Offshore Technology Roadmap for the Ultra Deepwater Gulf of Mexico

U.S. Department of Energy

November 2000

FOREWORD

The goals of enhancing America's energy security and providing diverse energy technologies for the future come together in "Offshore Technology Roadmap for the Ultra-Deepwater Gulf of Mexico." It represents an uniquely American solution to current international energy challenges. In "Powering the New Economy" the Administration identified meeting these challenges as essential to the continued economic growth of the new Information Age and its hunger for energy supply, energy reliability and energy infrastructure.

The U.S. taxpayers own vast untapped oil and gas resources underlying public lands and waters in the deepwater of the Western Gulf of Mexico; the Department of Energy's national labs posses technologies and the ability to develop solutions that can address key technology gaps; and the private investment community has the risk management tools necessary for large cutting-edge deployments. Like the Minerals Management Service's program of deepwater royalty relief, investment today will pay off in reducing America's dependence on foreign oil, and the application of new, safe and sustainable production processes. Simply bringing these national assets together is not enough to bring costs down and environmental protections up. Meeting the Nation's growing demand for energy through safe and sustainable deepwater energy development requires a deliberate, coordinated, and well-financed effort - it requires a detailed roadmap.

This report, and the roadmapping exercise that produced it, is the result of a series of transparent workshops held across the nation. A wealth of information was produced to compliment internal sources like the Energy Information Administration. The active participation of the Department's stakeholders is greatly appreciated. Walter Rosenbusch, Director of the Minerals Management Service (MMS) deserves special recognition. His partnership, participation and input were instrumental to the success of this effort.

I also would like to thank my friend Governor Mark White for his participation and support of this effort. In addition, I thank the following workshop chairs and moderators for their participation and contribution to the roadmapping efforts: Mary Jane Wilson, WZI, Inc.; Ron Oligney, Dr. Michael Economides, and Jim Longbottom, University of Houston; John Vasselli, Houston Advanced Research Center; and Art Schroeder, Energy Valley.

This report, however, does not represent the end of such long-range planning by the Department, its national labs, and its stakeholders. Rather it is a roadmap for accelerating the journey into the ultra-deepwater Western Gulf of Mexico. The development of new technologies and commercialization paths, discoveries by marine biologists, and the fluctuations of international markets will continue to be important influences.

With that in mind, let the journey begin.

Emil Peña

Deputy Assistant Secretary
for Natural Gas and Petroleum Technology

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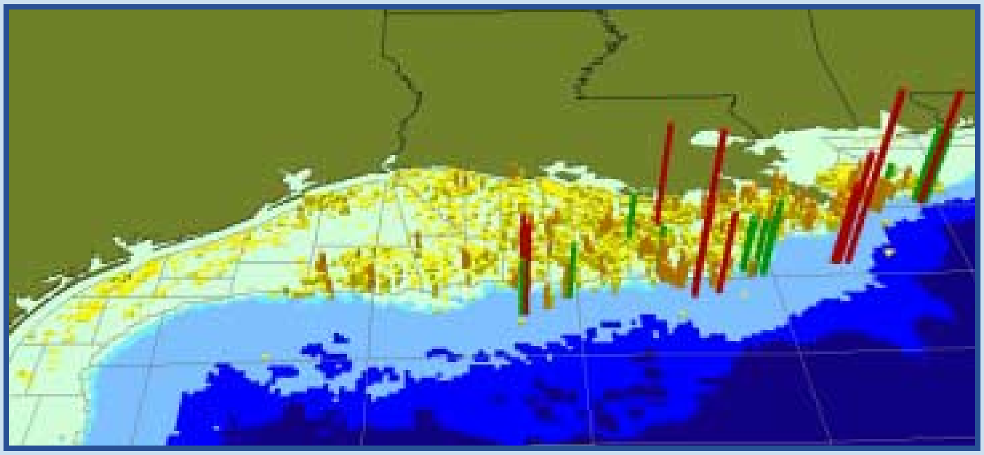
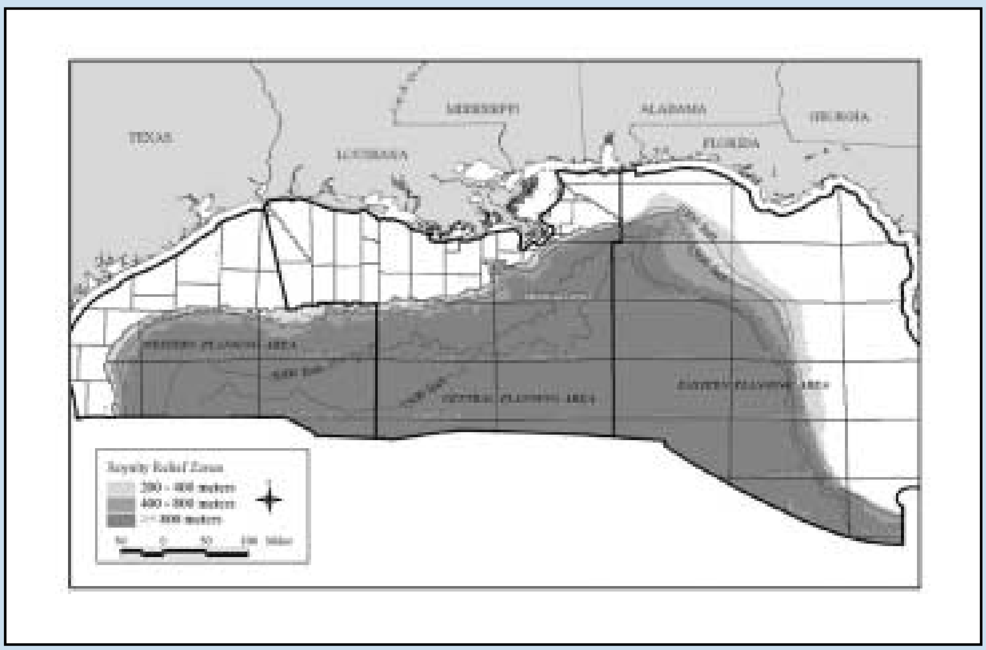


Maximum historical oil production rates for Gulf of Mexico wells. Taller bars indicate higher production rates. The data show numerous deepwater oil wells produced at significantly higher rates than ever seen in the Gulf of Mexico.



The Gulf of Mexico OCS is divided into Western, Central, and Eastern Planning Areas. The above exhibit shows the lease tracts, water depths, and Deepwater Royalty Relief Zones.

Source: Deepwater Gulf of Mexico: America's Emerging Frontier; Minerals Management Service, OCS Report MMS 2000-022, April 2000.

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The Purpose

The Offshore Technology Roadmapping (OSTR) is a major initiative to unite natural gas and oil producers, service companies, national laboratories, investors, non-governmental organizations, consumers/end-users, and various federal agencies in an effort to enhance the Nation's energy security through research, development and commercialization of technologies, and to explore the order of magnitude of funding needed for accelerated ultra-deepwater offshore energy development. Investment in new ultra-deepwater technology development is key to increasing energy security while also maintaining proper environmental stewardship. The U.S. Department of Energy's goal is to develop a roadmap of the actions that will make the energy resources of the U.S. Gulf of Mexico (GOM) ultra-deepwater a more fully contributing element of our Nation's energy security.

An effort to enhance the Nation's energy security through research, development and commercialization of technologies, and to explore the order of magnitude of funding needed for accelerated ultra-deepwater offshore energy development.

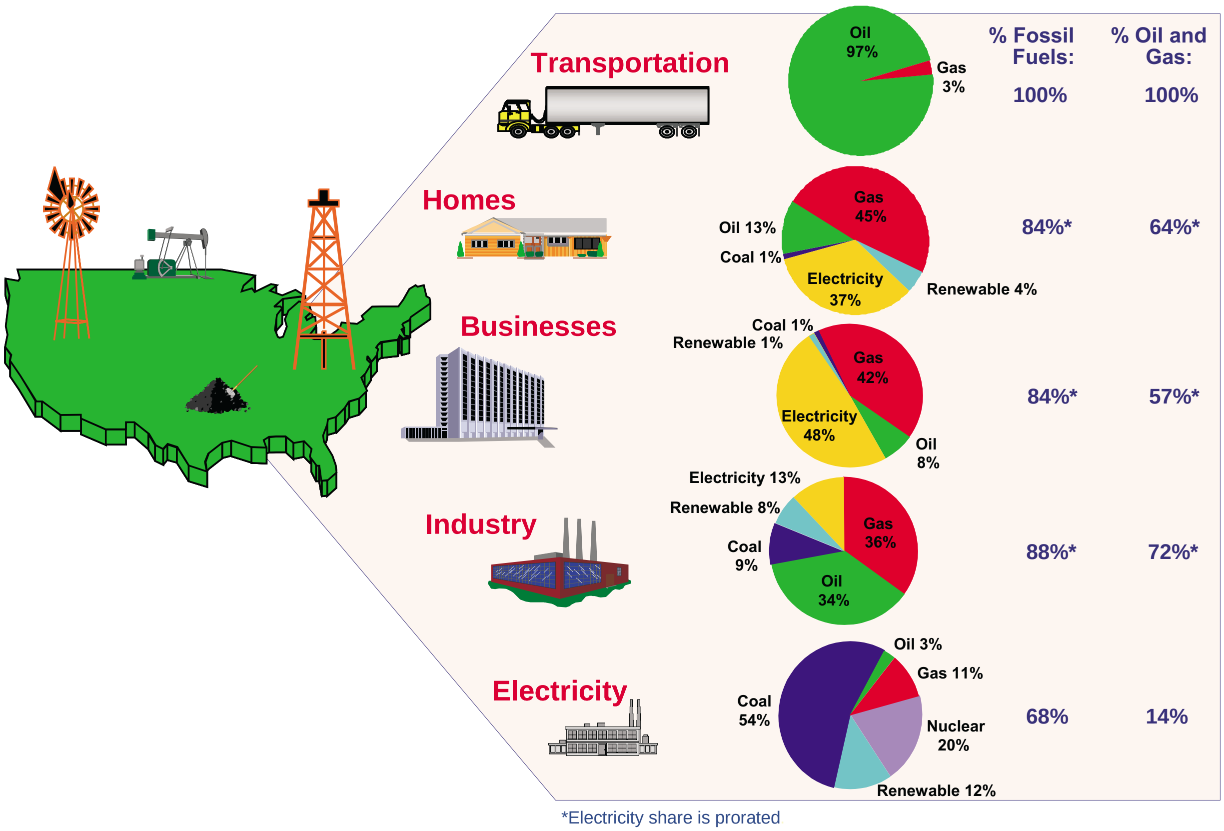
The Issue

The U.S. taxpayers own vast untapped oil and gas resources underlying public lands and waters in areas such as the Gulf of Mexico. The ultra-deepwater GOM holds enormous potential to help meet the Nation's growing demand for energy. Many experts believe that the deepwater reservoirs of the Gulf of Mexico have the potential to provide as much oil and natural gas as the North Slope of Alaska. Development efforts of this resource-rich area, although rapid, are not proceeding fast enough to meet the economy's growing demand or to slow the increasing reliance on imported supplies of oil. Projections by the Energy Information Administration (EIA) and others indicate that, in 2015, the U.S. demand for oil and natural gas will reach 25 million barrels/day and 30 trillion cubic feet (Tcf), respectively. Compared to U.S. consumption rates in 1999, this represents a 23 percent increase in demand for oil and more than 39 percent increase in natural gas demand. The U.S. has been increasing its reliance on oil and natural gas imports to meet this demand. It is imperative that future growth in demand be met in greater part by growth in U.S. production to reverse our Nation's growing dependence on imported energy.

The ultra-deepwater Gulf of Mexico (GOM) holds enormous potential to help meet the Nation's growing demand for energy.

The U.S., while an importer of oil, can remain dominant in the global petroleum industry through our collective technologies. The simple fact is that the petroleum industry is one of the key linchpins that drives the U.S. and global economy. Energy is essential to economic growth and critical to world peace and political stability. To understand the criticality of the petroleum industry to the U.S. economy, one must first understand the scale and impact of this industry. It is easy to overlook this fact because the energy industry has become very efficient at delivering product to the market. Only when supply is disrupted does our society take notice of the petroleum business that they take for granted. The accompanying Exhibit 1 illustrates the size of the natural gas and oil use relative to the other energy resources.

Exhibit 1. Our Economy Runs on Fossil Fuels



Reference: Energy Information Administration, Annual Energy Outlook, 2000.

It is also important to understand how our Nation's economy uses energy and where it comes from. Over 80 percent of the energy consumed during the course of any day in the U.S. comes from fossil fuels, and almost 85 percent of that fuel is oil and natural gas.

There are several other important points to be made about the dependence of our Nation's economy on oil and natural gas:

1. In 1998, the U.S. was using over 59 quadrillion British Thermal Units of natural gas- and oil-derived energy annually with about 37 percent from natural gas and 63 percent from oil.

2. The volume of energy that is supplied to the U.S. economy in the form of hydrocarbons cannot be replaced in the near future by any of the alternative fuels that have been developed.

3. Of the oil fraction, about 59 percent is imported and only 41 percent is domestically produced, a fact that leaves the Nation exposed to interruptions in supply and price shocks.

4. Most of the products that we take for granted, such as plastics and synthetic fibers are made from feedstocks of oil and natural gas.

THE CHALLENGE

Water depths of greater than 1,300 feet are classified by the Minerals Management Service (MMS) as "deepwater." Water depths of greater than 5,000 feet are classified as "ultra-deepwater." Deepwater production requires specialized technology. Ultra-deepwater requires even more sophisticated breakthrough technologies in order to achieve economically sustainable production. These greater water depths create unique production

. . . greater water depths create unique production challenges.

Glomar Explorer (photo courtesy of Global Marine, Inc.)

challenges compared to conventional offshore methods. Some of the challenges relate to technical and mechanical limitations, while others are associated with the high cost of current technology, and the pristine, yet hostile environment of the ultra-deepwater.

Scientific research and development (R&D) of new technologies that will lower the cost of bringing these new energy supplies to the consumer, while protecting the environment, are needed. Energy supply projections are based in part on the industry's investment in the development and advancement of key essential technologies. The cost to design and implement an ultra-deepwater technology demonstration program is on the order of hundreds of millions of dollars. Therefore, assuring timely development of the Nation's ultra-deepwater resources requires a deliberate, coordinated, and well-financed effort on the part of industry, government, and academia to address the key technological gaps that present a barrier to this development. This effort of proper stewardship of the Nation's energy and financial resources can enhance the Nation's energy security.

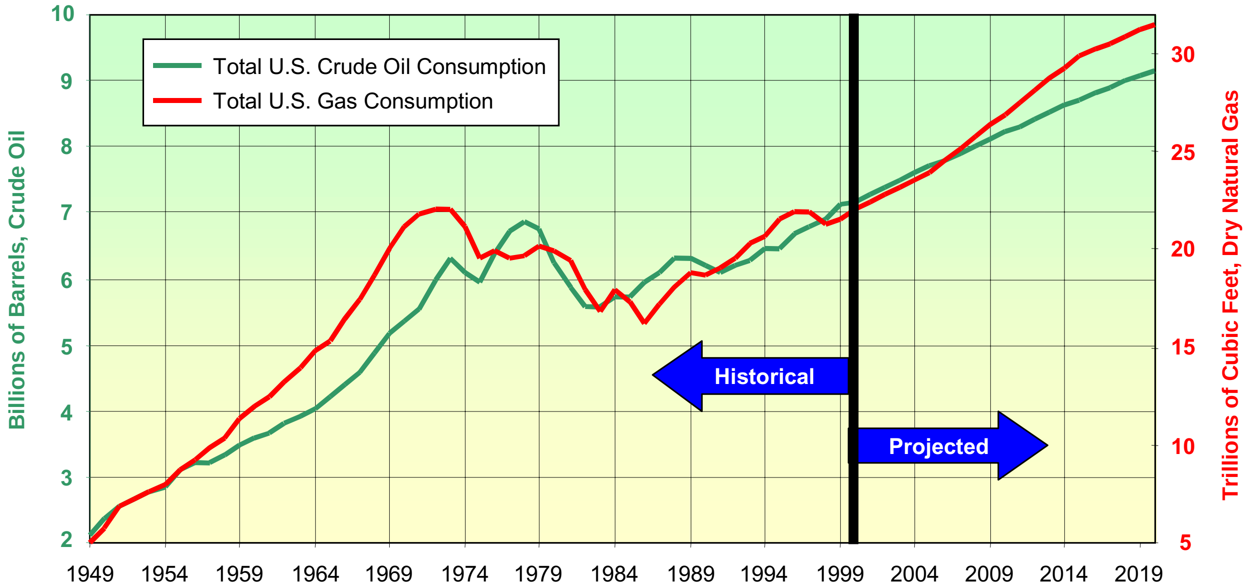
The Situation

Growing Demand: In the first half of the year 2000, the Nation's consumers faced a very tight gasoline market. Domestic crude oil and gasoline inventories were at historically low levels. The demand for natural gas was also at significantly high levels, resulting in natural gas future prices of about $5 per thousand cubic feet (Mcf). As cited in the National Petroleum Council's Natural Gas study (*Meeting the Challenges of the Nation's Growing Natural Gas Demand, December 1999*), domestic gas demand is projected to grow to 29 trillion cubic feet in 2010 and could rise beyond 31 trillion cubic feet in 2015 (see Exhibit 2), and this additional load presents many challenges to suppliers of natural gas. The study further states that this demand will be met by U.S. production, along with increasing volumes from Canada and some liquefied natural gas imports. Of note is the Council's belief that "...an unprecedented and cooperative effort among industry, government, and other stakeholders will be required to develop production from new and existing fields..." Technology and financial requirements are among the top three factors cited by the Council as critical to addressing the anticipated demand from natural gas. This OSTR is the first step in addressing this need in the ultra-deepwater Gulf of Mexico.

Price Volatility: Low oil prices two years ago (see Exhibit 3) created disincentives in the petroleum industry for exploration

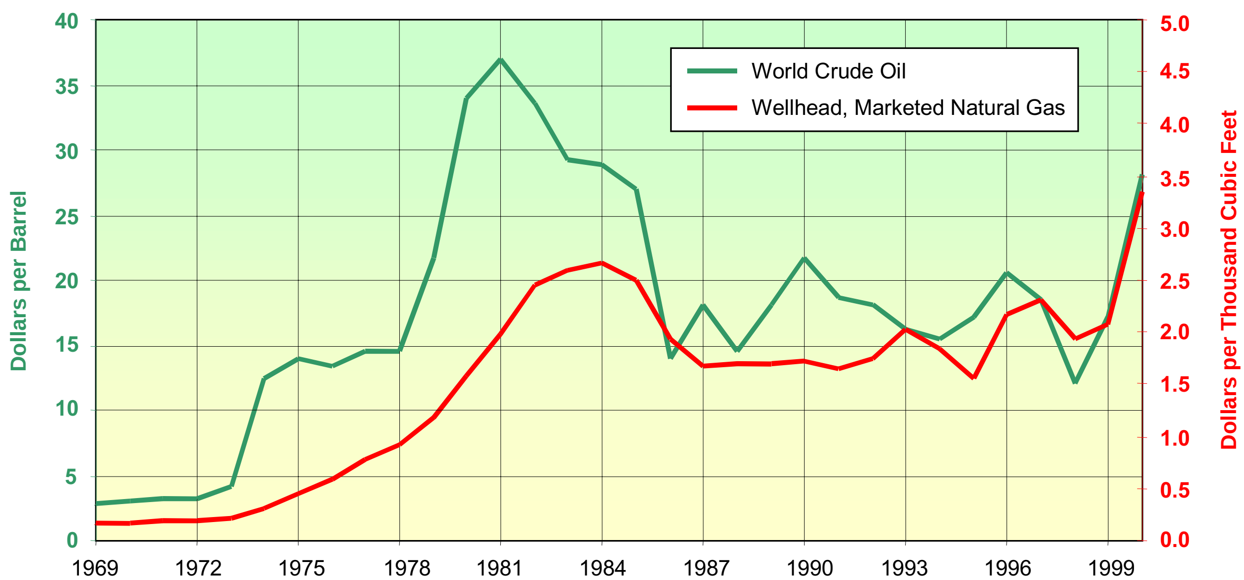
"...an unprecedented and cooperative effort among industry, government, and other stakeholders will be required to develop production from new and existing fields..."

Exhibit 2. U.S. Oil and Gas Consumption (1949–2020)



Source: Energy Information Administration

Exhibit 3. U.S. Oil and Gas Prices

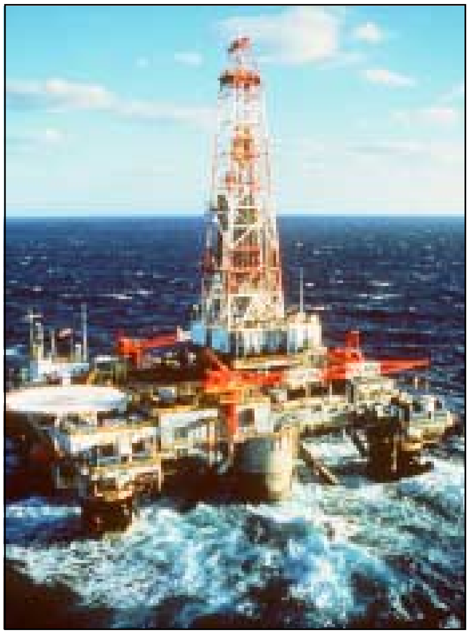


Source: Energy Information Administration

An initiative supported by industry, investors, regulators, and consumers, and has the goal to accelerate development of technologies targeted to increase U.S. ultra-deepwater reserves development is, therefore, in the interest of national security and national economic growth.

and production (E&P) spending. Oil service industry revenues have been impacted severely by reduced and/or deferred E&P projects. The only area that has withstood the pressure of extreme price volatility is the deepwater and ultra-deepwater Gulf of Mexico. This is because most projects in these regions are in early stages of exploration and development and near-term oil prices have little impact on return on investments. In addition, the reserves have been typically large enough to justify development, even when oil prices are lower; and production can be prolific enough to yield fast payback with the help of advanced technologies.

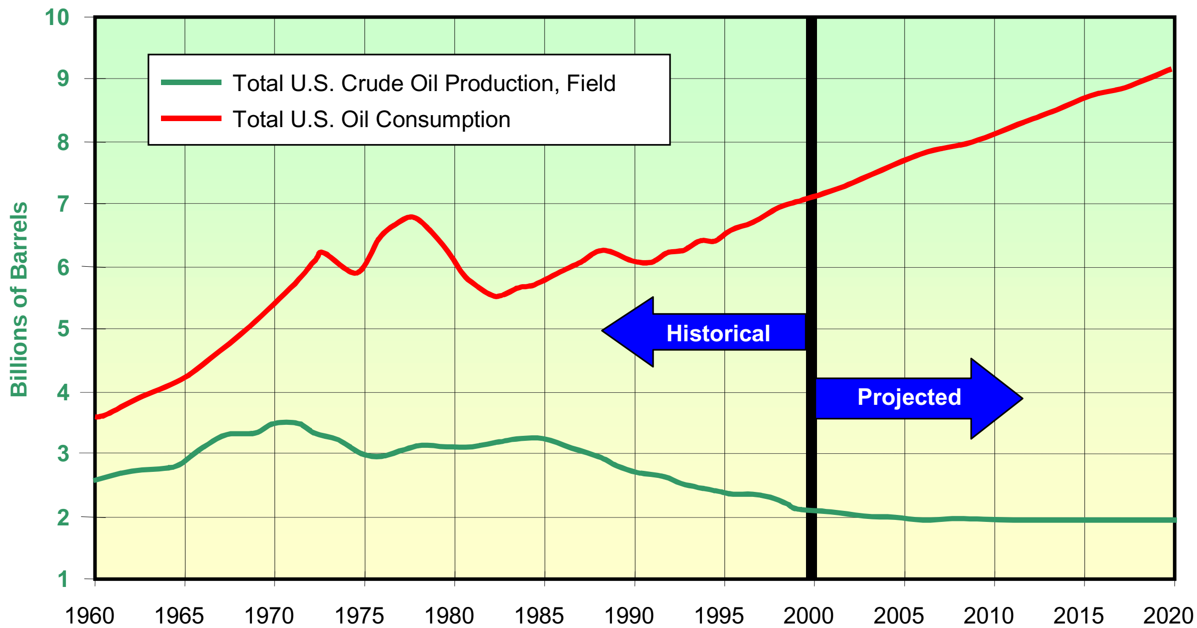
Extreme market volatility can negatively impact several sectors of the economy — both energy consumers and producers. Even as crude oil prices have rebounded, financial markets have remained cautious, money continues to be tight, and reinvestment in the domestic oil industry has not fully materialized. On the other hand, extreme market pressure for natural gas supply has driven the rig count to over 1,000, 80 percent of which is for the drilling of natural gas wells. At present, producing companies are pursuing several options for future investments including deepwater development and overseas partnerships with national oil companies. If the U.S. is to improve its energy supply balance, it is essential that investments be directed toward development of domestic resources, as well as other non-U.S. supply sources. To achieve this goal requires that industry and government work together to remove critical barriers to deepwater investment in the U.S. Accelerated development of deepwater and ultra-deepwater reservoirs has the potential to stabilize energy supplies and reduce U.S. dependence on imported sources. An initiative supported by industry, investors, regulators, and consumers, and has the goal to accelerate development of technologies targeted to increase U.S. ultra-deepwater reserves development is, therefore, in the interest of national security and national economic growth.



THE BACKGROUND

The Energy Information Administration reports that domestic crude oil production declined over the 1986 to 1996 decade from a level of 3.2 billion barrels in 1986 to 2.3 billion barrels in 1998 (See Exhibit 4). Domestic demand continued to rise, however, from 5.9 billion barrels in 1986 to 6.9 billion barrels in 1998. The difference was satisfied by increased imports, which have exceeded domestic production since 1994. Regionally, while relative levels of production from the lower 48 States and Alaska remained about the same, total production fell 26 percent in the Lower 48, and 21 percent in Alaska over the 1985-1996 period. Onshore production fell 30 percent over the period and its share of total production fell by 6 percent while offshore production increased by almost 8 percent. The above statistics in part reflect continuing depletion of the Nation's crude oil resource endowment, but other factors have influenced this trend. The size of new field discoveries is economically important because lifting costs per unit of production fall in response to increasing field size. In general, the largest fields in a new exploration area are among the first to be discovered. Therefore, since the onshore lower 48 States comprise the most intensively explored area on Earth, the remaining undiscovered oil resources occur in mostly small-to medium-sized fields—or in relatively unexplored areas such as the ultra-deepwater Gulf of Mexico.

Exhibit 4. U.S. Crude Oil Production and Consumption (1960–2020)



Source: Energy Information Administration

Deepwater GOM field discovery sizes have been several times larger than the average shallow-water field discoveries.

In its April 2000 report, *Deepwater Gulf of Mexico: America's Emerging Frontier*, the Minerals Management Services states that *The deepwater Gulf of Mexico (GOM) has recently emerged as an important oil and gas province and an integral part of the Nation's oil and gas supply. A major milestone occurred in late 1999 when more oil was produced from the deepwater GOM than from the shallow-water GOM. This trend in increasing deepwater production is expected to continue, along with high levels of exploratory drilling, development activity, pipeline construction, and shore support activities. Deepwater GOM field discovery sizes have been several times larger than the average shallow-water field discoveries. The deepwater fields have also been some of the most highly prolific producers in the GOM.*

In 1999, total GOM oil production reached an estimated 494 million barrels after producing about 300 million barrels per year for much of the decade. The increase has come from the deepwater and was highlighted in late 1999, when oil production from the deepwater portion of the GOM exceeded that of the shallow water for the first time in history. This historic change after 53 years of GOM production has been driven by several major factors that all coalesced in the later 90s. High flow rate wells have driven the economics of projects and have acted as a strong incentive to explore and develop deepwater leases. The use of subsea well completions has also contributed to the economics of deepwater projects.

Deepwater operations are very expensive and often require significant amounts of time between initial exploration and first production. A further constraint is the availability of drilling rigs capable of drilling deepwater wells. These factors are critical to the economic success of deepwater development. There has been a steady increase in deepwater rig activity during this time, and the number of rigs drilling in the deepwater GOM is expected to continue increasing slightly through 2001. However, according to MMS, even with the increased number of deepwater rigs, only a small fraction of the 3,670 active deepwater leases can be drilled before they expire.

Significant increases in drilling capacity are required if deepwater production is to have an impact on the Nation's energy supply in the near future. Exacerbating the tightness of drilling capacity is the competition for drill-rig resources from other deepwater areas including Brazil, West Africa and the Atlantic Margin provinces. As other deepwater areas start to be explored, this competition will become even more acute.

THE HISTORY

Deepwater oil production rose about 550 percent and deepwater gas production increased almost 800 percent from December 1992 to December 1999.

As indicated in Exhibit 5, leasing activity in the deepwater GOM increased steadily in the early 90s and exploded in 1996 because of, in part, the economic incentives introduced in the Deepwater Royalty Relief Act. The boom in deepwater leasing was also enhanced by the evolution of deepwater technology, several large deepwater discoveries, and excellent production rates coming from deepwater fields.

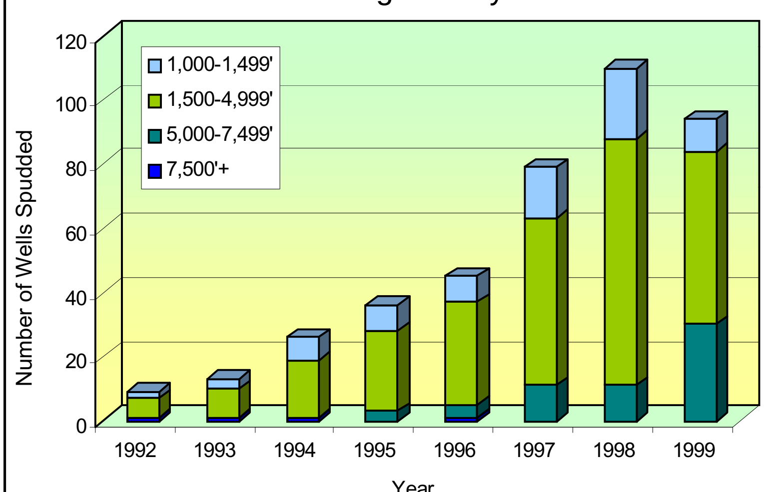
According to data from the Minerals Management Service, at the end of 1999, there were 30 producing fields in the deepwater Gulf of Mexico, up 30 percent in just 12 months and up 88 percent since 1997.

There are approximately 7,600 active leases in the Gulf of Mexico Outer Continental Shelf (OCS), 48 percent of which are in deepwater. Contrast this to approximately 5,600 active Gulf of Mexico leases in 1992, only 27 percent of which were in deepwater. On average, there were 27 rigs drilling in deepwater in 1999, up from only 3 rigs in 1992. Exhibit 6 shows the oil and gas production from offshore GOM. Deepwater oil production rose about 550 percent and deepwater gas production increased almost 800 percent from December 1992 to December 1999.

In 1998, deepwater oil production rose 47 percent over 1997 production, and in 1999 deepwater oil production increased an additional 41 percent over 1998 production. Similarly, deepwater gas production increased 47 percent in 1998, followed by a 51 percent jump in 1999. Although U.S. oil production declined about 410,000 barrels a day from 1994 to 1998, according to MMS, the decline would have been nearly twice as large if the deepwater GOM production had not increased by 321,000 barrels a day.

All phases of exploration and development moved steadily into deeper waters over the past eight years. This trend was observed by MMS in seismic activity, leasing, exploratory drilling, field

Exhibit 5. U.S. Gulf of Mexico Exploratory Drilling History



Source: Minerals Management Service, April 2000.

The number of wells spudded in the U.S. Gulf of Mexico has increased substantially over the last seven years. The most significant growth of late has occurred in water depths of greater than 5,000 feet.

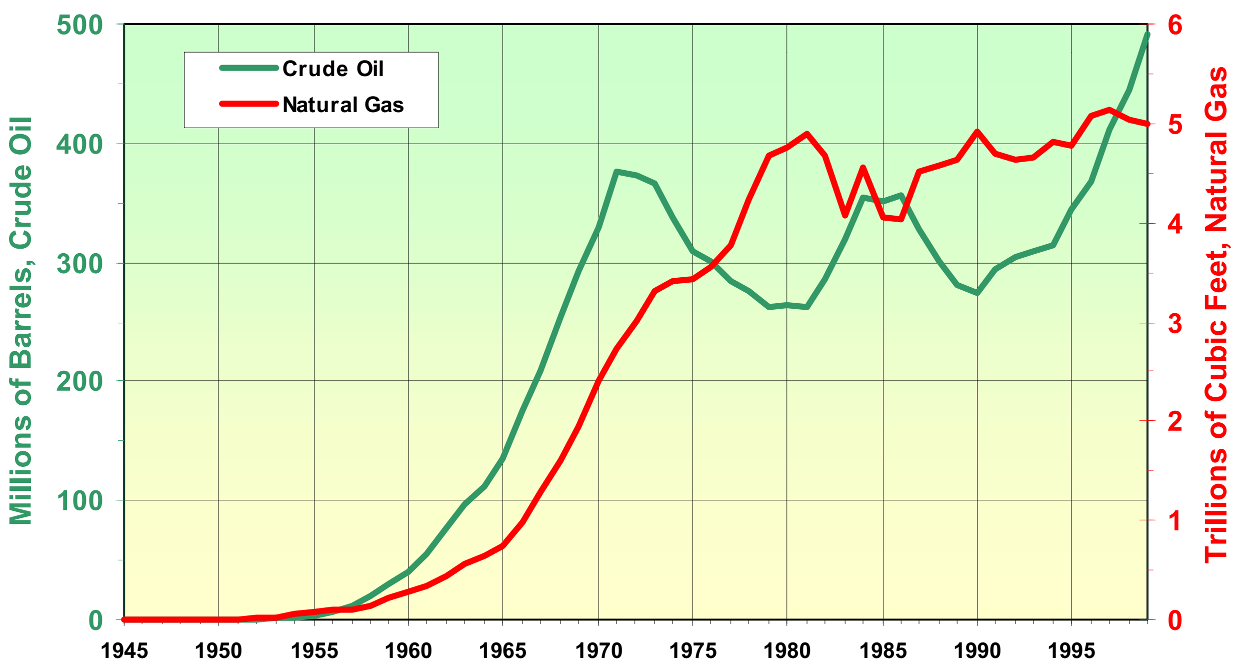
. . . a unique opportunity – the deliberate, focused, cooperative effort of industry and the government to develop the needed technology that will reduce the costs of developing the abundant supply of oil and natural gas from the deepwater GOM.

discoveries, and production. Major oil companies dominated deepwater leasing activity until 1996, when large independents joined the trend. Major oil companies continue to dominate deepwater oil and gas production, but MMS expects production from independents to surge in a few years, when anticipated discoveries on their 1996 through 1999 lease acquisitions begin production.

THE OPPORTUNITY

The recent unprecedented economic growth experienced by our Nation, fueled by ready supply and availability of energy sets the stage for a unique opportunity— the deliberate, focused cooperative effort of the industry and the government to develop the needed technology that will reduce the costs of developing the abundant supply of oil and natural gas from the deepwater GOM. This OSTR has been the first step in this process by bringing together all the stakeholders in a systematic fashion to identify the technology and other barriers to full development of the ultra-deepwater GOM, and to identify the order of magnitude cost needed in this collaboration.

Exhibit 6. U.S. Oil and Gas Production Offshore Gulf of Mexico



Source: Minerals Management Service

The true full cost of adding incremental production capacity for the Nation or world is the "activation index" or the total investment required to establish access to new oil expressed in dollars per barrel per day of stabilized production. To accelerate production from the ultra-deepwater GOM, the activation index needs to be reduced through technology innovation and other means.

The production of natural gas and oil is also limited in part by the capital available to develop new fields. Production is also limited by the annual decline in existing field production. The opportunity exists to attract more capital to the ultra-deepwater Gulf of Mexico through the use of advanced technology to reduce the "activation index", and through incentives for production. The Nation must invest in the development of better technology that can increase our domestic and, concurrently, global production capacity of natural gas and oil. We need to invest in tomorrow's technology today to bring stability to domestic markets. However, industry funding being committed to research and development of needed technology has deceased. The opportunity exists to change this trend through collaboration.

Research and development partnerships have become increasingly important in recent years. For example, collaborative research and joint industry projects have resulted in the transfer of advanced technologies developed in the U.S. national laboratories to the petroleum industry. Such collaborations have leveraged the resources of industry and government to offset the decrease in R&D funds being committed by the private sector.

The Process

The U.S. Department of Energy facilitated a series of workshops to develop a roadmap to identify producer needs, technology capabilities, investor considerations, possible environmental and safety challenges, government roles, and opportunities for collaboration in the ultra-deepwater GOM. The kickoff meeting was held at the Petroleum Club, Houston, Texas, on July 19, 2000. Exhibit 7 shows the workshops schedule.

Workshop participants included representatives from the producer community, technology suppliers/ service companies, national

Workshop participants included representatives from the producer community, technology suppliers/service companies, national laboratories, federal and state governments, and non-governmental organizations.

laboratories, federal and state governments, and non-governmental organizations (NGOs). This multi-disciplinary approach was used to identify and propose solutions to the challenges associated with deepwater resources development. The kickoff meeting was followed by regional forums focusing on producers, technology entities, investors, NGOs, and federal and state agencies. These interactive, facilitated forums were instrumental in identifying a "roadmap" for addressing major technology needs, environmental and safety challenges, potential government/industry roles, and opportunities for collaboration and investment. The process was inclusive and well attended by all of the stakeholder sectors. Each workshop was focused on addressing a specific question and a set of goals.

Investors Workshop

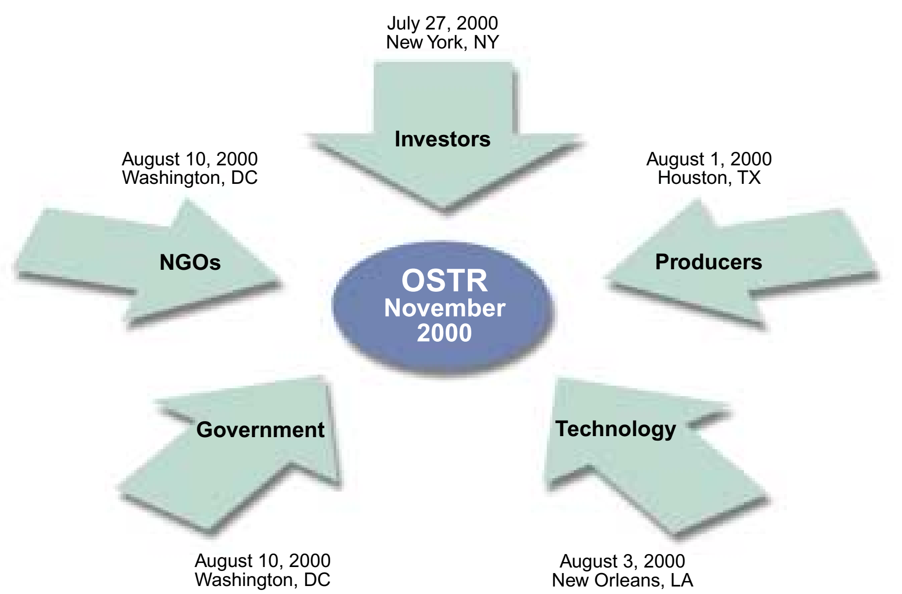
July 27, 2000, The Stock Exchange Club, New York, New York
Facilitated by: Art Schroeder, Energy Valley

Focus: What are the barriers to the investment needed to accelerate technological solutions for ultra-deepwater?

Goals:

- Identify the key factors that producers and technologists must address in order to attract

Exhibit 7. OSTR Workshops



investment for deepwater R&D technology development projects.

- Identify potential strategies or options that could result in greater availability of capital for investment in the development of technology.

- Identify key barriers to attracting investment capital to the energy sector, specifically deepwater technology R&D projects (i.e., financial risk, technical risk, payback time).

Producers Workshop

August 1, 2000, St. Regis Hotel, Houston, Texas
Facilitated by: Ron Oligney, University of Houston.

Focus: What are the technological barriers to the economic and sustainable production of the ultra-deepwater?

Goals:

- Identify technology vision from the perspective of the "major" producing company, large independent, mid-sized independent, and small independent producers.

- Identify the type of partnering relationships possible between the government and its stakeholders.

- Identify key areas of interest for cooperation. Identify successful models of cooperation.

Technology Workshop

August 3, 2000, Wyndham New Orleans at Canal Place, New Orleans, Louisiana
Facilitated by: John Vasselli, Houston Advanced Research Center.

Focus: What are the barriers to developing and implementing technological solutions for the ultra-deepwater?

Goals:

- Identify technology milestones for Fiscal Year (FY) 2001 - 2006 that respond to the priorities identified by the producer community.

- Identify key technology areas requiring the greatest amount of cooperation between stakeholders.

- Identify high cost areas requiring the greatest amount of investment capital.

NGOs Workshop

August 10, 2000, U.S. Department of Energy, Washington, DC
Facilitated by: Mary Jane Wilson, WZI, Inc.

Focus: What are the barriers to developing and implementing technological solutions for the ultra-deepwater?

“ . . . evolutionary elements of technology development must be tied together in a way that brings a revolutionary result.”

Goals:

- Identify highest priorities and concerns of the NGO community related to the technology associated with deepwater Gulf of Mexico development.
- Identify degree to which the NGO community will cooperate with the technology community in the development of deepwater technology.
- Identify options and strategies for continuing an open dialogue between the NGO community and deepwater Gulf of Mexico developers.

Government Workshop

August 10, 2000, U.S. Department of Energy, Washington, DC
Facilitated by: Emil Peña, Deputy Assistant Secretary, U.S. Department of Energy; Walter Rosenbusch, Director, Minerals Management Service.

It is the integration of individual components of technology into a coherent and well-executed development process that will improve the efficiency of deepwater development.

Focus: What can the federal government do to eliminate barriers and foster the development of technologies in and out of government using our collective strength to be a worldwide leader for sustainable energy development from the ultra-deepwater?

Goals:

- Identify areas of shared mission and appropriate roles.
- Identify key opportunities for cooperation.
- Identify existing and needed mechanisms for maintaining a long-term dialogue on this topic.
- Identify shared measures of success.

The Requirements

Appendix A provides a summary, highlights of comments and inputs provided at the kickoff meeting and the regional workshops. A list of workshop attendees is provided in Appendix B.

During the roadmapping process, stakeholders stated that “evolutionary elements of technology development must be tied together in a way that brings a revolutionary result.” A critical point is that no single technology was identified as holding revolutionary potential. It is the integration of individual components of technology into a coherent and well-executed development process that will improve the efficiency of deepwater development to make it competitive with other provinces. It will take major technology advances on multiple fronts in exploration, production, drilling, flow assurance and infrastructure to achieve the revolutionary results required to make deepwater a key component of the national energy supply.

Six major technology themes emerged from the workshops and these reflect the perspectives of the participants. These themes were: Evolutionary and Revolutionary Technologies, New Systems Architecture, First-Time Technology Demonstration, Infrastructure Improvements, Regulatory Innovations, and Improved Communication and Education.

Evolutionary and Revolutionary Technologies: Discrete technology solutions are capable of creating "evolutionary" improvements in energy exploration, development, and production from ultra-deepwater to address the challenge of significantly reducing the activation index of the ultra-deepwater. The environmental challenge of reducing discharge of potentially harmful fluids to near zero (zero emissions/effluents goal) will require "revolutionary" technology solutions. Therefore, the desire to promote a combination of both evolutionary "enhancing" technologies and revolutionary "enabling" technologies should be basic elements of the roadmap structure. Enhancing technologies are those technologies, methods, and processes that have direct impact on specific problems in deepwater exploration, appraisal, and development. These are usually hard technical improvements such as a new logging tool, or a new drilling technique. Enabling technologies, methods, and processes include business performance technologies, communications technology, information technology, human resource management, risk management, and training technologies. These enabling capabilities are not direct technical contributors to success, but help define the infrastructure that supports success in any business venture. As such, they are essential to the success of the deepwater enterprise.

New Systems Architecture: While "technology solutions" typically imply discrete element or subsystem hardware improvements, there is a general consensus that systems level "process improvements" associated with integrated design, real-time management of activities and functions, can have an equal or greater impact on reducing the activation index. Therefore, emphasis on systems engineering

Ultra-deepwater GOM development involves:

- **Evolutionary and Revolutionary Technologies**
- **New Systems Architecture**
- **First Time Technology Demonstration**

Additional aspects include:

- **Infrastructure Improvements**
- **Regulatory Innovations**
- **Communication and Education**

. . . government efforts can serve as a catalyst and facilitator for first-time operational demonstration of enhancing and enabling technologies.

and innovative design processes, which improve the management of uncertainties associated with all phases of energy exploration, appraisal, development, and production, should also be an element of the roadmap structure.

First-Time Technology Demonstration: A clear message delivered by all workshop participants was that the additional risks imposed by the operational first-time use of a technology is a major barrier to accelerating deepwater technology application. Therefore, the roadmap should include ways in which government efforts can serve as a catalyst and facilitator for first-time operational demonstration of enhancing and enabling technologies. By eliminating the enormous risk associated with the first-time application of a new technology, which some workshop participants referred to as the "bleeding edge" of technology, government and other stakeholders would address one of the greatest barriers to the introduction of new technology in deepwater.

. . . that first time use and demonstration of new technologies is a barrier to new technology introduction.

Companies are hesitant to be the first users of new technology in this very risky environment. This is a two-fold problem. First, new technology must be tested more thoroughly than existing technology, which causes a burden on technology developers and first-time users. Second, once the technology is successfully demonstrated, this one data point or "success story" is still viewed as a small success and not yet able to offset the enormous risk associated with the "bleeding edge."

In the past, major companies were willing and able to undertake the risk because of large holdings. Today, producers, with the billion-dollar ultra-deepwater projects in the balance, are not able to assume the additional risk associated with the development and application of new technology not yet proven in this arena. They look to service companies to fill in the R&D gap that was created in the 90s when low oil prices reduced R&D funding. Therefore, new technologies are often not funded or provided with sufficient resources to prove up new technology. No single company can shoulder this burden, and the R&D paradigm has shifted from a time when R&D investment was used to increase a company's competitive advantage to a time when R&D investment brings these same competitors together in joint industry projects. However, this is an option available only to larger firms. Many smaller companies are in a position where they are technologically disadvantaged because of lack of R&D funds especially during times of extreme market volatility.

In addition to the key technology themes listed above, several important aspects associated with the development of the deepwater GOM were discussed at length and deserve mention here as well as recognition in the roadmap process. While these themes are not directly related to technology solution they do represent critical issues and opportunities that are key dimensions of the overall strategy for developing energy resources in the GOM. These themes are:

Infrastructure Improvements: While much of the emphasis was placed on exploration, appraisal, development, and production technologies, there was a clear expression of concerns by workshop participants that not all critical issues were "high-tech" in nature. For new energy to get to the market, the energy and the people who produce that energy must get to shore safely and efficiently. A wide range of challenges, from roads, power, and emergency response to telecommunications, land-based storage and transport, must all be in place to handle the anticipated increase in ultra-deepwater production. While the emphasis of this Roadmap development is on technology, these infrastructure issues must not be neglected.

Regulatory Innovations: A theme that surfaced repeatedly during the workshops was the belief by industry that government policy can affect investment. They believed that one of the best ways to increase investment and accelerate technology innovation in the ultra-deepwater GOM is through regulatory innovation by government toward a position that promotes greater investment. Industry participants believed that government policy innovation could increase the region's economic competitiveness and have a significant positive impact upon the ability of the ultra-deepwater GOM region to attract the needed investment as compared to that of regions outside the U.S. This fact should be acknowledged and an internal government dialogue established to consider the full range of ways that the federal government could best serve to be a catalyst and facilitator for deepwater development. The growing coordination between the Department of Energy and the Minerals Management Service is an example of this important dialogue. It is essential that government provide incentives for

large independents, smaller operators, and service companies who do not have technology development budgets, to engage in this roadmapping process and commit funding and resources to ultra-deepwater. These incentives should be designed to expand the technology development base of the ultra-deepwater industry so that all stakeholders in the process will participate in the program.

Communication and Education*:* Apart from the specific initiatives and technology recommendations, the participants felt strongly that the open forum dialogue between the varied stakeholders at the workshops was beneficial and innovative in its own right. Strong interest exists to continue such discussions between and within industry, government, academia and non-government organizations. Perhaps of even greater importance is the need to educate the public regarding the strategic importance of domestic energy production to national security. Such education can have broad impact, ranging from encouraging a larger number of students to enter into an energy-related career, to promoting national awareness regarding the cost-benefit-risk tradeoffs associated with the U.S. domestic energy strategy. Within this strategy, the critical role that ultra-deepwater GOM energy production will play in the future economic security of the U.S. must be effectively communicated. Both the energy industry and government must be more proactive in educating the public as to the critical importance and value of the energy industry to the U.S.

One significant and potentially devastating risk to the success of deepwater GOM development is a critical shortage of expertise in several critical skills sets. The petroleum industry is an aging industry with a declining demographic profile. Over the next 10 years, nearly half of the technology and business leaders in ultra-deepwater will retire. At present, the industry is not able to attract top technical specialists due to the competition from other, more lucrative and stable industries. It is essential that industry work closely with government and academic institutions to create opportunities for the brightest and best young minds to enter petroleum disciplines. If current trends in enrollments in key geoscience and engineering disciplines are not reversed in the next few years, the industry will not have the skills needed to execute the number of ultra-deepwater developments needed to make the GOM a contributing element of the Nation’s energy security.

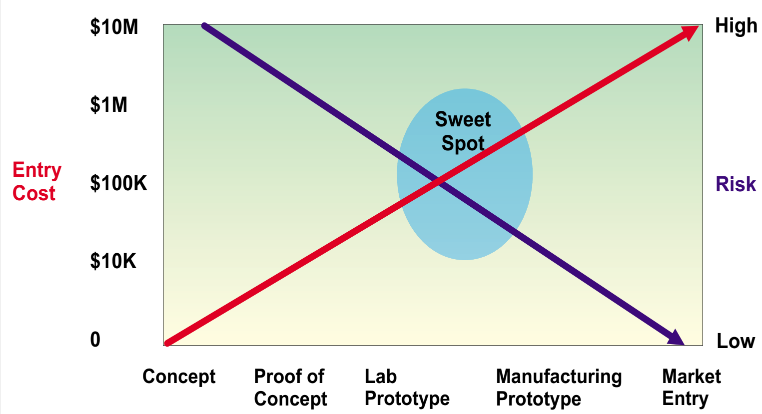
This situation is further exacerbated by the fact that the investment community has not seen sufficient financial returns in the oil and gas industry commensurate with the risks of new technology development. Private investment will remain limited until technologies have a reduced risk profile and more defined market acceptance. From a "risk mix" point of view, investors are interested in technologies that have very near-term applications and that can be licensed to other industries for quicker cash flow and reinvestment. Exhibits 8 and 9 "Preferred Entry Target" and "Preferred Mix of Risk," show the "sweet spots" where investors would be interested in funding technology commercialization. There seems to be a general consensus, particularly by non-industry investors, that outside these "sweet spots," it would be very difficult to attract capital. In particular, the entry cost diagram reveals that investments ranging from $10,000 to about $5 million are in the sweet spot. The cost to design and implement an ultra-deepwater technology demonstration program is on the order of hundreds of millions of dollars. This high cost prevents many deepwater operators from making the necessary investments in new technology that is essential to success. These large investments will require a collaborative approach involving operators, service companies, government, and academia.

However, recent positive developments indicate that the industry could be in the phase of the cycle where selected technology investments might provide a return attractive enough to warrant pursuit. Specifically: (1) energy prices have risen to a level that appear to have enough stability to provide a return; (2) stock prices have risen to the level where it is no longer attractive to "drill on the street" and producers will need to physically drill to replace reserves; (3) many producers and service companies have either severely reduced or eliminated their R&D departments or have shifted focus to rapid adoption and application of technology; and (4) technology was viewed by some as a differentiator that could provide superior returns.

Private investment will remain limited until technologies have a reduced risk profile and defined market acceptance.

Outside the "sweet spot," it is difficult to attract investor capital.

Exhibit 8. Preferred Entry Target



Source: Energy Valley, July 2000.

A technology progresses through a series of stages or phases on its way from concept to commercialization. With passage through each successive phase, the risk associated with the technology is reduced considerably. Conversely, the cost to acquire the technology rises significantly. The risk factor and cost factor scales on the above graph are logarithmic, and astute investors consider the intersection of these two factors to be the optimum relationship between risk and cost thereby referred to as the "sweet spot."

. . . 50 to 80 percent of the potential reduction in the "activation index" lies in the business process of integrating technologies together rather than applying individual technologies themselves.

The Strategy

The clear and deliberate consensus of producers, service companies and deepwater technologists is that 50 to 80 percent of the potential reduction in the activation index lies in the business process of integrating technologies together rather than applying individual technologies themselves. The processes that challenge deepwater offshore development can be met through the collaborative efforts described in this roadmap. The keys to affecting the process are:

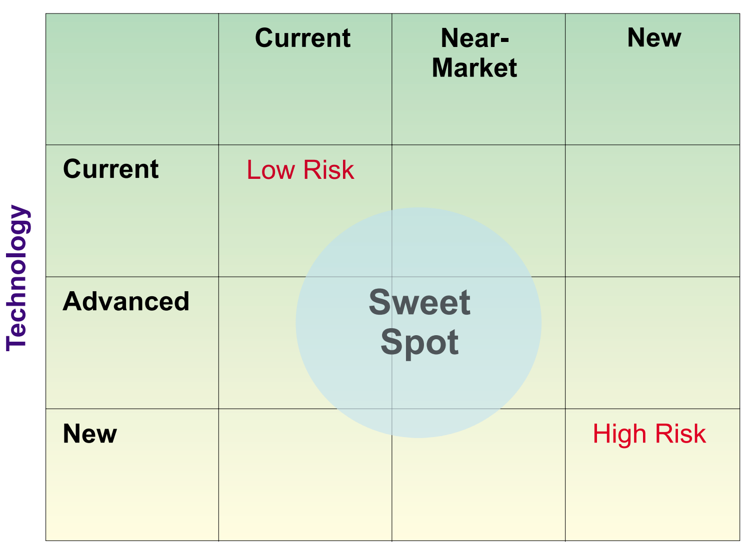
- Facilitating the development of enhancing technologies that will individually contribute to the success of deepwater by addressing key technical gaps.

- Creating a new and robust deepwater systems design model similar to the high-intensity design concepts used in other industries that incorporate individual enhancing technologies into an integrated whole. This synergism between components would result in greater cost-benefit to producers and ultimately to energy consumers.

- Facilitating the development of enabling technologies that will be essential to the success of deepwater development, including business processes, communication, education, technical training, risk management, and regulatory innovation.

The goal of the new system design model would be to assure that no single node or component failure will be able to cause the whole system to fail. The model will provide a mechanism for incorporating environmental research and protection. The model itself, like the Internet, becomes the rallying point that will invigorate ongoing efforts ranging from DeepStar, to the Natural Gas and Oil Technology Partnership, to Global

Exhibit 9. Preferred Mix of Risk



Reference: Energy Valley, July 2000.

Investors like to be on the leading edge of high growth markets using advanced, but proven technology. If they target markets that are too immature or distant, sales trickle and the Earnings Before Income Taxes, are addressed with technology that is too new, then customer acceptance can be slow and/or costs can be unpredictably high. This is sometimes referred to as being on the "bleeding edge."

Petroleum Research Institute (GPRI), to individual company technology centers, independent research entities such as Houston Advanced Research Center (HARC), and the consuming public. The participants suggested that the incentives necessary to accelerate use of advanced technology could come in various forms such as targeted royalty relief, R&D tax credits, and matching research dollars.

The roadmapping workshop participants concluded that the OSTR initiative should focus on:

- Support for development of new enhancing technologies that will address the technology gaps for deepwater development;
- Support for first time demonstration of new enhancing technologies;
- Support for enabling technologies that will assure a stable infrastructure for the implementation of the deepwater systems design model; and
- Support for the development of a deepwater systems design model that will integrate all of the enhancing technologies into a high-intensity-design system that is facilitated by the enabling technologies.

Whether the new systems design model produces "riserless drilling" or "seafloor drilling" or other advanced technologies, inherent in the design must be that it: (1) reduces the "activation index" sufficiently such that ultra-deepwater competes favorably with foreign sources of hydrocarbons; (2) addresses the ultra-deepwater rig availability that would result from a massive swing in activities to the ultra-deepwater; and (3) improves environmental performance and protection toward the goal of zero emissions and/or effluents.

> **. . . goal could be achieved through a combination of options and/or incentives that will cause private enterprise and market forces to support needed activities.**

THE ROADMAP

The goal of the Offshore Technology Roadmap is achieving significant accelerated growth in production from the GOM in order to enhance national energy security, and stabilize supplies of needed energy. This goal could be achieved through a combination of

options and/or incentives that will cause private enterprise and market forces to support the needed activities. These incentives will provide the boost needed to overcome the "bleeding edge," – the risk associated with first-time use of technology. As conveyed by the stakeholders participating in the roadmapping workshops, these incentives will need to support two tracks. One track could be tax or royalty incentives to producers to accelerate deepwater and ultra-deepwater production above and beyond a forecast baseline that is derived from a scenario without incentives. This baseline will need to be sufficiently challenging to encourage the use of new technologies in order to achieve maximum benefit from the incentive. The other track could support technology and system integration development and deployment such that new technologies are less risky and reasonably proven (successful first demonstration in an offshore environment) prior to full commercial use in ultra-deepwater projects.

The financial incentives track includes concepts that need further study. Examples include:

The goal of this roadmap initiative is to provide opportunities for new and better ideas to continually develop, rather than prescribe a specific path for technology investments.

- New tax incentives to foster cost-sharing on each project from a wide range of companies, especially those which, traditionally, have not been able to afford expenditures on technology development.

- Tax credits against ultra-deepwater production revenue so that costs can be recovered as new production is brought on line. This will not only inspire operators to invest in technology development, but it will encourage them to bring reserves on line rapidly in order to take advantage of the tax credit.

- Credits applicable only to fields in the U.S. ultra-deepwater that are brought on line after a given project is funded. This will encourage new field development at a greater rate.

- Tax incentives that will offset the investment risk faced by service companies and other technology developers.

The technology development track focuses on system integration. Implicit in defining a new system design model is an appreciation of the technology and subsystem components to be incorporated in the model. Table 1A identifies the systems and integration that need to take place in order to achieve an order of magnitude change in the rate of production growth in the ultra-deepwater U.S. GOM. These systems are shown with a sample time line for achieving development in a six-year horizon.

The goal of this roadmap initiative is to provide opportunities for new and better ideas to continually develop, rather than prescribe a specific path for technology investments.

The new technologies required to achieve the new system architecture are listed in Table 1B. The symbols in the technology table are also shown in the systems table to cross reference the technologies with the systems in which they are used. The list of systems and technologies is quite comprehensive but not prescriptive. This is deliberate.

Brief descriptions of primary categories listed in Table 1A follow:

High Intensity Design

High Intensity Design applies computer technology and clarity of organizational goals to streamline and optimize system design in an operationally quick manner. There are numerous inter-related decisions to be evaluated in a deepwater development and it is difficult at best for a person or team to fairly weigh all the options and consequences of decisions. The thrust of this effort is to use computational capability to enable virtual system design and operation with measurement of virtual output relative to desired organizational goals. It is envisioned that the interface for this system would be defined and published openly to enable industry to mold their offerings with plug-in capability to the high intensity design engine standard. "The process" was discussed in workshops as holding the key to at least 50 percent of potential savings – the high intensity design system is the attack on this potential area of savings

New System Architecture defines the evaluation process, platform, interfaces, and method of establishing decision rules for a new reservoir development design system.

High Intensity Design Engine defines the actual computational mathematics and mechanics of how components in a system will be optimized and integrated to enable a comprehensive virtual prototype and simulation of output and performance.

Component Optimization Modules are the plug-in modules for specific subsystems such as drilling system, separation, artificial lift, facility sizing, and intervention. A specific set of modules would be targeted first with others to follow as industry desires to become compatible with the new virtual design and optimization standard.

Accelerated Reservoir Exploitation

Accelerated Reservoir Exploitation effort challenges the current methods and standards of reservoir exploitation and seeks to increase project value by reducing uncertainty, shrinking time horizons and increasing recovery percentages. Current reservoir

Table 1A: Ultra-Deepwater Offshore Technology Systems Application Roadmap

		2001	2002	2003	2004	2005	2006
High Intensity Design	**New Systems Architecture**	Definition, Evaluation, and Concept Selection ▼◆▲✪+● ❍■❏	Develop Interface Definition & System Level Decision Rules ▼◆▲✪+● ❍■❏	Publish Open Architecture Definition ▼◆▲✪+● ❍■❏			
	High Intensity Design Engine	Conceptual Flow Sheets & Fast Productivity Index ▼+❏	Software to Host System Configuration ▼+❏	Develop System Optimization Computa-tional Mathematics & Hardware ▼+❏	Comprehensive Virtual System Optimization & Visualization Prototype ▼+❏	Pilot Application for Specific Ultra-Deepwater Field Development ▼+❏	
	Component Optimization Modules	Critical Components Identification ▼	Virtual Component Module Prototype for 3 Core Subsystems ▼◆▲●❏	Virtual Component Module Prototype for 3 Additional Core Subsystems ▼✪+❍	Virtual Component Module Prototype for 3 Additional Subsystems ▼■✷	Virtual Component Module Prototype for 3 Additional Subsystems ✷▼✪	
Accelerated Reservoir Exploitation	**Reservoir Property Verification**		Low Cost Micro Drilling Self Contained Fluid/Rock Sample Retrieval System ▲●❍◆	Alternative Subsalt Remote Sensing & Imaging Technology ◆▲✷	Final Reservoir Exploitation Design ▼◆▲●✷		
	Subsea Gathering Systems	Systems Definition and Early Design ▼◆▲●❍	Low Volume System Lab & Field Trials ▼◆▲●❍	High Capacity System Design and Component Testing ▼◆▲●❍	Offshore Shelf Well Field Trials ▼◆▲●❍	Ultra-Deepwater Field Trials ▼◆▲●❍	
	Reservoir Monitoring and Control	Systems Definition and Early Design ▼◆▲	Low Volume System Lab & Field Trials Plus Seismic Fluid Movement Monitoring ▼◆▲	High Capacity System Design and Component Testing with Adjustable Learning Completion Capability ▼◆▲✪	Offshore Shelf Well Field Trials ▼◆▲	Ultra-Deepwater Field Trials ▼◆▲	
Rigs/Reach/Riserless	**Riserless Drilling Systems**	Conceptual Engineering and System Architecture ◆▲✪●❍	Critical Component Development and Testing ◆▲✪●❍	System Integration and Alpha Testing ◆▲✪●❍	Shallow Water Trials ◆▲✪●❍	Deepwater Trials ◆▲✪●❍	
	System Integration While Drilling	System Concept Development Plus Materials & Placement Research ◆▲✪●❍	System Architecture Definition & Component Design/Testing ◆▲✪●❍	System Integration and Alpha Testing ◆▲✪●❍	Field Trials ◆▲✪●❍		
	High Capacity Production Wells		System Architecture ◆▲●❍	Critical Component Design & Testing ◆▲●❍	Field Trials ◆▲●❍		
	Intervention Systems	Conceptual Engineering & System Architecture ▼◆▲●	Remote Controlled Light Duty Intervention Robot ▼◆▲●	AUV Service Vessel Intervention Delivery ▼◆▲●	Remote Controlled Micro-Drilling and Workover ▼◆▲●	Fracturing and Cementing AUVs ▼◆▲●	First Time Field Demonstrations ▼◆▲●
Energy to Market	**Subsea Processing & Flow Assurance**	Acoustic Liquefaction, Membrane Separation, & Hydrate Formation/ Transport Research ◆▲✪+■❏	Subsea Processing Architecture & Interface Definition ◆▲✪+■❏	Critical Component Design & Testing ◆▲✪+■❏	System Integration & Testing ◆▲✪+■❏	Offshore Shelf Well Field Trails ◆▲✪+■❏	Ultra-Deepwater Field Trials ◆▲✪+■❏
	Hydrocarbons to Clean Fuel, Feedstock, Products	Research Interface with Clean Fuels Roadmap +■❏❋	Conceptual Engineering & System Architecture +■❏❋	Critical Component Development and Testing +■❏❋	System Integration & Testing +■❏❋	Offshore Shelf Well Field Trails +■❏❋	Ultra-Deepwater Field Trials +■❏❋
	Offshore Power Generation/Transmission	Superconducting Electric Transmission Pipeline Research +❊❋	Superconducting Electric Transmission Pipeline Research +❊❋	Conceptual Engineering & System Architecture +❊❋	Critical Component Development and Testing +❊❋	Critical Component Development and Testing +❊❋	System Integration & Alpha Testing +❊❋
Environmental Management	**Greenhouse Gas Sequestration**	See Greenhouse Gas Sequestration Roadmap					
	Well Control with Near Zero Spill Volume	Sensor Research for Early Detection of Loss of Well Control ▲✪■	System Development for Point-of-Loss Fluid Capture ▲✪■	Detailed Design and Model Testing ▲✪■	Prototype System Testing ▲✪■	Offshore Shelf Well Field Trials ▲✪■	Ultra-Deepwater Field Trials ▲✪■

Table 1B: Ultra-Deepwater New Technology

▼	**Advanced Reservoir Decisionmaking**	deeplook direct reservoir flow variable measurement	advanced semi-analytical methods	new solvers for massive number of equations	geographical corroboration of solution	
◆	**Remote Power Supply Systems**	high capacity transmission methods	downhole fuel cells	ROV / AUV / robotics power	in-situ power generation using native (reservoir) fluids	catalysis techniques for high pressure fuel cells using native fluids
▲	**Subsea/subsurface communications**	reliable wet-connect electrical system	wireless methods	filtering and transmitting acoustic signals for optimum couping	acoustic interbranch communication	
✪	**Materials**	advanced composites	non-metallic materials	new fabrication technology	adjustable property surface coatings	
✚	**Seafloor Chemical Process Engineering**	subsurface adaptation of GTL technology	high pressure fuel cells	micro-reactors for generation of chemicals and fuels	subsea product trains	
●	**Remote Control Drilling**	micro drilling	rig mechanization, modular tool set & robotics	remote mud package	convertible drill mud	reservoir fluid sampling and analysis
❍	**Wellbore Stabilization Methods**	expandable tubulars	casing-while-drilling systems	cementing while drilling	adjustable and reversible pore throat permeability control with cementation	rock fusion
■	**Simultaneous Transport Phenomena**	low-temp solid-liquid equilibria/vapor-liquid equilibria	complex deposition, hydrates, scales, organic solids, & particles	momentum, heat, & mass transfer under general flow conditions		
✷	**Subsalt Imaging**	advanced seismic methods	emerging non-seismic methods			
❑	**Advanced Separations**	compact seafloor / downhole separators	methane permeable membranes for gas upgrading	ceramic membranes	seafloor water conditioning for injection	
❈	**Superconducting Long Distance Transmission**	high capacity bundling	subsea packaging and installation methods	remote underwater splicing technology		
❊	**Carbon Waste Disposal**	new product stream definition and material conversion process	geologic sequestration	waste disposal methods		

exploitation methods are very stepwise and limited due to uncertainties in our knowledge of the subsurface strata and also due in part to the large capital commitments required in field development.

Reservoir Property Verification is one of the key hurdles in reducing perceived risk. This effort seeks to address the risks by providing more cost effective methods of collecting direct measurements of the properties in question such as reservoir rock and fluid quality.

Subsea Gathering Systems are a new way of developing reservoirs using underground networks of wells as opposed to individual wells.

Reservoir Monitoring and Control are critical to understanding and maximizing accelerated desired fluid production from a given reservoir. A multitude of sensing and control mechanisms are envisioned as a part of this initiative.

Rigs/Reach/Riserless

Much of the cost and risk in deepwater and ultra-deepwater reservoir development is related to rig/riser cost and the possibility of not being able to reach the desired reservoir target with a sufficiently sized hole to economically produce the required flow stream. Many of these problems are due to the “scaling–up” of technologies designed for shallower water and land use so they can be applied in ultra-deepwater where loads are higher, lengths are longer, and the environment is more harsh. This effort is intended to apply new technologies in remote operation, sensing , and robotics to change the paradigms of how a well should be drilled and maintained economically in ultra-deepwater.

Riserless Drilling Systems offer the potential of reducing the size and cost of drilling rigs which drive deepwater development costs. Some innovative systems in development today remove conventional risers but still require return lines to surface. This initiative investigates the potential of truly riserless drilling systems.

System Integration While Drilling is a combination of software and tools designed to allow modular construction of the appropriate drainage architecture for a given reservoir on the fly as it is drilled.

High Capacity Production Wells recognizes the high rates to be produced from deepwater wells or networks and addresses some unique concerns such as wellbore stability in drilling, redundancy concepts, and reliability of high rate capable tubulars.

Intervention Systems are critical to increased ultimate recovery percentages. This effort is focused on providing lower cost intervention services and a broader scope of remote intervention capability using robotics, and automated underwater vehicles.

Energy to Market

As reservoir developments move further from shore and into deeper water, infrastructure must be added to get produced fluids, gas or energy / power to market in some fashion. Even when Floating Production Storage and Offloading units are approved for use in the U.S. GOM, there will still be challenges for transporting associated gas. This initiative recognizes the need to solve the full problem including transport of product to market. There are several significant challenges in deepwater – namely flow assurance at cold seafloor temperatures, the high cost of sea surface facility / real estate, and the risks of high rate / high volume loses. In addition, the current pressure toward use of cleaner fuels must be weighed in the decisions of what fuels and products are actually produced and transported.

Subsea Processing and Flow Assurance is an effort to reduce the need for sea surface facilities and cost by placing much of the processing on the seafloor. This will also potentially reduce power requirements by separating unwanted fluids for reinjection without bringing them all the way to the surface and it could solve some flow assurance issues with conditioning of fluids at the seafloor.

Hydrocarbons to Clean Fuel, Feedstock, Products recognizes the need to produce future clean fuels, feedstocks, and products and proposes to produce these as near as possible to the source to avoid non-value adding transport and queueing of fluids at intermediate facilities.

Offshore Power Generation / Transmission is a recognition of the importance of electricity as a form of power transmission with potentially less threatening environmental consequences of a fault. If electricity can be generated offshore and power efficiently moved to shore while exhaust gases are re-injected to the reservoirs from which they were produced then greenhouse gas emissions may be reduced while also providing increased power availability to U.S. grids. Superconducting cables have the potential to deliver this increased capacity anywhere in the US with little or no losses.

Environmental Management

Environmental issues are crosscutting but are envisioned to require a special focus here due to the potential for significant impact on the environment and project economics. In addition, there should be methods specific to deepwater to control and capture fluids from any loss of well control event. Current methods predominantly attack losses once they reach the surface. In ultra-deepwater we do not want to wait for losses to reach the surface before they are captured. These issues in addition to the many environmental considerations in the other initiatives will need specific focus.

Greenhouse Gas Sequestration: There is a separate technology roadmap for greenhouse gas sequestration and this ultra-deepwater technology roadmap effort should be coordinated with the greenhouse gas effort.

Well Control with Near-Zero Spill Volume is a challenge to develop the needed technology to capture hydrocarbon fluids at the source of a loss event if it occurs in deepwater or ultra-deepwater. Sensors and remote deployment schemes should be developed to capture these fluids while they are still concentrated and before they are dispersed widely to the environment. Deepwater is unique in the sense that the seawater column near the seafloor may be much more hospitable climate for collection of lost fluids than the full water column and broad area rough sea surface.

A metric to evaluate technologies and systems could be utilized to ensure that the impact of technology developments causes market forces to support this effort by directing capital to the ultra-deepwater. This is critical to making the accelerated growth effort sustainable without constant federal government incentives. Other metrics and measures may also be established to ensure environmental stewardship while on this path of accelerated growth.

The Implementation

To expedite technology transfer of vitally needed commercialization of advanced technologies, including ultra-deepwater offshore technologies, the program implementation mechanisms could include the following:

- **Sponsor R&D for technology projects that use an unrestricted array of funding mechanisms** that range from industry-only funded projects to cost-shared arrangements with government that include funding from the mainstream investment sector.

- **A high-level concept development competition for the next generation deepwater architecture.** Several competing revolutionary ideas can be envisaged and proposed by consortia of industry / national laboratories / universities / others. Conceptually, the selected consortia could then be supported in critical mass by federal government to achieve a new open system architecture standard into which all of industry can invest each with its own piece of the technology puzzle; and

- **The Natural Gas and Oil Technology Partnership for technology commercialization collaborations.** The Partnership is an ideal mechanism for transfer of advanced technologies developed either at the national laboratories or through laboratory and industry collaborations. The Partnership is an established, functioning entity. The alliances established through the Partnership combine the resources and experience of the Nation's petroleum industry with the capabilities of the national laboratories to expedite research, development, and demonstration of advanced technologies for improved natural gas and oil recovery. This industry-driven program establishes active industry interfaces through review panels and forums that define industry needs, provide annual project reviews, and determines the priority of new proposals and ongoing projects.

The Department of Energy will create ways to ensure frequent input from stakeholders. This ongoing dialogue will cause the Department to analyze existing mechanisms and identify "best practices" for technology commercialization, identify opportunities for transferring these mechanisms across the Department of Energy complex, streamline the movement of technology exiting the national laboratories, and initiate processes to enhance technology commercialization.

. . . ongoing dialogue will cause the Department of Energy to analyze existing mechanisms and identify "best practices" for technology commercialization, identify opportunities for transferring these mechanisms across the Department complex, streamline the movement of technology exiting the national laboratories, and initiate processes to enhance technology commercialization.

Conclusions

Acceleration of ultra-deepwater development is essential to the future stability and security of U.S. energy supplies. This is a national need and it demands a national effort. Energy is critical to the continued growth of our economy. Steady erosion of U.S. domestic production, while new energy resources are being demanded in significant volumes, leaves the Nation exposed to supply disruptions. By mobilizing the Nation's economic, technical, and natural resources, we can and should develop more environmentally friendly domestic sources of energy. The natural gas and oil will continue to provide about two-thirds of our energy needs over the next 20 years.

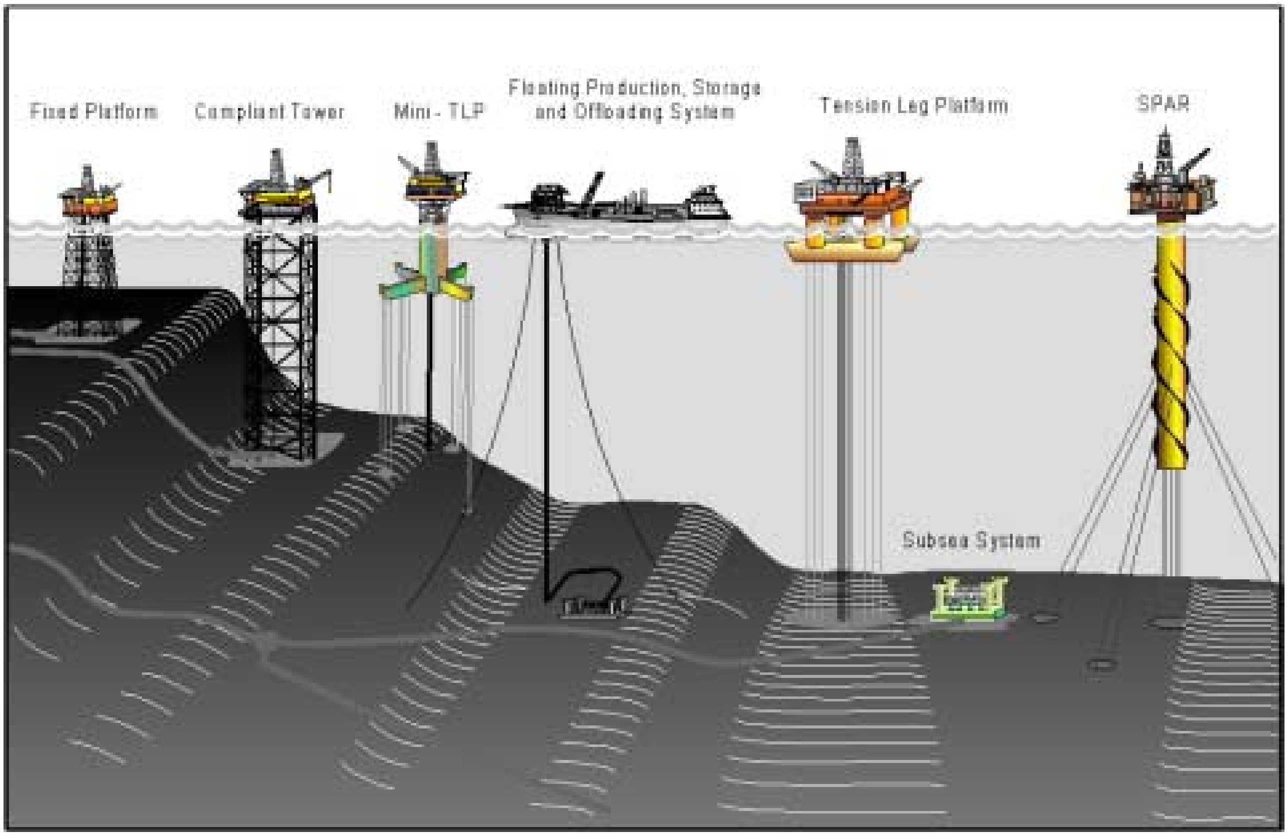
. . . the petroleum business has transformed itself into a high-technology industry . . .

Technology improvements are particularly important given the more difficult conditions accompanying new resources.

As addressed by the National Petroleum Council in its 1999 natural gas study, *Meeting the Challenges of the Nation's Growing Natural Gas Demand*, the petroleum business has transformed itself into a high-technology industry in the past three decades (Ref: "Natural Gas: Meeting the Challenges of the Nation's Growing Natural Gas Demand," National Petroleum Council, December 1999). Dramatic advances in technology for exploration, drilling and completion, production, and site restoration have enabled the industry to keep up with the ever-increasing demand for reliable supplies of oil and natural gas while maintaining reasonable prices. The industry is now challenged to continue extending the frontiers of technology. Ongoing advances in E&P productivity and environmental safety are essential if producers are to keep pace with steadily growing demand for oil and gas, both in the U.S. and worldwide.

Technology improvements are particularly important given the more difficult conditions accompanying new resources. Continuing innovation is necessary to sustain the petroleum industry's leadership in the intensely competitive international arena, and to retain high-paying oil and gas industry jobs at home. Progressively cleaner, less intrusive, and more efficient technology will be instrumental in enhancing environmental protection in the future. Reliable and affordable natural gas and oil supplies are critical to sustaining continued growth of the Nation's economy and quality of life.

APPENDICES



Deepwater development systems

Source: Deepwater Gulf of Mexico: America's Emerging Frontier; Minerals Management Service, OCS Report MMS 2000-022, April 2000.

APPENDIX A
WORKSHOP HIGHLIGHTS

This appendix includes a summation of views and opinions expressed by stakeholders who participated in the roadmapping workshops.

General Comments

- Deepwater Gulf of Mexico development, in principle, could take domestic oil production from its current level today (5.9 million barrels per day) to approach the peak achieved in 1970 (9.6 million barrels per day). It is believed that some of the most productive fields of the central Gulf of Mexico are in water depths of 10,000 feet and will require drilling of wells 28,000 to 35,000 feet total depth.

- Ultra-deepwater is a challenging environment, both technically and economically, the cost of failure is high, and the market is naturally reluctant to try new technologies. In addition, new technologies must provide appropriate benefits not only to the customer and the oil and gas company, but to the suppliers and the investors as well in order to truly be implemented by industry.

- Technology is central to the natural gas and oil industry and to its performance. Ultra-deepwater development is a particularly exciting opportunity and many companies are becoming active in deepwater exploration. Many discoveries are smaller in size and will require innovative approaches to develop economically. Continuing advances in technology are critical to the development of these resources.

- Research areas should be defined and reviewed based on industry needs. These needs include a better understanding of the ultra-deepwater environment. In recent years, industry has become more focused on applied research rather than fundamental research. However, the industry recognizes there are fundamental research opportunities in the areas such as new materials, the behavior of produced fluids, and alternative methods of processing the fluids.

- R&D is a business not an activity. It must deliver a product with speed and efficiency and start/stop when appropriate. It must pull from the global asset base of the industry and the best resources ("A-team") must be engaged. The effort must be customer focused and technology enabled, be driven by vision but measured by clear metrics, and focused to deliver near term with a sense of urgency that demands ruthless execution.

- R&D spending by the industry is very low as a percentage of revenues compared to other industries. This is basically possible because in the global economy, industry can "coast" on older technology by applying this technology in other areas of the world. In newer reservoirs and easier drilling environments around the world (compared to the remaining opportunities in the United States), new technology is less in demand. The industry will develop the technology to produce in deepwater and ultra-deepwater in the United States, but absent some outside stimulus, these developments will come at a very incremental pace. If there is a national interest in increasing U.S. domestic production in the near term, then stimulus could be applied to achieve this goal.

Investors Workshop

- Industry understands that deepwater development is an important business. Investment in technology must be justified either through the proprietary and strategic advantage that it offers to operators or through the attractive to investors because of larger return expectations.

- The S&P 500 is now composed of about 5 percent of energy companies. In 1980, it was about 28 percent. Since then, the market experienced a complete erosion of the capital base that was dedicated towards energy. Technology, on the other hand, is 30 percent of the S&P today and, back in 1980, it was less than 10 percent. The market has experienced a dramatic shift in the capital flows, along with a dramatic shift in the psyche of today's investor. Today's investor is more diversified, looks for liquidity and quick return, and is powered with information. They can afford to bounce from investment to investment very quickly. This creates an incredibly volatile environment for stocks that are related to commodities.

- There is a sense that investors are not familiar with the degree to which the energy business has historically invested in and implemented leading edge technology. Most investors believe the petroleum industry has fostered incremental rather than innovative or revolutionary technology. They also do not believe that major oil and gas companies are forward thinking in their approach to running their business and, perhaps these investors are not aware of the complexity of the many processes in the oil industry.

- Investment in technology for ultra-deepwater development will require collaboration across all areas of a single company and between companies. This collaboration must be pervasive, not just between oil and gas companies, but collaboration between oil and gas companies and their service providers; between oil and gas companies, governmental agencies, and non-governmental organizations; and between oil companies and investors.

- A major investment barrier is not having stable commodity prices and getting everyone to believe that they will stay stable. Many companies were not convinced the prices would stay stable and delayed their capital expenditures, and deferred exploration actions further out. This also affected the field service companies and forced them to wait on the sidelines.

- The independent producers and the E&P companies are now getting the benefit of increased cash flow because of the recent higher prices, but because the Wall Street is not rewarding them on their stock price, companies are obtaining better shareholder value by buying back their shares and paying down debt. Thus, instead of applying funds to exploration and drilling, companies are doing other things, which further exacerbate prices and supply problems.

- The investment climate for the next generation of global oil and gas resources development is being set now. Investment dynamics, once committed preferentially to deepwater or, alternatively, to the more obvious oil and gas exporting nations, could change the entire development of industry.

Producers Workshop

- For most operators, ultra-deepwater are depths greater than 6,000 to 10,000 feet. Extreme depths pose two challenges. One challenge occurs when there is a shallow target in 10,000 feet of water. The other occurs when there is a deep structure, maybe 15,000 to 20,000 feet deep below the 10,000 feet of water. Thus, a key challenge is that reservoirs lying under 6,000 to 10,000 feet of water with productive formation depths of

20,000 to 25,000 cannot be drilled to and are not producible with current technology.

- Challenges associated with deepwater operations are a lack of deepwater infrastructure, the need for dramatically reduced drilling and development costs, improving reservoir definition and characterization, increasing productivity and recovery, improving reliability, and insuring safe operability.

- Riser length, size, and weight necessary for deepwater drilling impose demands on surface facility buoyancy which translates into large, capital intensive drilling units with commensurately high daily rig rates. Rig rates for ultra-deepwater can range from $200,000 to $300,000 per day.

- Currently, deepwater accumulations of 100 million barrels and less are borderline economic and 88 percent of worldwide deepwater reservoirs are thought to be limited to this magnitude. To make these reservoirs economic requires reduced cost of rig operations, reduced cost of facilities, and reduced cycle time from discovery to first oil, in addition to addressing flow assurance issues and wellbore stability issues.

- Limitations in reservoir quality and areal measurements combined with the high cost of ultra-deepwater rigs also causes a concern and possible choice between more appraisal versus accelerated development. More appraisal causes production delays and higher appraisal costs, but reduces uncertainty and allows more efficient facility design. Accelerated or phased development lowers appraisal costs and reduces the time to first oil recovery, but results in less than optimal facility design.

- Infrastructure improvements will need to be addressed, including roads, pipelines, logistical support bases, coordination with states, and education of the workforce in new technologies.

- In order to make the deepwater projects economic, production requirements per well are estimated to be 30 to 40 million barrels per year due to large initial deployment and subsequent drilling and completion costs.

- Independent producers and small entrepreneurs should have input to the process and benefit from the program to encourage competition in the respective marketplaces in which these entities compete. Independents clearly stated a desire to explore, produce, and partner with the majors in the Gulf of Mexico. The increasing number of leases held by independents is proof of this trend.

- Independents offer the desire to help and work with the research organizations and often bring in creative individuals who tend to be entrepreneurial. On the other hand, independents, as smaller companies, do not have the capital resources for R&D and/or large investments.

- Involvement of independent producers in deepwater is necessary as part of the solution in assuring development of deepwater resources. The independents are good at mobilizing people, assets, and technology to move forward.

- Deepwater production operations must be performed in a safe manner to protect both the worker and the environment. Safety and environmental challenges represent another dimension of the technology challenges faced by operators.

- High rig rates and operational costs limit the number of exploration, appraisal, and development wells. This, combined with limitations on well testing, causes uncertainty in reservoir characterization, i.e., size, fluid volumes, fluid quality, and fluid mobility. These uncertainties raise the bar on field size needed to justify development.

- Station keeping technology is challenged, considering high current loads and the threat of hurricanes. This can lead to emergency drive-offs or drift-offs, which require riser disconnects from the sea floor wellheads and cause risk of damage due to the magnitude of the weights and momentum involved.

- Seismic or other remote imaging of geologic strata is challenged by salt layers which can mask true field size and result in costly dry holes or poorly developed fields.

- The oil and gas industry should take advantage of e-commerce and information management tools, i.e., establishments of a knowledge management network to create an environment through which everyone is connected for instant exchange of data and information. Such a network can be used to solve operational problems and expedite the decisionmaking process.

- Facility design itself is pushed to technology limits due to water depths in the U.S. Gulf of Mexico and the deepwater environment with challenges of vortex induced vibration in the drilling rise, mooring system design, and production process train sizing.

- The high levels of recoverable fluid volumes needed per well causes lower quality reservoir sections to be bypassed and less efficient exploitation of recoverable natural gas and oil resources. As reservoir quality reduces, the spacing between economically justified conventional wells increases in direct opposition to the need of what would be required to maximize recovery and minimize bypassed oil.

- The remote nature and deepwater environment increases the cost of mobilizing and performing well workovers or interventions, which are required to increase ultimate recoveries in shelf and land well analogs. With intervention options and improvements, ultimate recovery percentages can be increased by approximately 20 percent. High intervention costs not only limits recovery percentages achievable but it also increases sensitivity to production system reliability.

- Rough sea floor terrain, the threat of mud slides, and the distances back to existing infrastructure increase pipeline cost burdens, which must be borne by new field developments.

- Sea floor temperatures near freezing exacerbate the formation of hydrate and wax plugs in flowlines.

- The young geologic nature of deepwater reservoirs means they are mostly unconsolidated which challenges wellbore stability during drilling and long term completion reliability during production.

- Being able to safely discharge drilling muds and cuttings in every offshore province is key to the success of the industry. It has helped the industry to reduce costs and also manage environmental impacts. On the positive side in the ultra deepwater, discharges are in fact adding energy or nutrients into that environment. In 6,000 to 10,000 feet of water, the sea floor is a very low-energy environment. A positive benefit might well be the fact that as nutrients are increased, energy is added to the system, which may improve biodiversity.

- Properly addressing environmental issues is critical to making the deepwater and ultra-deepwater reservoirs an attractive energy resource. Concerns include accidental release of oil, chemical products, water and sediment quality, air quality and emissions, impacts on biological communities, operations environments, and socioeconomic impact. Two issues of particular interest are air emissions and the potential for larger volumes of hydrocarbons to be released in the event of a loss of well control.

- The public perception of oil spills is that the industry spills millions of barrels of oil all over the world. The truth is, if the industry were doing that, they certainly would not be in business today. There are a number of ways that the industry can improve its public perception by communicating advances in technology for containing oil spills.

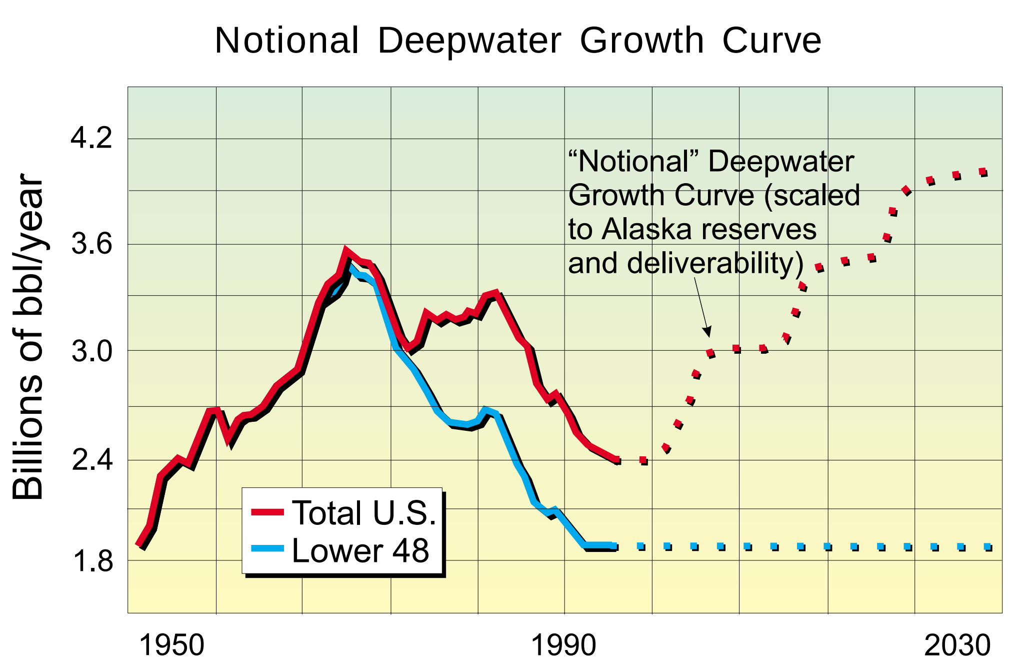
- Workshop attendees noted that the Department of Energy has funded other models for collaboration such as the Partnership for New Generation Vehicles (PNGV) program funded at $263 million per year, the Industries of the Future program funded at $70-90 million per year, and the USABC program funded at $250 million per year with 50/50 cost sharing.

- Dr. Michael Economides and Professor Ron Oligney of the University of Houston presented the following graph at the OSTR Producers Workshop held on August 1, 2000, in Houston, Texas, to indicate the significance of deepwater Gulf of Mexico oil production potential.

Technology Workshop

- Employing new technology is a significant barrier in and of itself. In ultra deepwater, the initial technology deployment represents a multi-million dollar investment. The risks and costs of failure for initial deployment are high. Testing of prototype technologies in marine environments or onshore before deepwater deployment, is an expensive challenge. Producers find it difficult to compromise current production and risk increased expense to support field trials of new technology.

- A key challenge concerning investment for the ultra deepwater involves the necessity to integrate highly complex systems, yet, it seems that less truly integrated R&D is being performed by industry. Market performance is not solely determined by the performance of the technology, but considerably by the system within which it integrates. Because field development expenses are significant, new technologies must rightly meet stringent testing and quality assurance requirements.



Source: Dr. Michael Economides and Professor Ron Oligney, University of Houston, August 2000.

These activities naturally impact the pace of new technology deployment and can adversely impact the economic return of the technology investments.

- Development of dual gradient drilling and riserless drilling will help in reducing costs. Advantages of these technologies include lower risk of formation damage, reduced number of casing strings, and larger wells for higher production rates. These technologies would also allow smaller, older drilling rigs to operate in deepwater. Areas requiring further work include development of subsea pumping and return of mud and cuttings to the surface thereby reducing the hydrostatic load at depth on the formation.

- The cost of operations or "activation" in deepwater needs to be reduced, characterized by some stakeholders as $13/barrel, comprising $3/barrel for finding, $5/barrel for development, and $5/barrel for operations. Targeted cost would be $9/barrel, comprising $3/barrel each for finding, development, and operations. This represents a 40 percent reduction in development and operation (activation) costs. Some of these savings can be realized from advances and improvements in prestack depth imaging, dual gradient drilling (fewer casings, slimmer wells, safer operations), riserless drilling, extended reach drilling, use of intelligent wells (lower intervention costs, real-time production monitoring, maximized production rates), and flow assurance.

- There is an extreme aversion to "first-time" utilization of any technology, particularly in deepwater. Companies do not want to take a chance and risk delays in production start up and/or costly production shut downs. They prefer new technologies to be proven both in quality assurance and in application before they can be considered for actual field installation.

- A "high-intensity" approach to design and commercialization is required to reduce the new technology deployment time frame or the cycle time. Further, evolutionary, rather than revolutionary, technologies will be able to recover deepwater offshore resources.

- Other barriers to recovering natural gas and oil from such greater depths are lack of experience and the cost of dual density drilling and expandable tubulars. The problem is associated with drilling and completing a large enough wellbore to allow significant daily production, i.e., 10,000 to 30,000 barrels a day. This would require five-and-a-half inch tubing or greater. Although expandable tubers will allow expansion of bore holes, they are expensive and new to the marketplace. New tools and equipment and more experience in this type of drilling and completion are required to reduce the cost of operations.

- Use of Autonomous Underwater Vehicles (AUVs) to search for hydrocarbon deposits also would reduce exploration risk. Advantages of AUVs include increased survey efficiency by reducing the reliance on the surface vessel, and the ability to obtain more accurate exploration data. However, further cost reduction and improvements are needed to increase AUV reliability, sensor resolution, and power consumption.

- Utilizing Floating Production Storage and Offloading (FPSO) and/or Floating Storage and Offloading (FSO) units can spread the capital expenditures over several fields. These are proven existing technologies and can eliminate the cost and technical risk of deepwater pipelines, and reduce flow assurance problems. Gas must be produced and exported, i.e., modular, compact gas-to-liquid conversion units would eliminate the need for deepwater pipeline and liquids can be delivered closer to the consumer. MMS and U.S.

Coast Guard approvals are required. Good operational scenarios for emergency conditions (i.e., for hurricanes and spill prevention and containment) also need to be developed.

- There are advanced technology and expertise that exist within the national laboratories that could have a positive impact on increasing production and increasing deepwater reserves. However, an easier access to this "treasure chest" with "better ways of doing business" needs to be established. Communication must be both to and from each party for optimum results.
- Alignment and focus are also barriers to technology development. Internally, within E&P companies, there is a need to align the technologists with the operations and the operational teams; and then there is the need to have an alignment between the E&P companies, the vendors, NGOs, and the regulators so the technology solutions are deployed and represent ongoing vital business opportunities for the companies and the vendors. The industry can benefit if all pieces were aligned and investments were focused for more effective use of limited capital and human resources available.
- Public funds for demonstration and/or testing will accelerate technology commercialization. Technologies should also offer economic return not only in offshore but also in shallow waters, as well as in onshore applications.
- Basic research is necessary in ultra deepwater environments to establish a clear understanding of the physical and ecological factors that will effect the types of technology that are utilized.
- The industry (particularly majors) has a culture that has been slow to embrace change. The preference has been for a slow evolution versus revolutionary change. Disruptive technologies are ignored until old solutions have been totally played out.
- Moving processing and pumping systems to the seafloor would reduce capital cost of production facilities. This would eliminate or reduce surface facility costs, lower pipeline size and costs, and reduce flow assurance problems. Further development is required on subsea separation equipment, subsea pumping, and power distribution and control.
- Gas hydrate formation is perhaps one of the more challenging issues that industry will have to face in the ultra deepwater. There are a number of proposals using various treatment chemicals, but ultimately the goal is prevention. Treatment is extremely difficult, which is of great importance and concern to industry in the area of technology development.

Non-Government Organizations (NGOs) Workshop

- NGOs vary in purpose and constituents and, although they are very diverse, they share overlapping interest and constituents. They consists of both environmental scientific organizations as well as socially directed groups. Because they are stakeholder in this process, they are expected to bring a balanced approach to deepwater development.
- Concerted effort is necessary to ensure that no undue duplication of effort causes delay from the time of concept to commercial application. Limited resources exist in the research laboratories, regulatory agencies, and the NGO community. It is important that all parties involved marshal the efforts of all stakeholders to ensure sustainable development.

- Accepted analytical procedures are needed to ensure that the full spectrum of impacts are defined and where possible, mitigated to ensure the highest quality of resource utilization. Analytical tools include both cost benefit analysis and life cycle analysis.

- Environmental concerns are of paramount importance. The new architecture and new technologies should target low greenhouse gas emissions, reduced discharges of pollutants, near zero spill volumes, and continued stewardship of the Nation's resources and the environment in general.

- Given the remoteness of the location and the uniqueness of the technological advancements necessary to achieve ultra deepwater exploration and production, fundamental trust must be established between the industry, the regulators, and other stakeholders through cooperation and sound process.

- Health, safety, and environmental issues will play a role in ultra deepwater development. An existing problem with the oil and gas industry is its reputation. The public perception of environmental performance has significantly hindered the ability of the industry to access offshore oil and gas resources. A very important role for the industry is to look at technologies that can more effectively improve environmental and health and safety performance as a means of building public trust.

- There is a need for training programs on deepwater drilling and production in terms of health and safety, hazards, and the environment. If workers are not adequately trained to operate in these environments, industry will have a problem, particularly in personnel safety.

- A critical problem currently faced by industry is recruitment and retention of personnel. Unfortunately, the oil and gas industry has developed a reputation for up and down cycles of cutting and hiring, which makes it very difficult for industry to recruit and hire qualified engineers and workers. The industry must find ways to make itself more attractive to new graduates.

- Many key environmental NGOs are not yet focused on the ultra-deepwater ecosystems. Greater outreach and education are necessary to engage them in developing technologies during the early stages of development.

- The ecosystems at ultra-deepwater depths are still being explored, many for the first time. Coordination of research has the potential to enhance our scientific knowledge of these ecosystems, and the demands they place on the new architectures being developed.

- The longer response times to reach a leak or spill at depth will require redundancies in engineering and the development of new fail-safe mechanisms and technologies. These same innovations stand to enhance environmental protection at shallower depths or onshore, thereby multiplying the commercialization potential of and technology developed.

Government Workshop

- Government agencies will need to coordinate their policies, regulations, and permitting requirements to streamline and fast track procedures to assist demonstrations of new technologies. Further, federal and state governments, industry, service companies, national laboratories, and investors need to work together as a team for successful technology commercialization as a single entity alone cannot make it happen.

- An equally important challenge for the industry in offshore development is statutory and regulatory requirements, i.e., those under the Clean Water Act, Oil Pollution Act, Coastal

Zone Management Act, and the Clean Air Act. DOE has aided the industry in the development of synthetic drilling fluids and has worked very closely with EPA in promulgating regulations that allow industry to use synthetic drilling fluids offshore and to be able to discharge the cuttings.

- DOE can play a role in bringing together those with technology, investors, and operators that are willing to try new technologies -- three necessary ingredients for successful commercialization.

- Funding research and development off the critical path of specific field developments is a role that the federal government (e.g., DOE) could play after definition of a new framework for deepwater developments, in addition to considering deepwater royalty relief, tax incentives, and other measures for new technology application.

- Financial incentives should be considered to accelerate the adoption rate of new technologies and to accelerate the growth of deepwater production beyond a status quo baseline forecast.

- The average technology commercialization cycle is about five years from its inception. This is often a significant barrier to new technology commercialization as companies seek faster return on their investments. A DOE role could be pushing forward promising technologies, and acting as a catalyst in bringing together technology providers, technology users, and technology investors.

- Regulatory acceptance of new technology is a key area where industry is making headway and is a key part of the process of evolving technologies. All interested parties need to continue to work together so that new technology can be adopted in the deepwater developments in a safe and environmentally sound manner.

- Regulations and technology must be coordinated, i.e., regulations should recognize technology capabilities and technology must recognize regulatory needs. In addition, regulations must provide a means to allow or promote the introduction of new technology that provides adequate assurance of its safety.

Appendix B
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Appendix C
References

1. Energy Information Administration, "*Annual Energy Review 1999,*" DOE/EIA-0384(99), July 2000.

2. Energy Information Administration, "*Annual Energy Outlook 2000,*" DOE/EIA-0383(2000), December 1999.

3. Economides, Michael, Ph.D., and Oligney, Ronald, "*The Color of Oil,*" January 2000.

4. Economides, Michael, Ph.D., "*Deep Offshore Initiative - A Compelling Rationale and Way Forward,*" August 1, 2000.

5. Banc of America Securities, Equity Research, "*e-Oil: Integrated Oil and Oil Services,*" March 2000.

6. Banc of America Securities; Equity Research, "*Offshore Drilling Contractors,*" August 1999.

7. NationsBanc Montgomery Securites, "*The Deepwater Opportunity,*" July 1998.

8. Miscellaneous presentations submitted at the regional OSTR workshops, including those provided by: Joe Foster, Baker Hughes; Michael Economides, Ph.D., University of Houston; Jerry Morris, Shell Technology Ventures; John Vozniak, ASME Petroleum Division; E. G. Ward, Offshore Technology Research Center; Ron Oligney, University of Houston; Art Schroeder, Energy Valley; Cyril Arney, Marathon; T. J. Collins, Oceaneering International, Inc.; Tom Prosser, Maurer Engineering; Paul Robert Hay, Texaco (Deepstar); John Vasselli, Houston Advanced Research Center; Jim Longbottom, University of Houston; Vik Rao, Halliburton.

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