by the National Energy Policy. This document highlights progress made by industry and government in meeting this challenge, and outlines how—with innovative technology and sound decision-making—our nation can achieve sustainable development of its oil and natural gas resources in the future.

New technologies and new ways of thinking

Advanced technologies enable oil and natural gas producers to keep pace with growing demand for oil and natural gas by recovering more resources. Today, an initial discovery can grow by as much as 10 times through additional drilling and application of new technology. As a result, the U.S. has been able to replace the natural gas reserves it has produced for 8 of the last 9 years, and to replace crude oil reserves in 5 of the last 6 years. Reserve additions have kept pace with production, even though fewer than half as many wells are drilled today as in the 1980s.

These same technologies also yield impressive environmental benefits. Oil and natural gas producers now:

Drill fewer wells to add the same level of reserves. Today, industry adds 2 to 4 times more oil and gas to the nation's reserve base per well than in the 1980s.

1 Report of the National Energy Policy Development Group, ***National Energy Policy***, May 2001.

Generate lower drilling waste volumes. Today, the same level of reserve additions is achieved with 65 percent less waste being generated.

Leave smaller facility footprints. The average well site footprint today is 30 percent of the size it was in 1970, and through the use of extended reach drilling, an average well can now contact over 60 times more subsurface area.

Achieve record levels of worker safety. Between 1990 and 1999, job-related injuries and illnesses of oil and gas industry employees decreased by 31 percent, more than that of all industry.[2] Worldwide, the overall fatality rate for the global E&P industry is at the lowest level since records have been collected.

Progress also stems from business practices and values that respond to our nation's ongoing commitment to a clean environment. Increasingly, energy companies are focusing on "the three pillars" of sustainable development: economic, environmental, and social considerations. Growing numbers of companies annually report progress on all three fronts to their investors and employees. The oil and natural gas industry makes major investments in environmental protection, both in complying with regulations and in implementing voluntary efforts, and industry and government actively learn from environmental and safety setbacks.

Over the past three decades, results have been dramatic.[3]

- Aggregate criteria pollutant emissions[4] from oil and natural gas operations fell by 48 percent between 1970 and 2002.
- Toxics releases from refineries fell by 41 percent between 1988 and 1997.
- Investments in double-hulled tankers, spill response equipment and operations, and spill prevention training have cut oil spills in U.S. waters by 90 percent since 1989.[5]
- As new emissions standards are implemented, tailpipe emissions of 28 new cars will equal that of just one 1960s-vintage car.

By building on this record of success, our nation can succeed in meeting the energy needs of generations to come, and in preserving the quality of our environment.

Sustainable development has been defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[6]

Myths about oil and gas

Myth: The oil and gas industry is Big Oil.

Reality: The Big Oil image is misleading. Independent oil and natural gas producers—small businesses typically employing fewer than 20 employees—drill 85% of the nation's wells and produce 65% of the natural gas and nearly 40% of the oil.[7] The Department of Energy has technology transfer programs targeted specifically to small independent producers.

Myth: Spills from exploration and production (E&P) are the leading cause of oil pollution in the oceans and in our rivers and streams.

Reality: To the contrary, the National Academy of Sciences found that offshore oil and gas E&P accounts for 3% of oil in the North American marine environment, and tanker and pipeline spills account for 8%.[8] Most oil in the sea comes from natural seepage, municipal/industrial runoff, and marine transportation.

Myth: Only large oil and gas companies have the capability to apply new technologies.

Reality: Independent producers are putting advanced technologies to work across the nation. For example, in Posey County, Indiana, next-generation logging tools, wellbore monitoring systems, and intelligent flow control devices are being put to the test in a 100-year-old, low-production oil field by Team Energy in collaboration with Schlumberger.[9] Prior to this, the only other field where this technology had been tested was in BP's Wytech Farm field in the United Kingdom —one of the most high-tech oilfield operations in the world.

Myth: U.S. oil imports come only from the Middle East.

Reality: Over 30% of U.S. oil imports come from our North American neighbors, Mexico and Canada. And, the U.S. itself is the world's second largest producer of natural gas, and third largest producer of oil.

2 American Petroleum Institute (API), ***Workplace Safety for the U.S. Petroleum Industry, 1990-1999***, January 21, 2001.

3 U.S. Environmental Protection Agency (EPA), ***National Air Quality and Emissions Trends Report: 2003 Special Studies Edition***, see www.epa.gov/air/aqtrnd03/; also API, www.ec-api.org/environment

4 Includes ozone, sulfur dioxide, nitrogen dioxide, particulate matter, carbon monoxide, lead.

5 U.S. Coast Guard, ***Annual Data and Graphics (1969-2001)***, see uscg.mil/hq/gm/nmc/response/stats/ac/htm

6 World Commission on Environment and Development (WCED), ***Our Common Future*** (The Brundtland Report), Oxford University Press, 1987.

7 Independent Petroleum Association of America (IPAA), ***Independent Producers: Meeting America's Energy Needs***, December 2001, see www.ipaa.org/govtrelations/factsheets/

8 National Research Council, ***Oil in the Sea III: Inputs, Fates, and Effects***, 2003.

9 Swager, D.R., and Bryant, I., "Independent's Illinois Basin Wells Serve as Test Beds for Next-Generation Technologies," ***The American Oil & Gas Reporter***, July 2002.

Our Quality of Life Relies on Oil and Natural Gas

Abundant and reliable energy supplies are critical to a strong U.S. economy

Today, oil and natural gas represent two-thirds of the energy we consume to heat our homes, power our factories, generate our electricity, and fuel our cars. They also provide raw materials for vital manufacturing industries—including chemicals, refining, plastics, and pharmaceuticals—that employ millions of Americans.

A balanced energy future cannot rely solely on increasing consumption of fossil fuels. That is why the U.S. Department of Energy engages in research to advance energy efficiency and renewable energy technologies, as well as public awareness campaigns to educate consumers and businesses on ways to reduce energy use. Yet even after factoring in energy efficiency gains, our nation's dependence on oil and gas is projected to continue growing.

Much of future demand can be met with North American resources

The good news is that, after nearly 150 years of production, U.S. oil and natural gas resources remain vast. Currently, 85 percent of the natural gas and 47 percent of the oil consumed in the United States are produced domestically. To ensure secure, reliable, and affordable oil and natural gas supplies, it is vital that our nation import resources from diverse and stable international trading partners. It is equally vital that domestic resources remain a viable part of our nation's energy portfolio.

If our nation is to ensure the sustainable development of domestic resources in the future, and the successful delivery of those resources to meet consumers' needs, we must meet 4 key prerequisites:

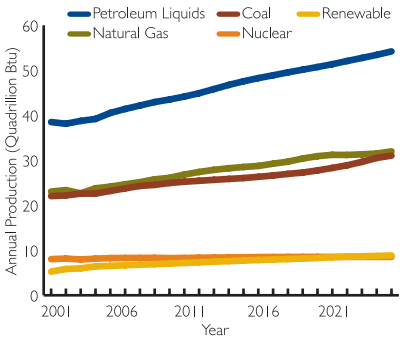
Continued technology advances in exploration and production. Most remaining oil and natural gas resources in North America exist in locations as diverse as the Alaska North Slope, deepwater Gulf of Mexico, the Rocky Mountains, and midwest farm lands. In addition, large resource potential remains left behind in discovered fields because it is not currently economical to recover. Producing these resources successfully will require continued technology advances and willingness by industry to accept associated investment risks.

Adequate oil and natural gas infrastructures. Once produced, oil and gas often make a long journey to reach consumers, utilizing the 180,000 miles of interstate natural gas pipelines and 200,000 miles of petroleum pipelines in North America.[10] Significant investments and informed policy-making will be required to support the continued reliability and necessary expansion of this network.

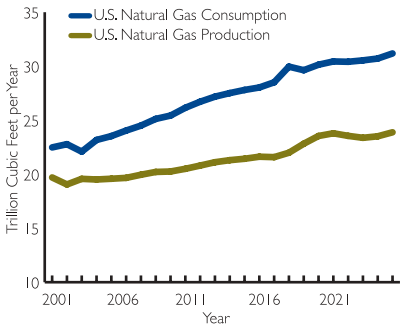
Investments in an ever-cleaner environment. While energy is vital to a high quality of life, so is a clean environment. The oil and natural gas industry is investing in proactive efforts to address concerns about potential global warming, by: finding alternatives to high carbon fuels; reducing emissions of greenhouse gases; and permanently removing, or sequestering, greenhouse gases that are produced. Other efforts target reducing emissions that impact local air quality and visibility, protecting surface water and groundwater, preserving plant and animal life, and collaborating with other interested parties to address concerns associated with the multiple uses of land.

Informed decision making. Responsibly developing North America's energy resources will require a continuation of our nation's long history of technological innovation and entrepreneurship. It will

U.S. Energy Production by Sources
By 2025, domestic consumption of oil and related products and natural gas consumption are each projected to increase by 42%.



U.S. Natural Gas Supply and Demand
The gap between domestic natural gas consumption and production is forecast to double over the next two decades, with imports making up the difference.



Source: Energy Information Administration, ***Annual Energy Outlook, 2004***

Voluntary industry actions to protect the environment include returning former oil and natural gas sites to a range of beneficial uses. In November 2003, the Oklahoma Energy Resources Board celebrated its 5,000th cleanup of an abandoned oil site. Producers and royalty owners have contributed over $20 million to the program since 1994.[13]

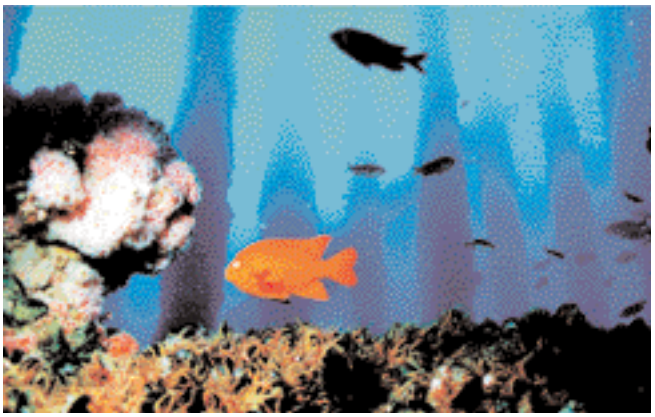


Photo by Bob Wohlers, courtesy of the California Artificial Reef Enhancement program

Beneficial reuse of resources include "rigs-to-reefs" efforts. For the last 13 years, a U.S. Minerals Management Service (MMS) program has helped convert over 150 offshore platforms in the Gulf of Mexico for use as artificial reefs. Some researchers report fish densities 20 to 50 times higher around active platforms.[14] *In 2002, MMS received a special citation for this program at the annual Offshore Technology Conference in Houston.*[15]

require attracting the "best and brightest" of future generations to the oil and natural gas industry. Just as important, it will require informed decision making, both in the public policy arena and in corporate boardrooms.

From conflict to consensus

Critical to informed decision-making is a knowledgeable public that understands the potential, issues, and trade-offs associated with the energy choices our nation faces. Responsible public involvement in energy development decisions is being seen in communities across our nation, where constructive participation is moving participants beyond conflict to consensus. Communities are finding solutions that balance the benefits of energy production with the ongoing drive for environmental protection.

Industry plays an important part in these solutions. Where companies once focused solely on complying with regulations, many now view environmental performance more broadly, as a core business value. Today's oil and natural gas producers are applying new technologies that simultaneously increase productivity and reduce impacts on the environment. The industry systematically evaluates environmental and safety setbacks as the basis for improved practices and methods. Companies are also participating in voluntary environmental stewardship efforts, and finding valuable uses for what were once undesired by-products. Both the environment and the bottom line are helped by efforts to minimize the flaring and venting of natural gas, to reuse or recycle drilling wastes, and to find other beneficial uses of by-product streams.

Investors are promoting such new "triple bottom line" thinking. Increasingly, the investment community weighs environmental and social performance equally with financial performance when assessing a company's long-term value, and many oil and natural gas companies report progress on environmental and social performance with a level of rigor comparable to that of their financial reporting. Similarly, more non-governmental organizations are making strategic decisions to proactively engage with business and government in an effort to promote new approaches, in sharp contrast to their confrontational posture of the past.

Government has a supportive role as well, working collaboratively with industry on common-sense approaches that reduce emissions, protect the environment, and meet energy needs. EPA's Natural Gas STAR program, for example, assists industry in implementing voluntary efforts to reduce greenhouse gas emissions. So far, the program has helped eliminate more than 176 billion cubic feet of methane emissions to the atmosphere, the equivalent of removing nearly 14 million cars from the road for one year or planting 21 million acres of trees.[11] In another effort, DOE is working with industry partners to demonstrate ways to sequester carbon dioxide in oil and gas fields and unmineable coal seams. In addition to removing greenhouse gases from the atmosphere, these projects can often produce incremental oil and gas—once again, yielding both economic and environmental benefits.[12]

10 Interstate Natural Gas Association of America, see www.ingaa.org; and Association of Oil Pipe Lines, see www.aopl.org

11 EPA, see www.epa.gov/gasstar/

12 DOE Office of Fossil Energy, see www.fossil.energy.gov/programs/sequestration/geologic/

13 Oklahoma Energy Resources Board, ***Oil and Natural Gas Industry Restores 5000 Abandoned Oil Sites***, November 18, 2003, see www.oerb.com

14 Dauterive, Les, ***Rigs-to-Reefs Policy, Progress, and Perspectives***, (MMS OCS Report 2000-073), U.S. Department of Interior, Minerals Management Service, October 2000.

15 U.S. Department of the Interior, Minerals Management Service, News Release May 14, 2002, see www.gomr.mms.gov/homepg/whatsnew/newsreal/020513hq.html

Advanced Technologies Make a Real Difference

From resource to market

Technology advances on many fronts are making the exploration, development, production, processing, and distribution of oil and natural gas cheaper, more efficient, and more protective of the environment.

Advances in one area often spark innovations in others, accelerating productivity and efficiency. For example, horizontal drilling would not be effective without knowing where to put the well, which depends on advances in 3-D seismic technology. Measurement-while-drilling technology, supported by developments in fiber optics, advanced sensors, and mud pulse telemetry, helps ensure that the driller can steer the well to its desired destination. Looking to the future, the evolution of drilling will combine the application of expandable tubulars, telemetry, remote sensing, and robotics, facilitated by wireless or fiber optic technologies.

Following are highlights of these technologies and others that have helped improve productivity and environmental performance, from the initial search for resources to their delivery to the marketplace.

Exploration

Pinpointing oil and natural gas resources

Satellite imagery and **aeromagnetic surveys** from aircraft can target oil and gas prospects more rapidly and cost effectively than conventional ground survey. Since the surface is never touched, remote sensing also minimizes environmental impact.

Where on-the-ground information gathering is required, **3-D seismic** technology is used, often coupled with sophisticated visualization techniques. These methods allow geologists to better "see" underground to locate potential sources of oil and gas, dramatically improving exploration success rates, reducing drilling costs, and minimizing environmental impacts. Advanced planning and smaller footprint 3-D seismic technologies such as non-explosive detonators and backpack-sized equipment can ensure that impacts are as localized as possible.

Today, a single geophysicist processes information encompassing an area 10 times that typical in the 1980s.[16] Since the first **3-D visualization** center opened in 1997, over 125 centers have been established worldwide.[17] The result is that substantially fewer wells are drilled to find considerably larger volumes of resources.

Application of 3-D seismic technology over time (called **4-D seismic** technology) was first tried in the 1980s and has grown tremendously in the last decade.[18] 4-D seismic helps in optimizing field operations and in increasing the recovery efficiency in producing fields.

16 Williams, Peggy, "Seismic in the 21st Century," ***Oil and Gas Investor***, May 2002.

17 Giertson, Christopher, "Visualization—Does It Make a Difference?", ***Journal of Petroleum Technology***, February 2003. A 3-D visualization center merges siesmic and other data to provide 3-D images of subsurface rocks and fluids.

18 Lumley, David, "Concept Represents Next Wave in 4-D," ***The American Oil & Gas Reporter***, January 2001.

Drilling, Completion, and Stimulation

Going farther and deeper, faster and cheaper

Thanks to developments in computing and **fiber optic sensor** technology, today's drillers have tremendous information at their fingertips on what is happening in a reservoir beneath the surface. Small, lightweight fiber-optic-systems capable of withstanding high temperatures, pressures, and physical shocks measure and report subsurface characteristics, enabling well operators to respond to changing conditions in real time. Monitoring is invaluable in guiding **directional drilling**, allowing as many as 35 **horizontal wells** to be drilled and produced from a single 5-acre drilling pad. Productivity, safety, and environmental performance all benefit from these advances.

Another technology that is changing exploration and production is **slimhole drilling**—drilling holes of a diameter of 6 inches or less. Slimhole drilling can be used in the early stages of exploration and in re-entering existing small-diameter wells to reach new reserves in mature fields. Compared to conventional drilling, the technology saves money, reduces footprints, and cuts waste, noise, visual impacts, fuel consumption, and emissions. Even greater reductions in costs and environmental impacts can be achieved with **micro-hole coiled tubing drilling**. Using **microelectronics** for guidance control and formation evaluation, this technology is envisioned to permit exploratory drilling to targets at 5,000 to 7,000 feet with 2-inch diameter boreholes.[19]

Fiber optic systems are increasingly being applied throughout a reservoir's life to optimize production. One example is "smart wells" technology, which collects data on well performance and reservoir properties downhole that can be monitored from anywhere in the world via the Internet.[20]

19 DOE Office of Fossil Energy, see www.fossil.energy.gov/programs/oilgas/microhole/

20 Tubel, Paulo, "Fiber Optics Enable Well Monitoring," ***The American Oil & Gas Reporter***, January 2001.

Production

Innovative strategies minimize water production

U.S. petroleum production generates 15 billion barrels of water annually[21]—on average, 7 to 8 barrels of water per barrel of oil. Today, operators are using advanced reservoir management techniques to enhance well placement and reduce water production. In the future, **downhole oil/water** and **gas/water separation** could dramatically reduce the amount of water produced up the wellbore, cutting operating costs and decreasing the possibility of groundwater contamination from produced water spillage onto the soil.

Improving oil recovery efficiency while reducing greenhouse gases

Nearly two-thirds of discovered oil resources in the U.S. still remain untapped. Over the last 20 years, advances in technologies associated with the injection of steam, carbon dioxide, other gases, and various chemicals have **enhanced oil recovery** in discovered fields. Looking into the future, the injection of CO_2 generated from industrial operations into oil fields may result in both incremental oil production and environmental benefits by **sequestering the CO_2** deep in the ground and reducing greenhouse gases in the atmosphere.[22]

Efficiency gains lead to reduced emissions

Simple changes to field equipment or operating procedures can yield major efficiency gains in oil and gas operations. By installing timers and pumping during off-peak hours, for example, Equinox reduced power costs in Illinois' South Albion field by 25 percent without reducing production rates. And, these measures extend the life of the field.[23] In western Canada, BP replaced older mechanical governors on its reciprocating engines with an electronic control system that could maintain more optimal operating conditions. The operation's emissions of CO_2 were reduced by 27 percent, nitrogen oxides by 35 percent, and carbon monoxide by 99 percent.[24]

Pipelines and Gas Storage

Bringing oil and natural gas safely to consumers

Pipeline operation and construction now employ **lasers, robotics, high-strength materials, satellite imagery**, and **high-speed computers** to ensure safety and reliability. High-resolution **"smart pigs"** are one example. These robotic devices move inside a pipeline to locate corrosion or other anomalies by using magnets and ultrasonic sensors. The next step will be for these same "pigs" to perform repairs as well. Another kind of device—a lightweight, handheld detector recently demonstrated by CyTerra in a DOE-sponsored study—could prevent excavation crews from inadvertently striking underground pipelines.[25] On the horizon, **fiber optic cable** systems now being developed will sense when construction activity, leaks, or ground movements could potentially harm subsurface pipe or cause environmental impacts, and signal to operators when corrective action is needed.[26]

Refining and Retail

Ensuring safe and environmentally responsible operations at refineries and service stations

Advances in **automated process** and **system controls**, **solvent extraction**, **catalysts**, and **emissions monitoring** enable refiners to produce ever-cleaner fuels, while improving their environmental performance and meeting challenging marketplace demands. By the late 1990s, U.S. refineries were recycling more than 60 percent of their residual wastes.[27] In addition, new **leak detection** technologies, sponsored in part by DOE,[28] are helping better control refinery emissions of methane, volatile organic compounds, and other potential pollutants.

Advances in "refining" natural gas—through **gas-to-liquids** technology—could convert large portions of the world's "stranded" natural gas resources to useful liquid fuels. Developments in technologies such as ceramic membranes can help economically produce valuable fuels with no sulfur or benzene pollutants. A number of companies—in many cases partnered with entrepreneurial technology developers—are now pursuing pilot projects to test the economic viability of this promising technology.[29]

In the past, underground tanks—storing 30,000 to 40,000 gallons at a typical retail service station—were subject to spills and leaks. Today's stations feature new tanks lined with fiberglass or other **durable coatings**, or use **cathodic-protection systems** to help prevent corrosion. Protection devices prevent the overfilling of tanks, and basins catch fuel spilled when the delivery hose is uncoupled from the fill pipe. Devices alert station owners to leaks as small as 0.1 gallon per hour, and **vapor recovery units** reduce "fugitive emissions" from tanks by 95 percent or more.

21 API, ***Overview of Exploration and Production Waste Volumes and Waste Management Practices in the United States***, May 2000.

22 DOE Office of Fossil Energy, see www.fossil.energy.gov/programs/sequestration/geologic/ and www.fossil.energy.gov/programs/oilgas/eor/

23 Coston, David and Dicus, Bryan J., "How to reduce electrical power costs without sacrificing production rate," ***World Oil Special Report,*** September 1999.

24 BP Canada, ***Energy Efficient Gas Production in Western Canada***, (undated factsheet), in Natural Resources Canada, Office of Energy Efficiency, ***Heads Up***, Vol. 1, No. 22, November 15, 2002.

25 DOE, "From Battlefield to Backyard...Military Landmine Detector Successfully Adapted to Pinpoint Buried Natural Gas Pipelines," ***Fossil Energy Techline***, August 2003.

26 DOE, "Experimental Fiber Optic Cables to Warn of Potential Pipeline Damage," ***Fossil Energy Techline***, January 21, 2003.

27 Energetics, Inc., ***Energy and Environmental Profile of the U.S. Petroleum Refining Industry***, December 1988.

28 DOE Office of Fossil Energy, "Vehicle-Mounted Natural Gas Leak Detector Passes Key Road Test," ***Fossil Energy Techline***, October 2, 2003.

29 Toal, Brian A., "Gas-to-Liquids," ***Oil and Gas Investor***, July 2002.

Opening the Way to a New Energy Future

Innovations yield greater productivity and fewer impacts

Nearly 150 years after the birth of the U.S. oil and gas industry, resources remaining in the ground are still double those produced. Yet recovering these domestic resources will pose challenges requiring innovative thinking and advanced technologies, with increased attention to environmental protection.

Major contributions to future domestic supplies must come from new frontiers in such geologically challenging and operationally complex settings as the Alaska North Slope, deep formations, deepwater offshore, and lower permeability formations in the Rocky Mountain States. Today's producers are applying a host of new technologies to minimize the environmental impact of oil and natural gas operations in these frontier regions.

Advancing the deepwater frontier

In the deepwater frontier, for example, cutting-edge technologies such as multilateral drilling and subsea completion have continued to push the limits of offshore exploration and development into increasingly deeper waters. The first offshore well was drilled in 1947 in the Gulf of Mexico in just 20 feet of water. In the last three years, 14 new deepwater discoveries have been made in water 5,000 feet or deeper. Today, the Gulf of Mexico Outer Continental Shelf is one of the world's great hydrocarbon basins, producing approximately 30 percent of U.S. oil production and 23 percent of U.S. natural gas production.[30]

In the last few years, equipment standardization has reduced the costs and installation times of subsea well technology, contributing to rapid growth in deepwater development and production in the Gulf of Mexico and around the world. The use of subsea wells enables continued utilization of existing infrastructures, minimizing the need for new offshore structures and reducing environmental impacts. Subsea completions now account for approximately 40 percent of deepwater natural gas production, and 25 percent of deepwater oil production.[31]

Deep sea well production rates have risen dramatically in the last decade, allowing resources to be produced with far less drilling. In Shell's 1-Tcf Mensa field, the first well produced over 100 million cubic feet per day.[32] This field has been developed with only four subsea wells.[33] In 1992, the National Petroleum Council estimated that a field of this size would require 30 to 40 wells to develop.[34]

Stepping lightly and leaving a good impression

Similar gains are evident in the Alaskan North Slope. Since the Prudhoe Bay field was developed in the mid-1970s, technological innovations such as directional drilling have dramatically shrunk operational footprints. At the Alpine field, for instance, surface facilities take up fewer than 100 acres, less than 0.2 percent of the total area of the 40,000-acre field.[35]

Other technological innovations have furthered less intrusive development in Arctic environments. One is temporary ice roads, which largely eliminate the need for permanent gravel roads to serve pipelines or transport exploratory drilling equipment. Ice pads replace gravel pads for drilling exploratory wells. Ice roads and pads melt in the spring with minimal effects on the tundra. Another approach, used in conducting initial seismic surveys, relies on large all-terrain vehicles with huge, low-pressure, balloon-like tires. These vehicles carry substantial loads across the tundra, leaving virtually no tracks. To further protect the tundra, such operations are conducted only in the winter, when the ground is frozen solid and wildlife is absent.

30 U.S. Department of Interior, Minerals Management Service, "Ultra-Deep Drilling Record Set, Deepwater Energy Exploration Expands," News Release, March 4, 2004.

31 U.S. Department of Interior, Minerals Management Service, Deepwater Gulf of Mexico, ***America's Emerging Frontier***, (OCS Report MMS 2000-0022), April 2000.

32 Shell Oil Company, see www.offshore-technology.com/projects/mensa/

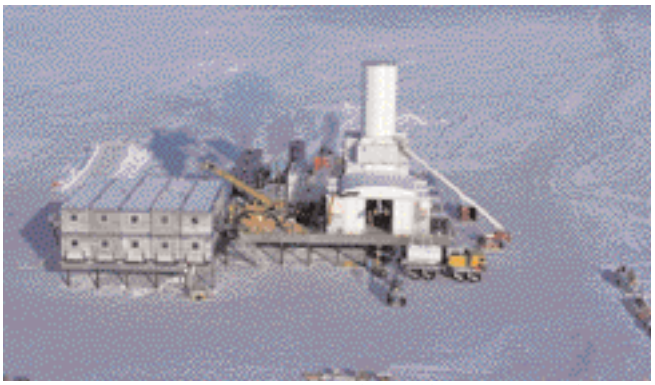
33 Shell Oil Company, see www.countonshell.com/sepco/where/offshore_shell/ mensa.htm

34 National Petroleum Council, ***The Potential for Natural Gas in the United States***, December 1992; see www.npc.org

35 ConocoPhillips, see www.conocophillips.com/global/na/alaska.asp.

Courtesy of ChevronTexaco Corp.

In a desertlike area of San Joaquin Valley, ChevronTexaco has combined new technology and more efficient operations to bring new life to the 100-year old Lost Hills field. Within the past five years, operating costs have been cut in half. Lost Hills and nearby Cymric field now produce 28 million more barrels of oil annually than they did in 1996. Greatly improved safety performance is a core element of this success story.[40]



Courtesy of Anadarko Petroleum Corporation

Recently, a one-of-a-kind modular arctic platform was successfully demonstrated south of the Kuparuk field, Alaska, in a well targeting natural gas hydrates. Anadarko's Arctic Platform design eliminates the need to build drilling pads of ice or gravel, significantly reducing impacts on the Arctic tundra.[41]

Beyond the Arctic, oil and natural gas operations coexist with wildlife and ecosystems in other sensitive environments. The 26,800-acre Rainey Preserve in southern Louisiana—the Audubon Society's largest wildlife sanctuary—hosts the Attwater prairie chicken, an endangered species. With close monitoring, there has been little impact on the marshes or wildlife disturbance from production of gas (and some oil) from 37 wells. Revenues from these leases are being used to preserve more lands or improve habitat elsewhere.[36] Similarly, in the heart of the Hagerman Natural Wildlife Refuge near Lake Texoma in northeast Texas, Venoco is economically producing oil and gas with little impact. In the high water season, operating equipment is removed from many of the wells to minimize potential contamination of the refuge.[37]

New life for old fields

As in frontier areas, large amounts of domestic resources remain in discovered fields. These resources have been left behind because they are currently not economical to recover. With their marginal profitability, many fields are in danger of being abandoned, cutting off access to their valuable resources for future generations.

However, even in the most mature U.S. basins, industry is breathing new life into older fields once thought on the verge of abandonment, increasing reserves by applying new technologies and concepts. In the Overton field in East Texas, for instance, Southwestern Energy has increased production 10-fold since 2001 and decreased drilling costs through better understanding of the geology and improved fracture technology. Another example is found in the Cedar Creek Anticline on the Montana-North Dakota border, where Burlington Resources is pursuing the world's largest all horizontal well water flood. Today, the field has close to 200 horizontal wells, each producing 300 barrels per day—6 times the production of a typical vertical well at about the same cost.[38]

Photo by Tom Till

In Wasatch-Cache National Forest, a Merit Energy operation demonstrates how oil and gas drilling can take place on federal lands. As one visitor reported, "The oil and gas structures … are the cleanest I have ever seen. The whole complex is so well hidden that even from the scenic overlook of the valley you can't spot any of the wells or production facilities."[39]

36 Baden, John A., "Let Greens Bid on Proceeds of ANWR Oil Production," ***Bozeman Daily Chronicle***, April 5, 2000.

37 Venoco, see www.venocoinc.com/creek.html

38 Williams, Peggy, "New Life in Old Basins," ***Oil and Gas Investor***, October 2002.

39 Michael Murphy reported on his visit to the site in September 2002 as part of a trek sponsored by the Public Lands Interpretive Association and ***National Geographic***, (http://americanfrontiers.net/journals/)

40 ***Chevron Now***, "Recapturing the Lost Hills," August/September 2001.

41 DOE Office of Fossil Energy, "Alaska Well Targets Gas Hydrate, Produces Wealth of Information, ***Fossil Energy Techline***, March 1, 2004.

Reshaping Tomorrow's Energy Economy

A new century of opportunities and challenges

Many envision the eventual transformation of our nation's energy economy from one based largely on combustion of fossil fuels to one based on alternative sources of energy. Powering tomorrow's cars and buildings with electricity from hydrogen fuel cell technologies, for example, could substantially reduce emissions of air pollutants and greenhouse gases. Natural gas—one of the most promising fuels for deriving hydrogen—can play a pivotal role in the emergence of these new technologies.[42]

In the coming decades, our nation's energy security will continue to depend on sufficient supplies of oil and natural gas to support U.S. and global economic growth. Meeting energy demands will require ongoing innovation, as oil and natural gas fields become ever-more challenging—geologically, operationally, environmentally, socio-economically, and politically. To remain competitive, some operators may integrate processing onto field sites, converting the crude oil and natural gas to higher-value forms of energy. Processing may include conversion of gas to liquids or liquids to gas, or generation of electricity on or near the site. Large deposits of natural gas reside in other countries far from energy markets. Connecting these "stranded" natural gas resources with people, factories, and power plants needing the energy is a primary reason for the innovations and investments behind a growing international liquefied natural gas business. Recovering more of the "stranded" oil resource in producing oil fields will be critical in reducing U.S. dependence on imported oil.[43] Finally, companies will pursue greater operational flexibility, enabling them to slow down or ramp up production or change their product mix in response to changing market conditions.

Meeting future energy needs will also require exploring new resource frontiers such as oil sands and shales, and natural gas hydrates—natural gas and water frozen into a solid. A vast source of potential future energy supplies, gas hydrates are concentrated in arctic permafrost regions and in the sediments of the ocean's deep waters.

The adage "think globally, act locally" may apply to oil and natural gas development, as both industry and government will be challenged to create more positive results in local settings and, at the same time, support broader societal objectives related to economic prosperity and quality of life within the global community. Efforts toward the development and demonstration of zero environmental impact technologies and more systems-oriented approaches to address energy and environmental issues may hold promise in this regard.

Thinking small, with giant results

Along with resource frontiers, there are exciting technology frontiers to develop as well, including nanotechnology—the science of creating functional structures at the molecular level.[44] Many oil and gas companies are taking initial steps in pursuing potentially promising areas for new technology.[45] For example, one could conceive of small computers, the size of a pinhead ("nanobots"), injected into a reservoir to characterize how fluids are flowing. Or micro filters could be used to facilitate additional recovery of oil or gas, to separate oil and water in the reservoir, to remove pollutants from produced oil and gas, or to clean up environmental damage where it has occurred. Nanotechnology could be used to make anything smaller, more durable, anti-static, and anti-corrosive—all conceivably leading to greater efficiency and reduced environmental impact.[46] DOE's Office of Basic Energy Sciences is playing an important role in nanotechnology research.

Estimated volumes of U.S. natural gas hydrates range from 100,000 to 300,000 trillion cubic feet, over 100 times more than current estimates of U.S. recoverable gas resources.[47] Research is under way to better understand this vast resource. Critical questions include how gas hydrates form, where they are located, how they could be used as a future source of supply, and how they affect the global carbon cycle, long-term climate, and sea floor stability.

42 DOE Office of Fossil Energy, see www.fossil.energy.gov/programs/fuel

43 U.S. Energy Information Administration, ***The Global Liquefied Natural Gas Market: Status and Outlook***, (DOE/EIA-0637), 2003.

44 Nanotechnology addresses structures on the scale of a nanometer—one-billionth of a meter—which is to a human hair as that hair is to the thickest redwood tree.

45 Clark, Judy, "Buckyballs and all," ***Oil and Gas Journal***, August 25, 2003.

46 Goa, Torbjorn, "Nanoscience—a small scale revolution," ***Oljedirektoratet, Norwegian Petroleum Directorate website***, October 10, 2002 (www.npd.no/English/Emner/Ressursforvaltning/nano_teknologi.htm)

Increasing computer power drives technology progress

The ever-increasing power, speed, and affordability of information processing will transform exploration and production, making advanced tools and techniques widely available. Consider that processing seismic information for a square kilometer tract required 800 minutes in 1985 but takes only 10 minutes today. Similarly, the cost of analyzing a 50-square mile survey has fallen from $8 million in 1980, to $1 million in 1990, to $90,000 today.[48] As computing improvements continue, independent producers are rapidly becoming the primary adapters and users of new technology. Even the small independent can have access to off-the-shelf software and cost-effectively deploy it on a desktop computer. More effective technology transfer through industry networks and government programs are helping to make new technologies widely accessible to independents.

The continued advancement of technology in the oil and gas industry—and the inevitable environmental improvements that will result from these advances—will be constrained only by the level of commitment, imagination, and resourcefulness of those focused on its pursuit. Both the private and public sectors have responsibilities for facilitating this advancement, which is in the best interest of the oil and gas industry, and of the nation as a whole.

> *The oil industry still produces oil, but it has been infused with so many new technologies that it should be thought of as one of the new manmade, brain-power industries like biotechnology.*[49]
>
> *— Lester Thurow, Professor of Economics and Management, Massachusetts Institute of Technology*

Sustainable development of our resources will depend on sustaining innovation. Tomorrow's pioneers in the natural gas and oil industry will rely on such diverse disciplines as geology, environmental science, engineering, and information technology.

47 Gautier, D.L., Dolton, G.L., Takahasi, K.I., and K.L. Varnes, ***National Assessment of U.S. Oil and Gas Resources***, (USGS Digital Data Series 30), CD ROM 1985.

48 Rauch, Jonathan, "The New Old Economy: Oil, Computers, and the Reinvention of the Earth," ***The Atlantic Monthly***, January 2001.

49 Thurow, Lester, Speech at Price Waterhouse World Energy Conference, November 1997.

Recognizing the importance of proactive and voluntary efforts to improve environmental performance, organizations like the Interstate Oil and Gas Compact Commission (IOGCC), the Minerals Management Service (MMS), the Society of Petroleum Engineers (SPE), and the Canadian Association of Petroleum Producers (CAPP) issue environmental stewardship awards to recognize outstanding corporate and public-sector achievements. Recent award winners include the companies and organizations whose names appear here.

Contributors

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