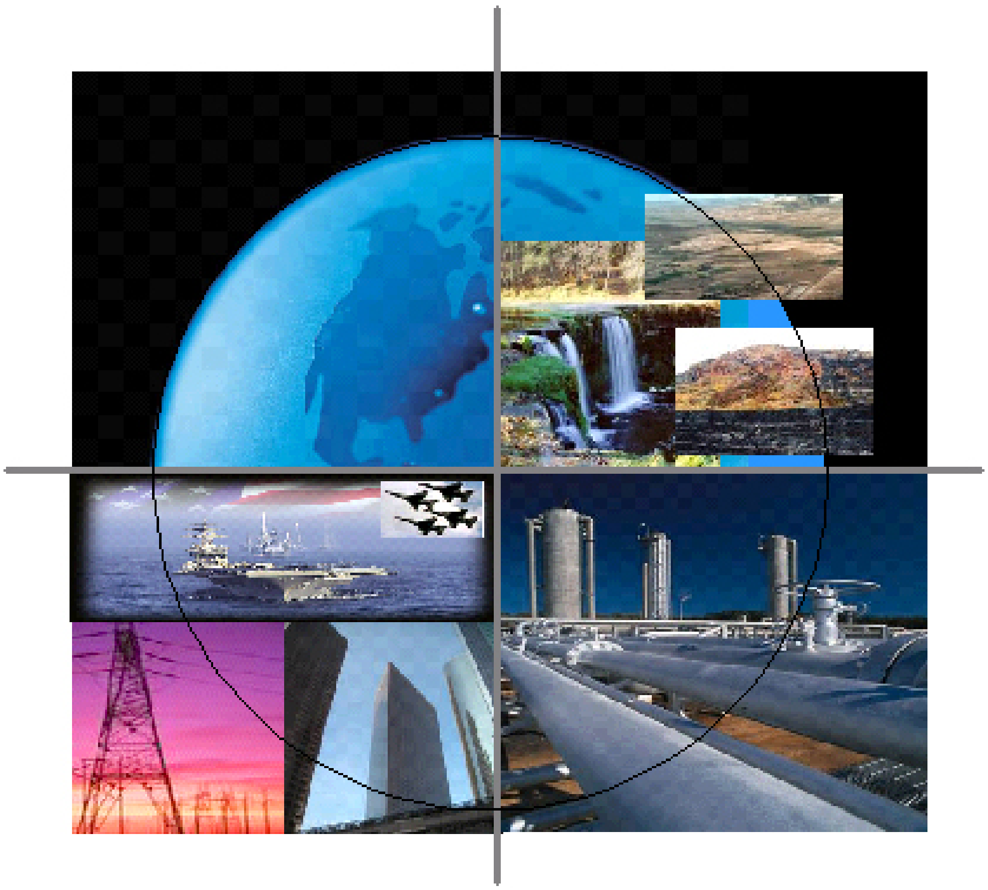
Strategic Significance of America's Oil Shale Resource

Volume I
Assessment of Strategic Issues



Office of Deputy Assistant Secretary
for Petroleum Reserves

Office of Naval Petroleum
and Oil Shale Reserves
U.S. Department of Energy
Washington, D.C.

March 2004

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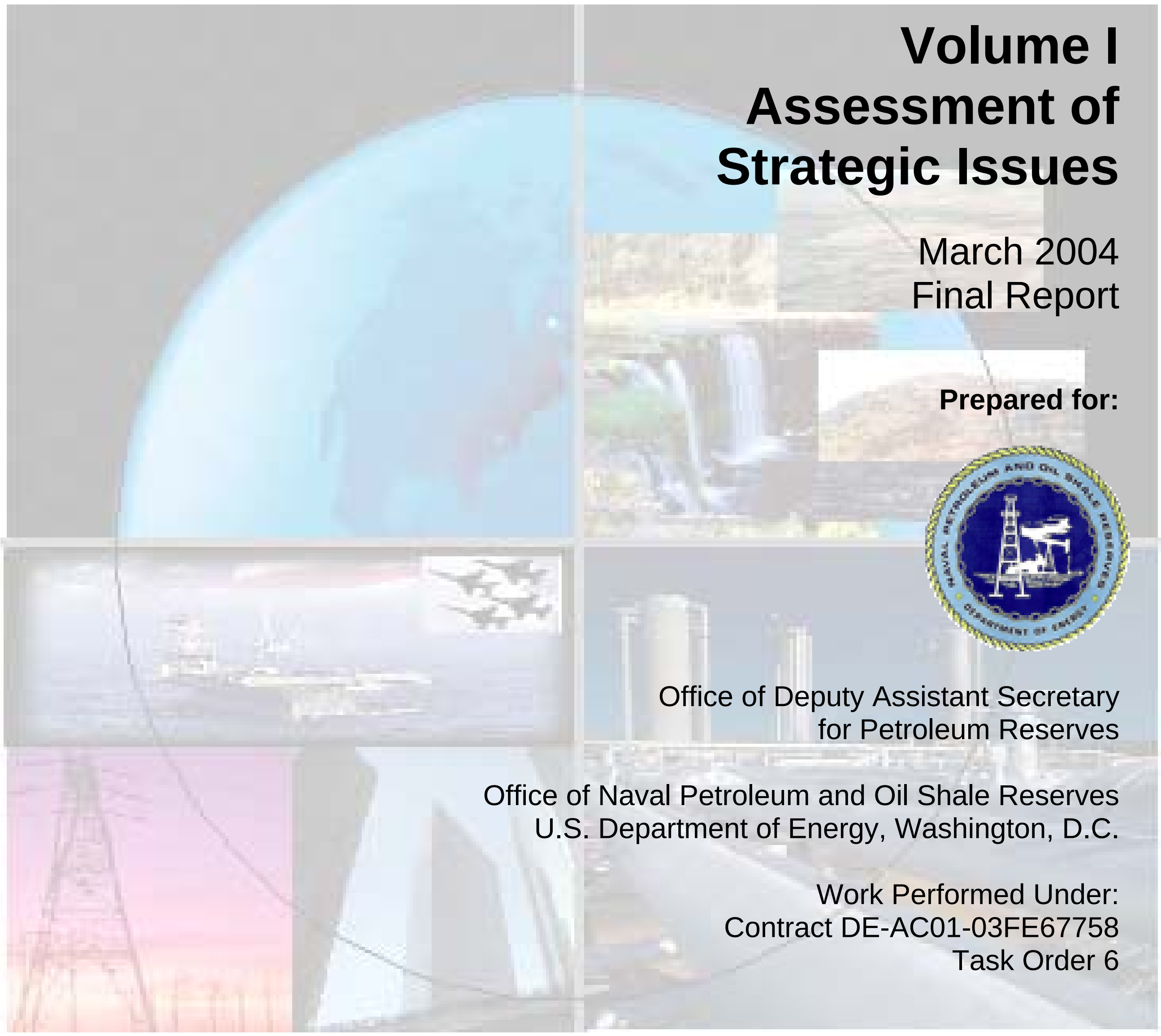

Volume I
Assessment of Strategic Issues

March 2004
Final Report

Prepared for:

Office of Deputy Assistant Secretary
for Petroleum Reserves

Office of Naval Petroleum and Oil Shale Reserves
U.S. Department of Energy, Washington, D.C.

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Foreword

It is generally agreed that worldwide petroleum supply will eventually reach its productive limit, peak, and begin a long-term decline. What should the United States do to prepare for this event? An objective look at the alternatives points to the Nation's untapped oil shale as a strategically located, long-term source of reliable, affordable, and secure oil.

The vast extent of U.S. oil shale resources, amounting to more than 2 trillion barrels, has been known for a century. In 1912, The President, by Executive Order, established the Naval Petroleum and Oil Shale Reserves (NPOSR). This office has overseen the U.S. strategic interests in oil shale since that time. The huge resource base has stimulated several prior commercial attempts to produce oil from oil shale, but these attempts have failed primarily because of the historically modest cost of petroleum with which it competed. With the expected future decline in petroleum production historic market forces are poised to change and this change will improve the economic viability of oil shale.

It has been nearly two decades since meaningful federal oil shale policy initiatives were taken. In that time technology has advanced, global economic, political, and market conditions have changed, and the regulatory landscape has matured. As America considers its homeland security posture, including its desired access to diverse, secure and abundant sources of liquid fuels, it is both necessary and prudent to reconsider the potential of oil shale in the nation's energy and natural resource portfolio.

Commercializing the vast oil shale resources would complement the mission of the Strategic Petroleum Reserve (SPR), by measurably adding to the country's energy resource base. Addition of shale oil to the country's proved oil reserves could occur in a manner similar to the addition of 175 billion barrels of oil from Alberta tar sand to Canada's proved oil reserves. As a result of the commercial success oil from tar sand, production now exceeds 1 million barrels per day. U.S. oil shale, which is as rich as tar sand, could similarly be developed and become a vital component in America's future energy security.

This report was chartered to review the potential of oil shale as a strategic resource for liquid fuels. Volume I reviews the strategic value of oil shale development, public benefits from its development, possible ramifications of failure to develop these resources and related public policy issues and options. Volume II characterizes the oil shale resource, assesses oil shale technology, summarizes environmental and regulatory issues, and reviews tar sand commercialization in Canada as an analog for oil shale development in the United States.

A Peer Review meeting of selected experts from government, industry, business and academia was held February 19-20, 2004. Comments and suggestions were received and incorporated into the two volumes; comment excerpts are provided in Appendix B. The reviewers agreed, based on the current and anticipated energy climate and the issues addressed in the report, that preparation of a Program Plan for oil shale is now warranted.

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Special recognition is due to those who directly performed the work on this project. The principal authors included, Mr. Harry Johnson (INTEK), Mr. Peter M. Crawford (INTEK), and Dr. James W. Bunger (JWBA). Mr. F.J. (Butch) Gangle of DOE/NPOSR is acknowledged for his immense effort in the review and critique of this report. Ms. Cortney Allen of INTEK served as the Administrator responsible for the day-to-day management of the project. Mr. Fred Hartsock of AOC is recognized for his effort in the production of the report.

The authors and sponsors also wish to recognize and thank the numerous experts from industry, government, and academia who reviewed the drafts of this document and who provided invaluable insights and comments in writing and through their participation in a peer review meeting.

While acknowledging the significant contributions of participating individuals and organizations, any error of facts, omission, or inconsistency remains the responsibility of the Project Director and Program Manager.

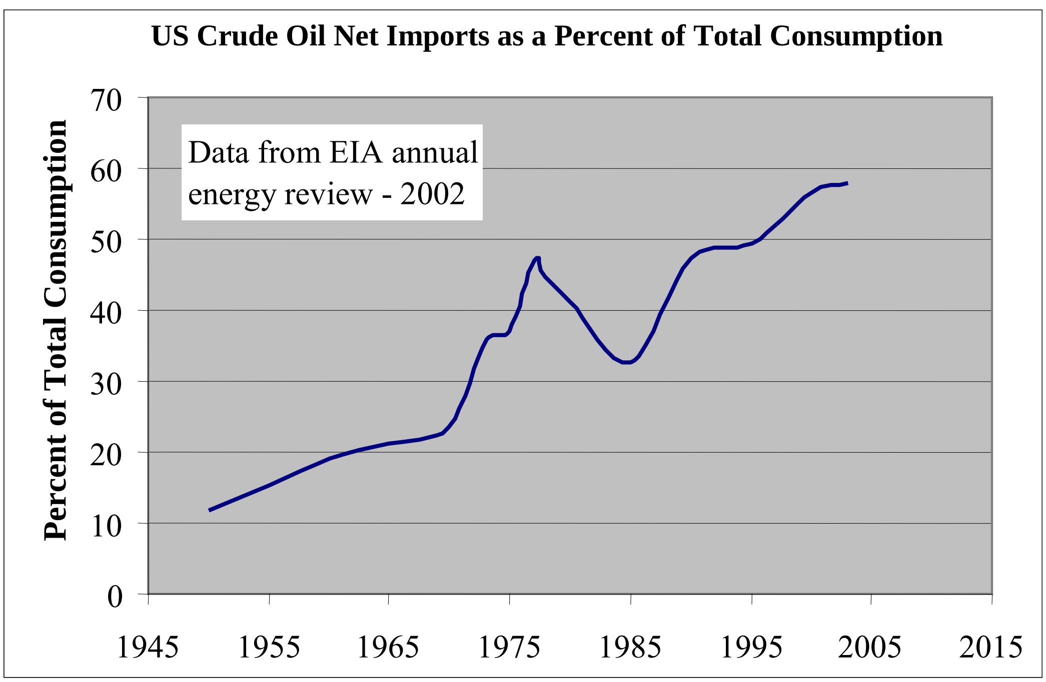
1.0 Overview

The growing dependence of the United States on foreign sources for its liquid fuels has significant strategic and economic implications. The United States has been a net importer of oil for more than 50 years, and today, imports nearly 60 percent of its liquid hydrocarbon needs (***Figure 1***). The U.S. Department of Energy (DOE) projects that U.S. imports may double, to 19.8 MMBbl/D by 2025. By then imports will exceed 70 percent of demand, the vast majority coming from Organization of Petroleum Exporting Countries (OPEC). As imports rise, America's vulnerability to price shocks, disruptions, and shortages will also increase[1].

The expected increase in demand for imported oil comes at a time when other consuming countries are also increasing their demand for oil, primarily from OPEC. Is such a growing dependence on imports and on OPEC acceptable? Is it even possible for OPEC to meet the ever-increasing world demand for oil? And if it is possible, is increasing dependence on OPEC oil in the best long-term interests of the United States?

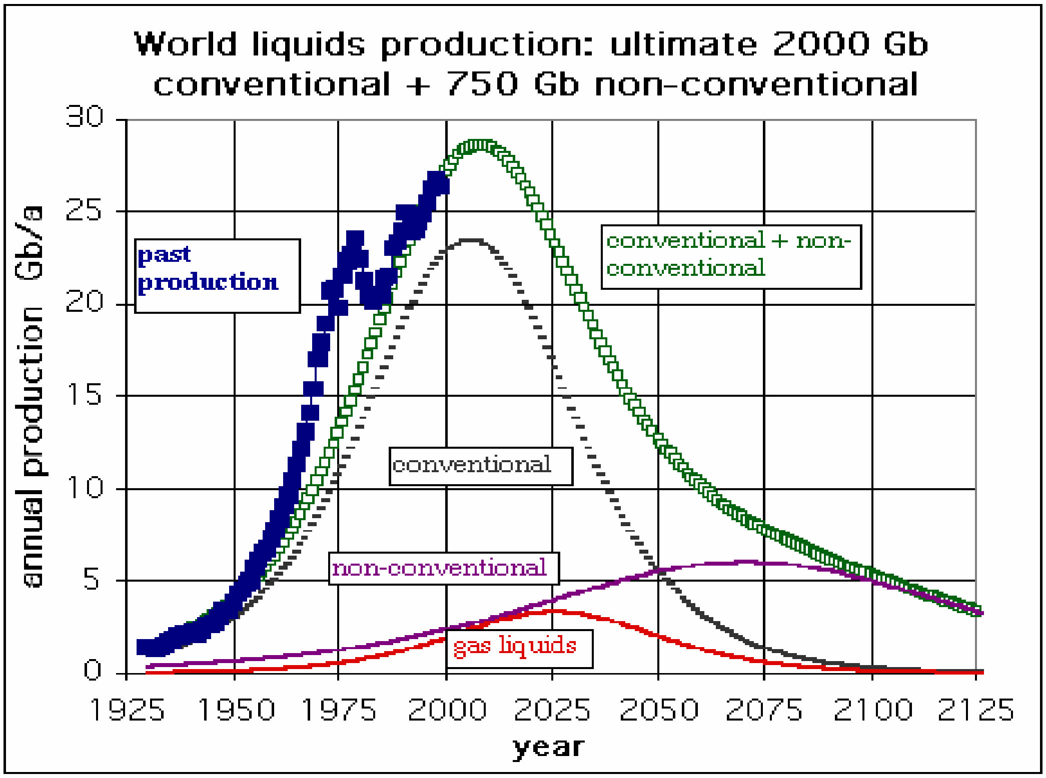
Adding urgency to these questions is the indication that world oil production may peak sooner than generally believed, accelerating the onset of inevitable competition among consumers (and nations) for ever-scarcer oil resources. ***Figure 2*** illustrates the supply peak concept, first espoused by Dr. M. King Hubbert (Ref. 1), and now being debated by a number of respected petroleum experts (Ref. 2, 3, 4, 5, 6, 7, and 8). All of these experts agree that world petroleum supply will peak; the question is when? When the petroleum production peak occurs, the consequences will be severe if import-dependent nations have not prepared for it.

Figure 1. The United States is Increasingly Dependent on Imported Oil



[1]Data, projections and analysis in this contractor-prepared report may differ from current U.S. Department of Energy publications and projections. This report is designed to stimulate discussion and does not represent an official position of the U.S. Department of Energy (For additional information, please see title page disclaimer).

Figure 2. World Oil Production is Projected to Peak (Ref. 8)



The OPEC embargoes in the 1970s provide an historic lesson and offer insight to the potential impacts of petroleum shortages (see section 5.4). Shortages, albeit temporary in the 1970s, drove oil prices higher, and led to high inflation, high unemployment and high interest rates, all at the same time. These adverse effects can be expected in the future if the U.S. once again experiences a supply shock.

U.S. options for producing more liquid fuels are effectively limited to unconventional fossil energy sources, namely liquids from oil shale, coal, and tar sand. The world's conventional oil resources total 2.7 trillion barrels while North America's unconventional resources total 3.7 trillion barrels. North America's resource base of unconventional oil exceeds the world's remaining conventional oil by nearly 40 percent (***Figure 3***).

Conventional oil resources consist of three categories, described by the U.S. Department of Energy's Energy Information Administration (EIA) (Ref. 9, Pg. 37) as follows:

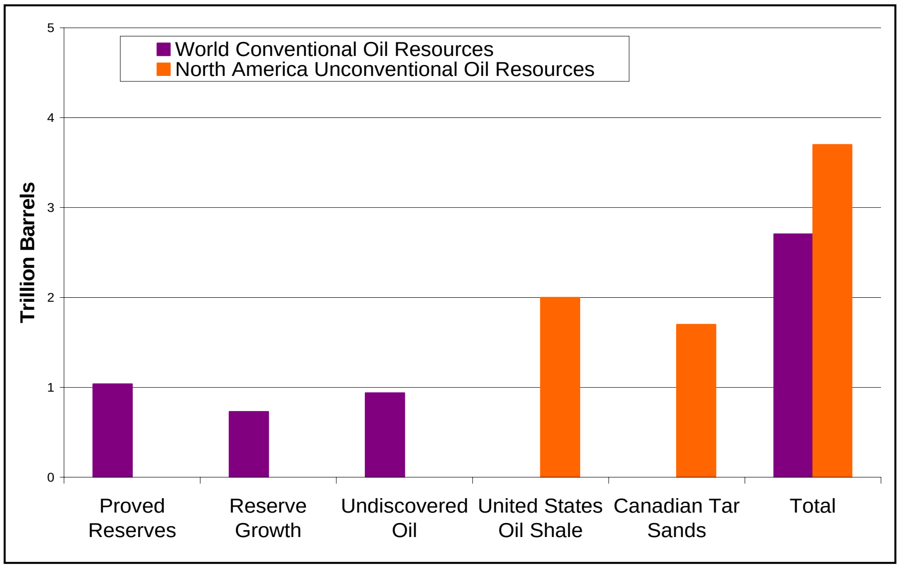
❖ Remaining proved reserves (oil that has been discovered but not produced) taken by the EIA from the annual assessment of worldwide reserves published by the *Oil & Gas Journal*,

❖ Reserve growth (increases in proved reserves that occur over time as oil fields are developed, as discussed in Appendix A of this report) using data from the U.S. Geological Survey (USGS) World Petroleum Assessment, and

❖ Undiscovered oil (oil that remains to be found through new field exploration) that also using USGS data.

Most of the world's known unconventional oil resources are located in North America. Some 1.7 trillion barrels of oil are contained in the oil sands of Canada (Ref. 9, Pg. 40). An additional 2.0 trillion barrels are contained in oil shale located in Colorado, Utah, Wyoming, Kentucky, Ohio and Indiana (oil shale resources discussed in Volume II).

Figure 3. Unconventional Oil Resources Exceed World Conventional Resources (Ref. 9)



In terms of resource base, richness, accessibility, and expected production efficiency, U.S. oil shale has many of the same characteristics as Alberta tar sand. (See Volume II). Oil shale, coupled with Alberta's rapidly evolving tar sand industry, has the potential to provide a secure, steady base for North America's energy needs for at least 100 years.

Achieving the benefits offered by commercialization of the Nation's oil shale resources will require significant investments by the private sector, long lead times, and effective public policies designed to support industry actions while protecting the environment.

This study explores the potential of the oil shale resource base and the technologies and policy options available to stimulate oil shale development. Issues and barriers that must be overcome are outlined along with alternative policy options. The Nation's untapped oil shale resources offer a long-term source of reliable, affordable, and secure oil, but only if the need is recognized and proactive measures are taken now.

2.0 National Energy Policy

In 2001, the White House proposed a National Energy Policy (Ref. 10) calling for programs to increase domestic oil and gas production, to convert to hydrogen technology, to develop renewable energy, to conserve energy, and to enhance nuclear energy options, among other program elements. In response, the Department of Energy (DOE) issued its 2003 Strategic Plan, which recognizes that

> *"As imports rise, so does our vulnerability to price shocks, shortages, and disruptions."*

Energy security is therefore a major goal:

> *"Goal 4: ENERGY SECURITY: Improve energy security by developing technologies that foster a diverse supply and delivery of reliable, affordable, and environmentally sound energy by providing for reliable delivery of energy, guarding against energy emergencies, exploring advanced technologies that make a fundamental improvement in our mix of energy options, and improving energy efficiency."*

The DOE expects the shortfall between energy demand and domestic production to increase 50 percent by 2020. The United States will then require imported oil to meet more than 70 percent of its domestic consumption. The Department cites just three options available to address the future oil needs:

1. Import more oil
2. Improve energy conservation and efficiency
3. Increase domestic oil production

The plan concludes that the long-term solution to our economic and environmental challenge:

> *"…is to make a fundamental change in our mix of energy options and, therefore, America's energy future."*

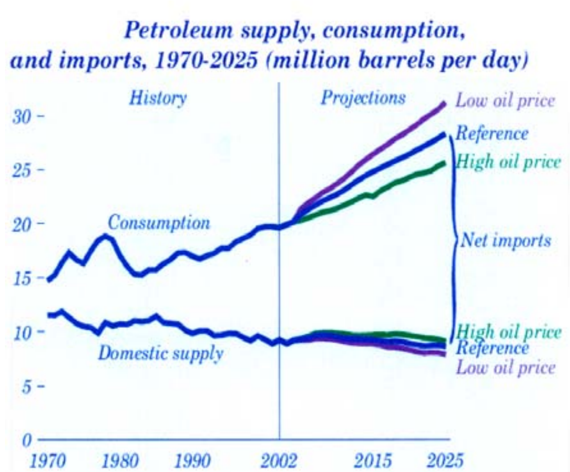
Oil shale development will diversify and increase the supply of domestic energy. The Nation's 2 trillion barrel untapped oil shale resource base could make a significant contribution to our future mix of energy options.

3.0 U.S. Petroleum Requirements

3.1 Domestic Requirements

In 2002, the United States consumed 19.8 MMBbl/D of oil and oil products, of which 10.5 MMBbl/D, or 53% was imported (Ref. 11). Over the foreseeable future, demand will grow while domestic production is expected to continue its decline. For the reference case U.S. demand is expected to reach 29.2 MMBbl/D by the year 2025, of which nearly 19.8 MMBbl/D will be imported (***Figure 4***).

Figure 4. Historical and Projected U.S. Petroleum Demand and Supply (Ref. 12)



These increasing imports will occur at a time when there is also growing competition from other countries of the world for conventional petroleum supplies. Rising world oil demand will add upward price pressure on petroleum prices. Higher world oil prices could cost the U.S. economy $1.1 trillion in gross domestic product (GDP) between now and 2020, as American consumers pay more for gasoline, diesel, jet fuel, heating oil, and other petroleum products (see Analysis in Section 5.2).

3.2 Military Requirements

The Department of Defense has a strategic requirement to maintain secure sources of liquid fuels to mobilize its aircraft, naval fleets, and land vehicles at home and around the world. Heightened concerns over domestic security intensify the need for the military to ensure that secure fuels are available to protect the Nation, to support U.S. forces positioned overseas, and to project force when it is deemed necessary to protect America's strategic interests and global commitments.

To support this strategic requirement, the military pre-positions fuel supplies in the United States and around the world. As these stocks are drawn down, the military purchases replacement fuels from global markets. If replacement fuels are not available in a timely manner, military capabilities are at least temporarily diminished. Domestic sources for military fuels must be re-evaluated in the context of rising import dependencies and increasing vulnerability to supply interruptions.

Of direct importance are:

- ❖ Supplementing decreasing domestic production
- ❖ Maintaining fuel performance for the legacy fleet
- ❖ Keeping fuel costs as low as possible during peacetime to facilitate training.

The development of oil shale resources at this time would help meet all of these needs.

The need for secure supplies and the potential for oil shale to contribute to that need were formally recognized as early as 1912, with the establishment of the Office of Naval Petroleum and Oil Shale Reserves (NPOSR). The original intent for establishing this office was to assure a secure supply of petroleum for America's naval fleet. Today, the interest is far more complicated; the need is integral to the entire military complex. Fittingly, NPOSR is currently part of the Office of Strategic Petroleum Reserves in the U.S. Department of Energy.

In the early 1980s the NPOSR and the Department of Defense Energy Office commissioned a study to analyze establishing a Defense Petroleum Reserve to provide to the military a ready supply of crude oil for refining to jet fuel and gasoline in times when Defense pre-positioned war reserves might be drawn down below minimum strategic levels.

Physical shortages, or even the prospect of shortages, can have a serious adverse effect on military strength. In the 1970s, when actual shortages did occur, then Secretary of the Air Force, John C. Stetson, observed:

> *"It is the trends [higher costs and reduced availability] that bother me and the conviction that unless we begin to lick our fundamental liquid fuels problem, and the larger energy problem, this country will inevitably grow weaker from a military standpoint." (Ref. 13).*

Since the Nation was not at war, the military had a low-priority call on the Strategic Petroleum Reserve and could only replenish reserves through conservation. This meant reduced training with an attendant adverse impact on military readiness.

Today, wars in Afghanistan and Iraq, a production shortfall of 2 million barrels per day from Venezuela and Nigeria, and no call on the Strategic Petroleum Reserve, have very likely placed a strain on pre-positioned military fuel supplies.

Shale oil has been proven to be an excellent source of fuel for military needs, in large scale tests conducted during the 1980s, and in more recent tests in Australia. The Navy's participation in oil shale developments, and in performance and acceptance R&D work that was completed at that time, was extensive. Even with changes in requirements for military fuels, the results support the viability of shale oil fuels and products to meet current military fuel needs.

America's domestic oil shale resources are more than adequate to assure military fuel requirements. Shale oil development can play a vital strategic role by providing the military with long-term, secure access to domestic fuels that are not vulnerable to interruption. This could provide an important advantage to preparedness planning and mission execution.

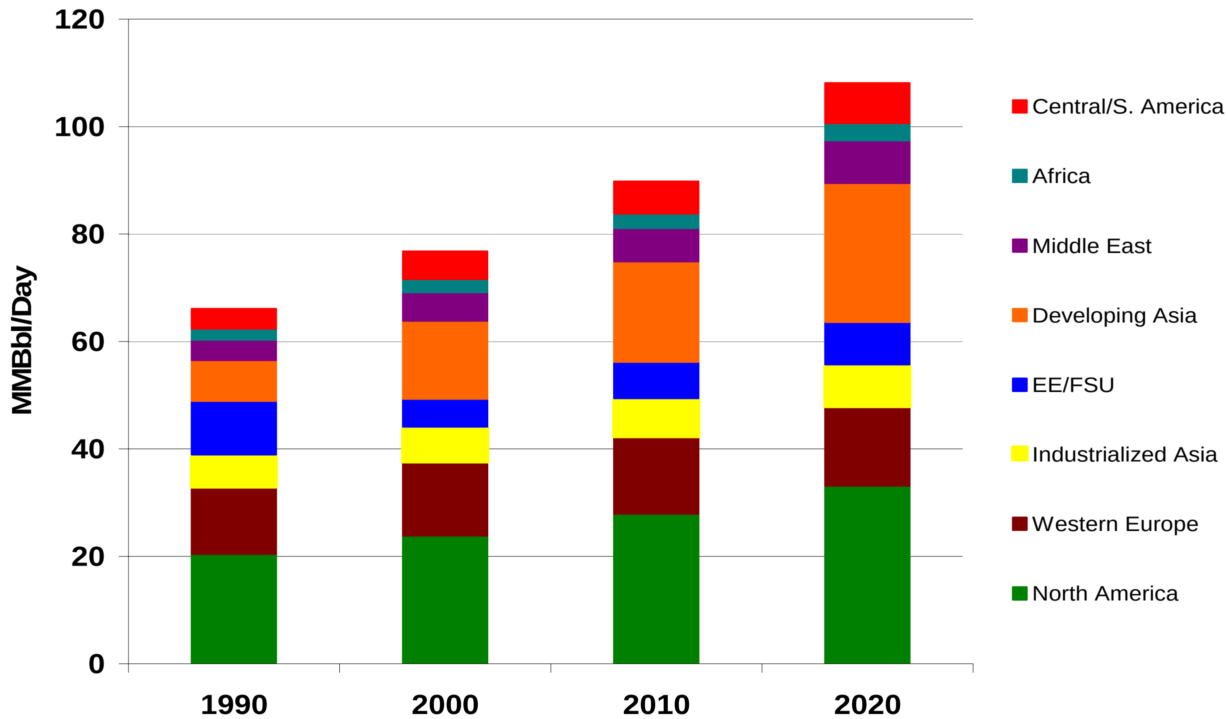
4.0 World Petroleum Situation

4.1 Oil Demand

World demand for crude oil (including natural gas liquids) is projected by the U.S. Energy Information Agency to increase from 77.1 MMBbl/D in 2001 to 89.7 MMBbl/D in 2010, an increase of 12.6 MMBbl/D in just 9 years. (Ref. 9, p. 185) The forecasted oil growth rate is 1.7 percent per year, a significant increase over the actual 1990 to 2001 rate of 1.4 percent (***Figure 5***).

The projections are based on the EIA Office of Integrated Analysis and Forecasting's National Energy Modeling System (NEMS), an integrated market-based approach to energy analysis. The NEMS model correlates numerous historical interrelationships governing supply and demand, with the common interface being the price and quantities consumed by the end-user. In the reference case, the model projects that the real price of crude oil

Figure 5. World Oil Consumption by Region (Ref. 9)



(in 2001 dollars) will remain steady, at about $26.50/bbl, in 2025 ($48/bbl in nominal price). This model assumes that no shortage will develop.

Three other organizations provide forecasts comparable to the EIA's: the International Energy Agency (IEA); Petroleum Economics, Ltd.; and, Petroleum Industry Research Associates. All of the projected growth rates for energy consumption fall within 0.2 percentage points around the EIA reference case (Ref. 9, Pg. 19). All of them also project that the world's consumption of oil will increase in a manner similar to the EIA reference case (Ref. 9, Pg. 21).

The demand for oil may be underestimated in these forecasts. For example, oil demand in China is projected by the EIA to grow, on average, 3 percent per year. By 2010, China will consume 6.5 MMBbl/D, second only to the United States' forecasted demand of 25.2 MMBbl/D (Ref. 9, pg. 185).

However, China's booming economy may already be making the EIA 2003 forecast obsolete. In September 2003, China's monthly crude-oil imports grew almost 60 percent as compared with September 2002. Year-to-year imports are up about 30 percent as the economy of China expands.

Higher living standards are making new cars affordable for more Chinese. Car production for the domestic market nearly doubled in the first seven months of 2003 to more than 1 million vehicles, and it is expected to increase five-fold within a decade. *The Wall Street Journal* cites increased Chinese demand for oil as a fundamental reason for the high price of world oil in the fall of 2003 (Ref. 14).

4.2 Oil Supply

All official forecasts project that plentiful oil supplies will be available, that supply will balance with demand, and the real price of oil will remain steady at or near 2001 price levels.

Other recent and unofficial projections challenge IEA and EIA projections. A growing number of petroleum geologists believe that oil production will soon become limited by geologic constraints, irrespective of demand requirements. The issues are framed quite clearly in a series of special reports by the *Oil & Gas Journal* (OGJ) (Ref. 2 thru 5). The OGJ articles illuminate arguments regarding an eventual peak in world oil supply that, if accurate, would cause oil prices to spike and cause unprecedented and difficult economic adjustments to follow.

The two sides of the debate are being referred to as the depletionists and the non-depletionists. Depletionists argue that world production will peak, perhaps in the near term, and that the advent of the peak portends a long, painful decline with serious world-wide economic consequences. Non-depletionists argue that advances in technology and favorable investment climates will continue to stave off the peak in production long enough to promote a smooth transition to other energy forms with higher use-efficiency.

Campbell and Laherrère, in a 1998 Scientific American paper titled "The End of Cheap Oil," pointed out that:

> *"About 80 percent of the oil produced today flows from fields that were found before 1973, and the great majority of these are declining." (Ref. 15)*

Discoveries *did* peak before the 1970s as shown in ***Figure 6***. This figure also shows that no major new field discoveries have been made in decades. Presently, world oil reserves are being depleted three times as fast as they are being discovered. Oil is being produced from past discoveries, but the reserves are not being fully replaced. Remaining oil reserves of individual oil companies must therefore continue to shrink. For example:

> *"Royal Dutch/Shell Group, one of the world's largest oil companies…failed for a third year to find as much oil as it pumped" (Ref. 16).*

The disparity between increasing production and declining discoveries can only have one outcome: a practical supply limit will be reached and future supply to meet conventional oil demand will not be available. The question is when peak production will occur and what will be its ramifications. Whether the peak occurs sooner or later is a matter of relative urgency, but does not alter a central conclusion; the United States needs to establish a supply base for its future energy needs using its significant oil shale, coal, and other energy resources.

4.3 Declining World Oil Production

In spite of projections for growth in non-OPEC supply, it appears that non-OPEC and

Figure 6. Growing Disparity Between World Production and World Discoveries (Ref. 2)

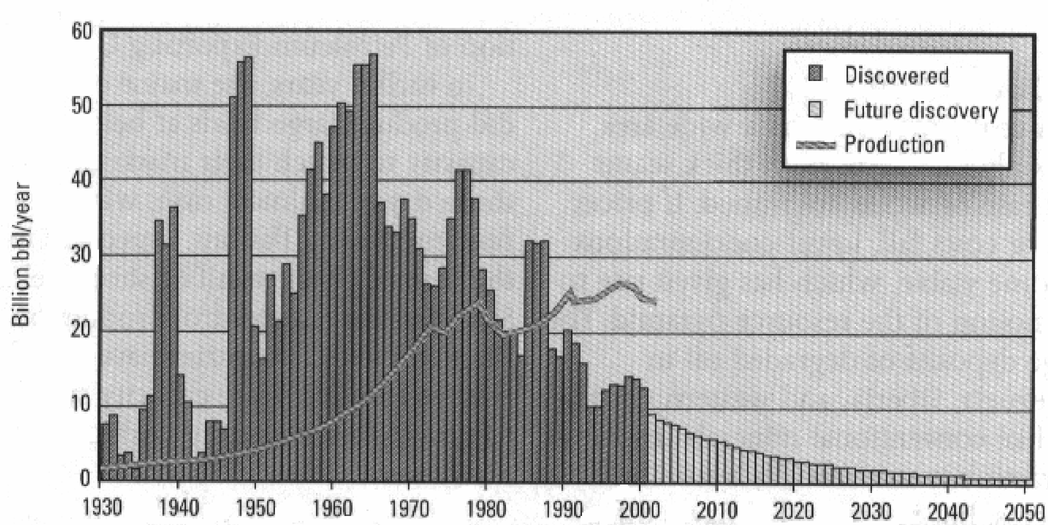
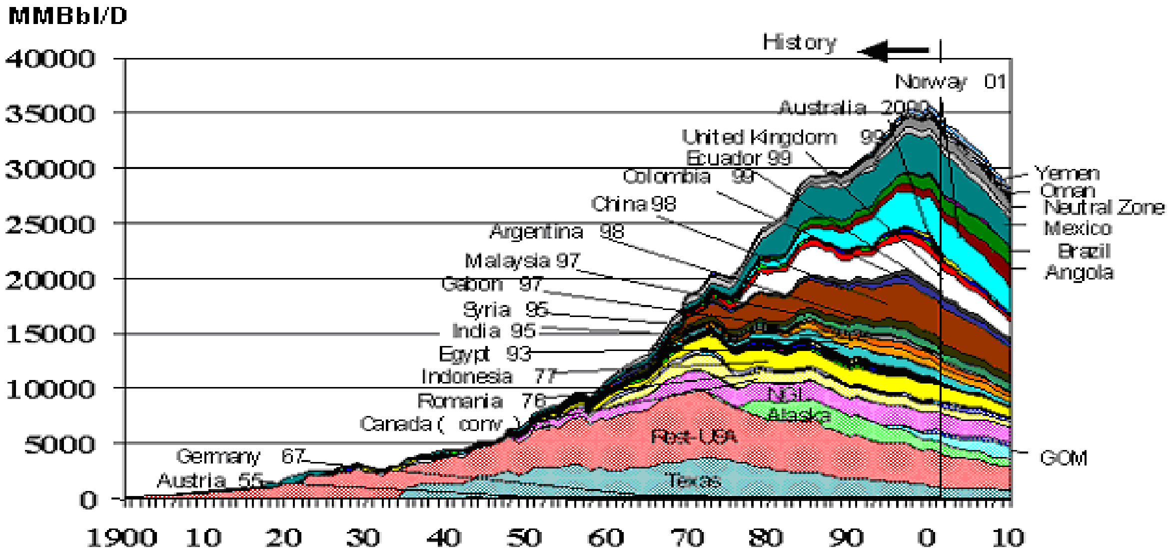


Figure 7. Non-OPEC, non-FSU Oil Production Has Peaked and is Declining (Ref. 17



non-Former Soviet Union Countries (non-FSU) have already peaked and are currently declining (***Figure 7***).

The production cycle of the countries shown in Figure 7, and the cumulative quantities produced reasonably follow Hubbert's model (see Appendix A for a more in-depth discussion). Although there is no agreement about the date that world oil production will peak, forecasts presented by USGS geologist Thomas Magoon (Ref. 6), the OGJ, and others expect the peak will occur between 2003 and 2020 (the year the prediction was made follows the name). What is notable about these predictions is that none extend beyond the year 2020, suggesting that the world may be facing shortfalls much sooner than expected by the EIA.

2003 – Campbell, 1998

2003 – Deffeyes, 2001

2004 to 2019 – Bartlett, 2000

2007 – Duncan and Youngquist, 1999

2008 – Laherrère, 2000

2010 to 2020 – International Energy Agency (IEA), 1998

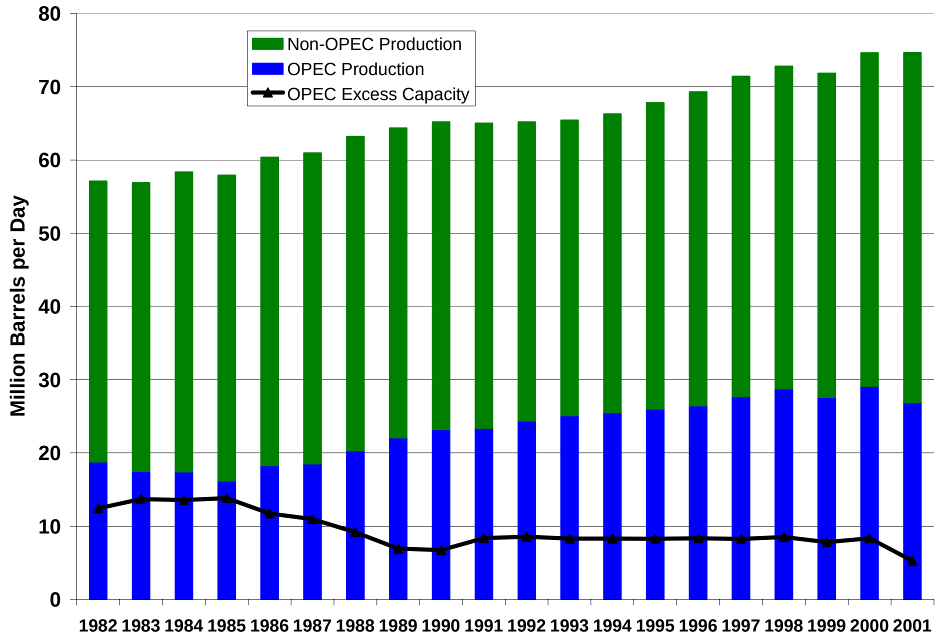
2020 – Edwards, 1997

World production has not yet peaked because output from Russia is growing and, at this point in time, OPEC has excess capacity. The United States and other oil consuming nations of the world are dependent on OPEC not only for imported oil, but also for data and information related to OPEC reserves. As a matter of policy, OPEC holds confidential the estimated oil reserves of the OPEC members.

For the past two decades, OPEC, primarily Saudi Arabia, has assumed the role of the world's "swing" oil producer. Swing capacity entails the ability to offset increases or decreases in supply elsewhere in the global market by increasing or decreasing oil production, thus maintaining market equilibrium and dampening the economic impacts of supply changes. By 1982, OPEC had developed a surplus productive capacity of about 63 percent of its annual production. However, OPEC's excess productive capacity declined significantly over the next 20 years, as shown in ***Figure 8***, and is now less than 5 MMBbl/day, or about 20 percent of current annual OPEC production.

Once OPEC's excess productive capacity is gone and its oil production peaks, OPEC

Figure 8. OPEC Excess Productive Capacity Is Declining (Ref. 18)



exports will begin an inexorable decline. At that point in time, the oil markets will shift from what has traditionally been a buyer's market to a seller's market. The production decline and shift of control to the sellers could produce escalating world oil prices.

4.4 Effect of Investment on Oil Production

Models that predict continuing growth in supply also assume that investment capital and investment opportunities with acceptable risks will be available. Because the models are based on correlations of historic relationships, the predictions necessarily assume business-as-usual (Ref. 12, p 49). Hubbert models do not directly address investment and instead look at the historical experience of producing fields. The Hubbert analysts assume that sufficient new exploration and production investments will NOT be made, because adequate geologic opportunities will not be present. Therefore, projections of increased investment may NOT be realized. For example:

> *"Foreign direct investment in some Middle East countries has practically dried up..." "These [investment] trends suggest that there is a lack of new investment opportunities that can generate returns high enough to satisfy shareholders." (Ref. 19, pg. 20).*

A major part of the world's future oil supply must come from OPEC sources, principally Saudi Arabia. Saudi Arabia has been able to maintain a production capacity of about 10 million barrels per day. The Saudi productive capacity is projected by EIA to nearly double, increasing to 19.5 million barrels per day by 2020 (Ref. 9, page 235). It is not now apparent, however, that adequate investments are being made in the Saudi fields to double oil production by 2020.

Economic, political and legal risks are significant factors when making investment decisions. Without the opportunity to find and produce oil, within acceptable levels of risk, capital investments will not be made. Without massive new investment, new supply cannot keep up with demand. Production will peak and decline and oil prices will rise.

5.0 Significance of Oil Shale Development

Projected demand compared to potential supply suggests a continued widening of the gap between oil demand and oil supply. The essential policy question for the United States is how will this gap be filled? The potential impact on the U.S. economy is a critical question that requires immediate attention.

Every effort needs to be made to reduce oil demand. Conservation and improved end-use efficiency are essential. Higher (real) prices will naturally force consumers to conserve and live within supply constraints. However, a severe supply-demand discontinuity could lead to worldwide economic chaos.

One of the most cost-effective initiatives the United States could take to prevent this from occurring is to reduce its own call on world oil by supplying more of its own needs. Bringing new liquid fuel supplies on line in significant quantities in the near future may be essential to achieving this goal.

The adverse impacts of shortfalls could be substantially mitigated by development of fuels derived from oil shale. The oil shale resources of the Nation total 2 trillion barrels. As much as 750 billion barrels has a richness of 25 gal/ton or greater and could be produced with near-term adaptations of existing technology.

Without arguing the rate at which shortfalls may occur, and instead looking to what is possible with a coordinated industry-government effort, it is possible that an oil shale industry could be initiated by 2011, with an aggressive goal of 2 MMBbl/D by 2020. Ultimate capacity could reach 10 MMBbl/D, a comparable capacity to the long-term prospects for Alberta's tar sand.

An analysis was conducted to assess the potential benefits and impacts that could be achieved by the development of a domestic shale oil industry. The results of that analysis are provided in the remainder of this section of the report.

Oil shale development can play a vital role in the future economic well-being of the Nation. While oil shale's direct economic value to the Nation may approach $1 trillion by 2020, other strategic and national security benefits may not be fully measurable in dollars. The benefits of oil shale development will continue well beyond the forecast period, as the resource base is capable of producing for more than 100 years.

5.1 Significance to Oil Price

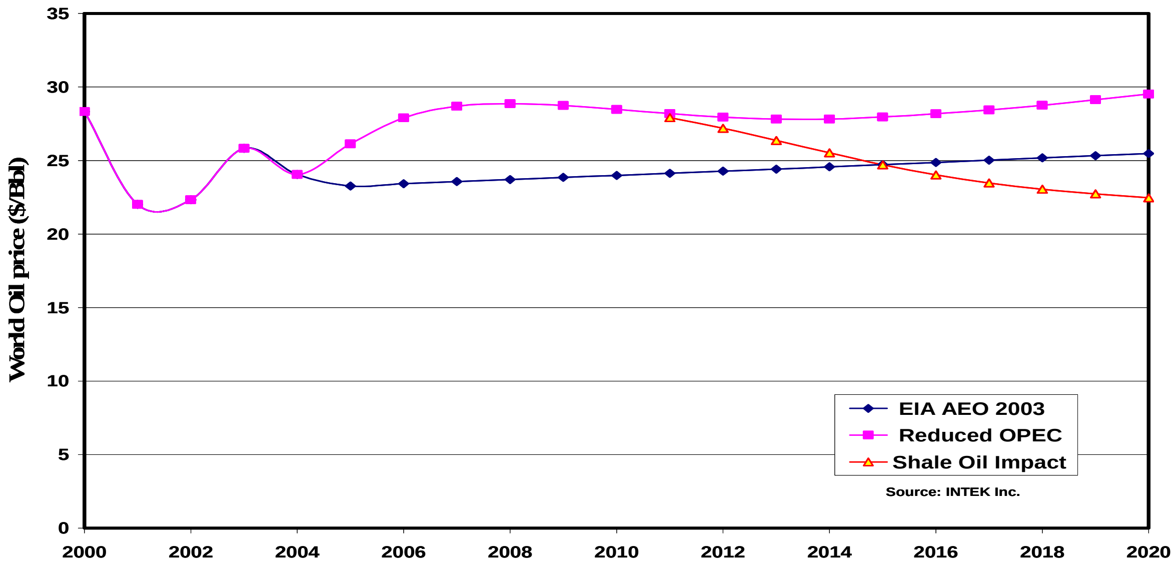
Higher world oil prices will increase the costs of gasoline, distillate oil, jet fuels and other products made from petroleum, negatively impacting economic activity and reducing the U.S. Gross Domestic Product (GDP). The impacts of higher prices on the U.S. economy were evaluated for the purpose of this study (Ref. 20).

The analysis assumes that the established decline in OPEC productive capacity (see Figure 8) will continue through 2020. Continued loss of OPEC excess productive capacity will tighten world wide supplies and increase the world oil price by an estimated $5 per barrel (in constant dollars) as compared with the EIA AEO 2003 forecast (***Figure 9***).

The analysis assumes that shale oil production begins in 2011 with initial production of 0.2 MMBbl/D and reaches an aggressive goal of 2 MMBbl/D by 2020. Shale oil development will decrease U.S. demand on world oil supplies; which will reduce the world oil price by over $5 per barrel as compared to the reduced OPEC case.

The positive impact on world oil price shown in *Figure 9* will continue beyond the forecast period, since production will continue and., unlike conventional petroleum, there will be no natural production decline associated with the resource. Shale oil production can con-

Figure 9. Reduced OPEC Productive Capacity Will Increase Oil Prices (Ref. 20)



tinue at a constant, or increasing, rate for many decades.

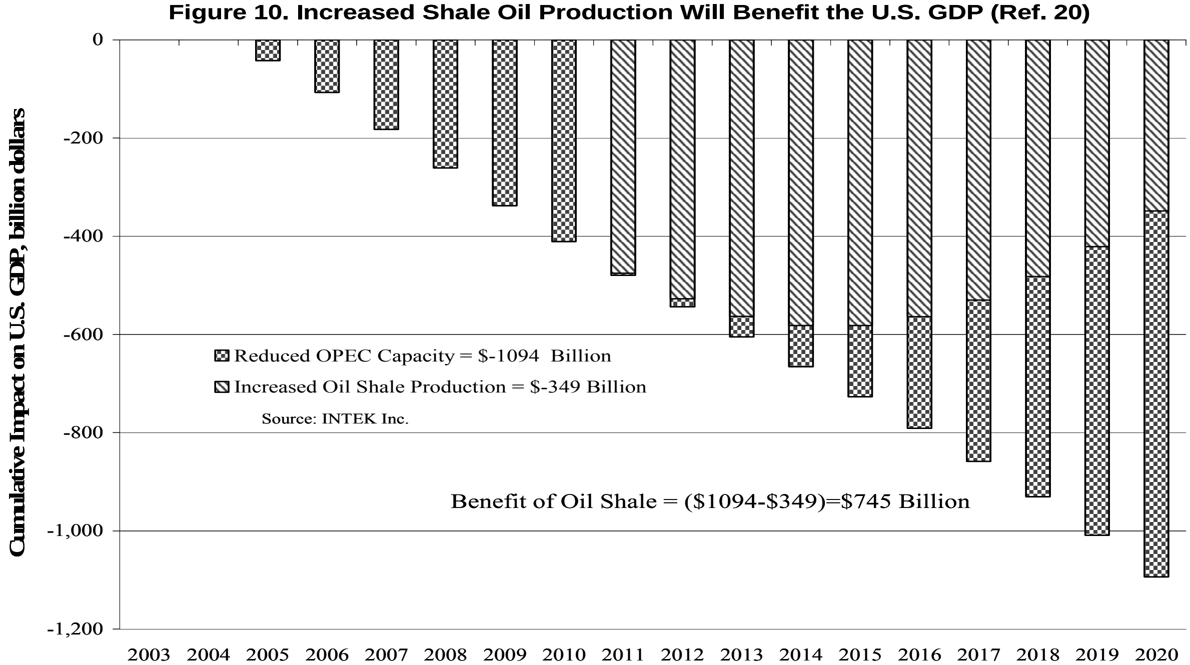
5.2 Significance to Gross Domestic Product (GDP)

Over the forecast period, reduced world oil supplies will cost the U.S. economy $1.1 trillion as higher world oil prices drive up the costs of gasoline, jet fuel, distillate, and other products (***Figure 10***).

This cumulative negative impact on GDP begins to moderate when shale oil becomes available in 2011 and increased oil supplies cause the world oil price to fall. By 2020, the cumulative negative impact on the GDP has been reduced from $1.1 trillion to $0.3 trillion. Oil shale development therefore has a direct positive value to the U.S. economy of $0.8 trillion over a 10-year period. With continuing shale oil production the value to the economy will accumulate beyond the forecast period.

Shale oil production could directly offset much of the loss of OPEC production, and hold down both world oil price and, the price consumers pay for gasoline and other fuels.

Figure 10. Increased Shale Oil Production Will Benefit the U.S. GDP (Ref. 20)



5.3 Natural Gas By-Products

Natural gas, a clean-burning fuel, is an essential component of the Nation's energy future. North America has been able to meet most of its natural gas needs in the past, but there will be a growing shortfall of domestic gas production to supply increasing demand. To fill this gap, the United States is beginning to turn to Liquefied Natural Gas (LNG) imports. It is apparent that the Nation will soon become increasingly dependent on LNG imports to satisfy its projected natural gas demand.

Shale oil development could contribute to domestic natural gas supply in two ways:

1) shale oil can be used as a substitute for natural gas feedstocks in chemical processes, and free up natural gas for other uses, and
2) in-situ technologies for shale oil production can produce as much as one-third of the heating value of its total production in the form of natural gas (discussed in Volume II).

5.4 Consequences of Failure to Act

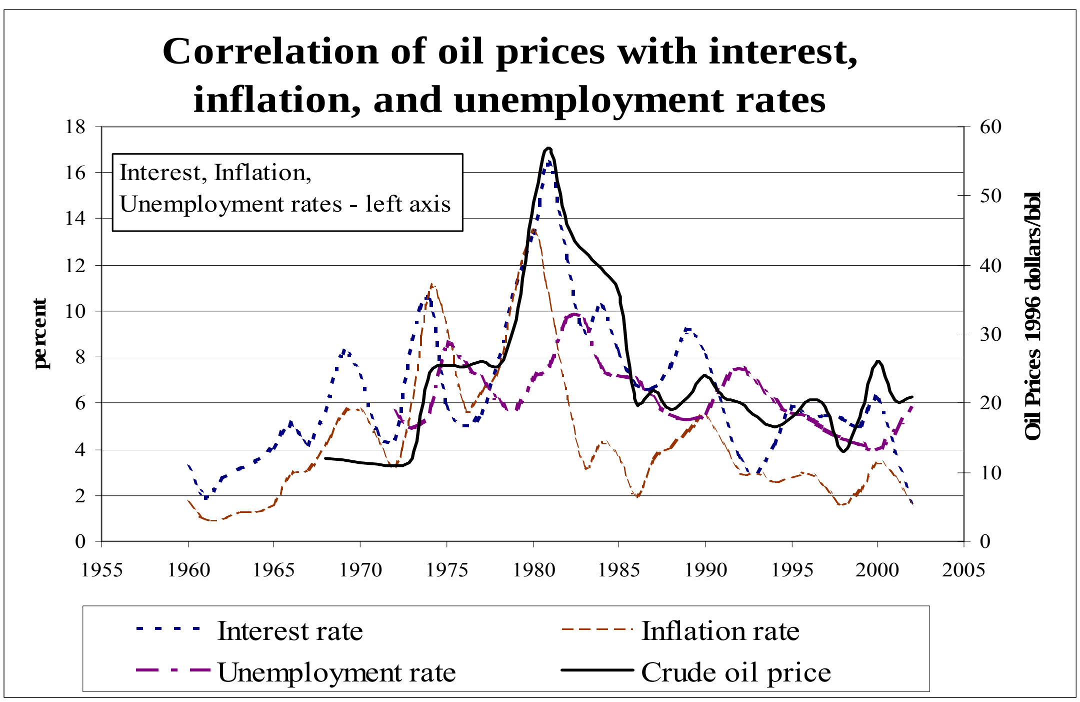
Worldwide competition for oil could result in price escalation and supply disruptions similar to those experienced in the 1970s. Unlike the crisis of the 1970s however, this time relief by simply finding more conventional oil will not be possible.

During the oil price shocks of the 1970s the United States experienced rising interest rates and high inflation, resulting in the condition known as 'stagflation', defined as slowing growth in the economy accompanied by a general rise in prices. The relationship between oil price, inflation, interest rate, and unemployment is presented in ***Figure 11***.

The effects of the oil price spike of the 1970s are succinctly summarized by Blanchard as follows:

> *"…the four-fold increase in oil prices imposed by OPEC in 1973-74 raised price levels throughout the economy while slowing economic growth at the same time. This left policy-makers in a quandary.*
>
> *World central banks, worried about a se-*

Figure 11. Correlation of Economic Variables over the Past 40 Years



> *vere economic slowdown, chose loose monetary policies and inflation took off. The 1973 Arab oil embargo created a massive price rise and economic dislocation, from Tokyo to Paris to Chicago. The explosion in oil prices ushered in a decade of "stagflation" in which inflation soared while economies stagnated. By the end of the decade, the United States experienced double-digit unemployment, double-digit inflation and double-digit interest rates." (Ref. 21)*

In the 1970s, a 5 percent imbalance between supply and demand created shortfalls of liquids, gasoline, and long lines at the pump. At that time, high price was less of a worry than availability of fuel. Such a loss, even though a small percentage of total needs, was enough to adversely affect the flow of goods and the mobility of people, with severe consequences to the U.S. economy.

The period of the 1970s represents a model, at least for the early stages of a supply shortfall. If peak production occurs unexpectedly, the United States will likely experience all of the negative effects seen in the 1970s. The comfortable supply situation of the past decade gives an impression that the favorable supply trends can continue indefinitely. The danger is that we are now lulled into a false sense of security.

Realistically, there are no economically acceptable alternative sources for (liquid) fossil fuels, other than fossil resources themselves, in the intermediate time frame. Oil shale and coal represent our largest, most economically attractive fossil energy resources. A serious shortfall can only be avoided through proper planning and effective action to enable development of these resources before the coming crisis occurs.

5.5 National and Public Benefits of Unconventional Fuels Development

The United States has a unique opportunity to provide a secure future of fuel supplies by developing its vast western oil shale resources. Canada has already taken major steps in developing its vast tar sands deposits. This development, reviewed in Volume II, has resulted in oil production that is approaching 1 MMBbl/D. Production is expected to increase to 2.5 MMBbl/D by 2025.

The Alberta Energy and Utilities Board estimates that the proven tar sand reserves total 174 billion barrels. *Oil & Gas Journal* (OGJ) accepted the estimate of tar sand reserves (Ref. 22), vaulting Canada up the ranks of the world's largest reserves, ahead of Iraq and just behind Saudi Arabia. OGJ created a brief storm of controversy, since, for the first time, unconventional oil reserves were used to extend conventional oil reserves. Now, it is generally accepted that Alberta tar sands can be produced at a profit and can certainly compete against the world price of crude oil. Similar development is possible for U.S. oil shale resources.

Oil shale deposits are located throughout the world, but the richest known deposits are concentrated in the United States, specifically in Colorado, Utah, and Wyoming. Oil produced from shale can be refined to high quality military fuels and gasoline for domestic use.

With a resource base of 2 trillion barrels, oil shale has a production potential similar to the tar sand resources of Canada. Once developed, U.S. oil shale resources will be similar in extent and energy potential to Alberta's tar sand reserves. When oil shale and tar sands are considered together, the United States and Canada will be able to claim the largest oil reserves in the world. These resources can serve as North America's energy bridge to the future, until other energy resources and technologies can be developed and commercialized.

Production of liquids from oil shale and coal is conducted on a small scale in other parts of the world, but in the United States, there is no comparable industry that is producing oil from these unconventional resources. Past technical studies, research and development, and field operations have proved the existence of these resources. They are of sufficient magnitude and quality to supplement domestic oil production, and to slow down and possibly even offset the rate of decline. The significance of the strategic potential of oil shale development is quite clear.

5.6 Benefits of Oil Shale Development

Oil shale development holds the promise of assuring the Nation's secure access to strategically important fuels to drive the economy, meet national defense needs, and fulfill global commitments. Commercialization will provide significant public benefits, including: increased fuels availability (both liquid and gas), improved military readiness, reduced risk of supply disruptions, reduced imports, improved balance of payments, new federal and state royalty revenues, new federal and state tax revenues, and increased domestic employment and increased economic growth.

As an important secondary benefit, development of oil shale will place appreciable downward pressure on the world prices of crude oil, improving not only America's economy, but also that of the rest of the world.

Reduced Price of Crude – A long-term reduction of oil price spurs GDP growth by reducing the input costs to manufacturing and transportation industries

Increase in GDP – As discussed in Section 5.2, a domestic oil shale industry with a productive capacity of 2 MMBbl/D by 2020 would largely offset the $1.1 trillion in negative impacts on gross domestic product that will likely occur if OPEC productive capacity continues to fall.

Improved Balance of Payments – Greater domestic production both reduces imports and lowers oil and product prices, directly reducing the Nation's balance of payments deficit.

Increase in Employment – The direct economic activity associated with western oil shale production will be concentrated in largely rural areas of Colorado, Utah, and Wyoming. This activity will result in high-paying direct new jobs in the oil shale industry, as well as indirect new jobs attributed to other commercial activity in support of the oil shale industry. Actual labor requirements will depend on the mix of technologies chosen by industry to develop the resource. However, as many as 100,000 direct and indirect new jobs could be created by the construction and operation of a 2 MMBbl/D shale oil industry (Ref. 23).

Assured Supply – Perhaps even more important than the direct economic benefits, oil shale will experience high production assurance. Once proven, oil shale resources could be viewed as strategic reserves to be conserved or produced at greater rates, as needed. America has been the most efficient producer of oil and natural gas in the world. The same principles of resource conservation and production efficiency will likely be applied to oil shale resources.

Increased State and Local Tax Revenues – State and local revenues will increase with new revenues from income taxes, sales taxes, resource severance taxes and royalties, real estate taxes, and other revenues associated with the increased economic activity.

Increased Federal Revenues – Federal revenues will be enhanced by corporate and personal income taxes generated by direct and indirect economic activity associated with oil shale development. In addition, mineral royalties and lease fees will grow from the development of a domestic oil shale industry. As the steward of more than 80 percent of the richest oil shale lands in the Nation, the Federal government could collect royalties and lease payments of about $2 billion/year (2 million barrel/day production) from oil shale development on Federal lands. Currently, 50 percent of Federal lease royalties from public lands is shared with the producing States.

Development of Technology for Export – The development of environmentally-sound, efficient shale oil production technology experience and know-how may prove applicable in other parts of the world. Approximately 26 other countries possess commercial quantities of oil shale to which U.S. developed technology may be applicable. New technology may provide the basis for business opportunities while simultaneously easing the world petroleum shortfall.

Strategic Benefits – Domestic oil shale production would provide assured liquid fuel supplies for over a hundred years, ensuring the Nation's ability to meet its international obligations around the world.

Greater Supply Diversity – Oil from oil shale will be a new source of conventional transportation fuels, as unconventional fuels are developed and commercialized.

Favorable Fuel Quality – Shale oil with its favorable chemical composition, would become the preferred source of premium aviation turbine (jet) and diesel fuels.

Policy decisions by State and Federal officials to encourage, stimulate and accelerate private sector investment in oil shale commercialization will impact the extent and timing of these potential national and public benefits. Public policy options, including commercialization incentives, that might be considered to reduce barriers and stimulate investment are presented in the next section of this report.

6.0 Policy Issues and Options

Clearly, policy-makers have strong reasons to promote oil shale development for the purpose of ensuring the secure availability and affordability of fuels to drive the Nation's economy, to provide for the national defense, to foster the creation of new jobs, and to meet America's responsibilities and commitments around the world.

The Federal government is the steward of the vast majority of the Nation's high-yield oil shale resources. The Federal government has an inherent role to help mitigate economic, technical, regulatory, and institutional barriers and constraints to facilitate industry investments and activities required to achieve national goals. Development of the Nation's oil shale could avert major costs to the economy and deliver significant strategic national and public benefits.

Energy resource development and commercialization are primarily private sector functions. However, private industry is unlikely to place billions of dollars of investment capital at risk for oil shale development in the absence of a clearly articulated and well-defined national policy.

A clear statement of national policy is needed, to the effect that: *efficient oil shale development, conducted within the principles of resource conservation, and with respect for the environment, is critical to the Nation's security and future economic health and should be vigorously encouraged and pursued.*

It will be important to evaluate public policy issues and options associated with oil shale in the context of the full range of alternatives that are available to stimulate increased domestic fuels production. Currently, these alternatives include heavy oil and tar sand, coal liquids, gas-to-liquids (GTL), hydrogen, gas hydrates, and renewable energy resources, as well as oil shale, which is the focus of this report.

Effective public policy cannot be made in a vacuum. Numerous stakeholder concerns must be identified, addressed and resolved, as summarized in ***Table 1***. As the analysis and consideration of alternatives proceeds, input from all public and private stakeholders will be needed. Achieving consensus on the need for oil shale development, acceptable approaches, and effective incentives and controls can yield the community's "permission to practice", allowing development to proceed.

6.1 Public Policy Issues

Public policy issues associated with development of Western oil shale resources and associated barriers to commercialization were identified and addressed in prior commercialization efforts (Ref. 24 and Ref. 25). The issues are considered in several general categories:

Technology (6.1.1)

Economic (6.1.2)

Environment and Regulation (6.1.3)

Socio-economic Impacts (6.1.4)

Other Institutional Barriers (6.1.5)

Many of the issues have been mitigated by lessons learned, advances in technology, changes in public policy or changes in global petroleum economics and market outlook. Others may have been exacerbated by regulations or resource constraints that are more stringent.

6.1.1 Technology Constraints and Policy Issues

Technology constraints can impact energy project performance, reliability, efficiency, product quality, and environmental impacts, as well as project economics. Technologies for mining and preparation of oil shale ore and for upgrading shale oil for use as fuels or chemical feedstocks are largely proven, although not at commercial scale. Technologies for in-situ recovery or surface retorting will require addi-

Table 1. Strategic Fuels Target Audiences and Stakeholders

Sectors	Category	Concerns	Members
Federal	Defense	Domestic defense fuels, Global force projection fuels, Supply disruption impacts and contingencies	DoD, NSC
	Energy Resources	Adequate, affordable fuel supply, Technology readiness, Resource evaluation/access/leasing, Environmental protection	DOE, NAS/NRC,DOI / BLM / USGS, EPA, DOT
	Legislative	Economic growth, Employment, Budget	Appropriations, Armed Forces, Energy Resources, and Budget Committees; Western and Eastern oil shale state members
	Executive	National security, Budget, National economy	NSC, OMB, Treasury
State and Local	Governors, Legislatures, Counties and Localities	Jobs, Water resources, Economic activity, Infrastructure, Environment	Utah, Colorado, Wyoming, among other states
Industry	Energy Mining Refining Chemical	Capital investment, Labor supply, Product markets, Government policy, Oil price/investment risk, Access to capital, Resource access, Compliance costs	Large and Small Companies, Technology Manufacturers, Industry Associations, NPC
NGOs	Energy, Environment, Citizen groups	Impacts on air, water, land use, ecosystems and socioeconomics.	NRDC, Sierra Club, Brookings, RFF Other interest groups
International	Economy, Trade	Economic growth/recession, Capital flows	OECD/ IEA; Estonia Canada, Australia, China, Brazil

tional development work. Scale-up engineering requirements may add significant front-end development costs. Industry will rely first on current commercial practices and the experience of the past, in matching technologies to resource characteristics and settings. There are numerous technology barriers still to be overcome. Public policy options that are available to help industry overcome these barriers are listed in ***Table 2***.

and surface restoration may be adapted from other industries.

Lessons learned from previous experience with near commercial-scale pilot plants, and advances developed since 1991, should now be applied and demonstrated for Western oil shale production at commercial scale in the United States.

An initial commercial-scale plant provides the opportunity not only for technology improvement from operating experience, but also to reduce greatly the uncertainties in capital and operating costs.

Table 2. Technical Barriers and Policy Options

Technical Barriers	Policy Options
Surface retorting technology is ready for commercial scale demonstration (>10,000 Bbl/D), but not proven. New ATP process is not proven with U.S. western oil shale.	Federally-funded R&D. Commercial loan guarantees, Federal R&D tax credits to stimulate private sector R&D investment and assumption of risk.
In-situ recovery technology is not proven at commercial scale; technology advances suggest feasibility with additional R&D.	R&D tax credits to advance and demonstrate pure and MIS approaches. Assured prospects for price floors that minimize risks for large investment.
Shale mining; Both open-pit and room-and-pillar mining are demonstrated; Selection criteria reflecting optional mining approach by resource and process would be useful.	Publishing a mining process selection and criteria matrix could advance future projects.
Upgrading: oil cleanup, metals and minerals treatment, and value-enhancement processing.	CRADAs (Cooperative Research and Development Agreements) Competitive solicitations with cost-sharing.

Many processes were demonstrated at pilot scale between 1940 and 1990. Surface retorting technology has been further advanced by the evolution of the ATP process in Canada and its field demonstration in Australia. In-situ conversion and recovery technology continues to advance with laboratory and field research currently underway by Shell Oil in Colorado. R&D has also yielded improvements in oil shale processing. Use of shale oil as an asphalt additive in more than 20 field tests has established its benefit for improving asphalt life.

Similarly, environmental controls developed for other energy industries, including coal mining, petroleum refining, power generation, and chemicals manufacturing, appear to be applicable to future oil shale projects. New environmental technologies, especially related to reduction of emissions, effluent discharges

Design, development and demonstration activities will likely be conducted by industry, if economic, regulatory and institutional risks and barriers to oil shale technology advancement and commercialization are identified and resolved. Once the strategic benefits of making significant shale oil production available to the economy are recognized, government can help accelerate the pace of industry R&D through a variety of incentives, including R&D tax credits, perhaps with little or no revenue impact to the federal treasury. Government funded or cost-shared R&D should focus on resolving potential 'showstoppers' in resource accessibility, technology and products.

6.1.2 Economic Barriers and Policy Options

America has viable domestic energy resources and can implement effective policy options to provide liquid fuels to help meet the Nation's needs, reduce economic impacts of tighter global oil markets, and meet strategic requirements to fuel our military. Policy options include measures to stimulate development of heavy oils, oil shale, coal liquids, gas liquids, and gas hydrates, among others.

Sufficient lead-time is required, however, to commercialize any supplement to conventional petroleum production. The Nation must start now to respond to peaking global oil production to offset adverse economic and national security impacts.

The major barriers to oil shale industry commercialization in the United States are economic. Massive capital investments will be required by industry. Long lead-time will precede commencement of revenue streams. Policies that shorten lead-times or reduce pre-revenue and early stage capital and operating costs will have an enormous beneficial effect on project economics.

Shale oil has been proven in large-scale tests to be a high quality and environmentally desirable feedstock for jet fuel and other military and civilian fuels. There is little doubt that the domestic market can absorb every barrel of shale oil produced as offsets to imported crude oil. Extraction of nitrogen compounds and other marketable chemicals from shale oil can add to its value, although these markets may be limited in volume

The SOMAT (shale oil modified asphalt) product used as an additive in asphalt paving has been demonstrated to extend pavement lifetime. This value-added use could increase the revenues for commercial production.

The principal economic barriers to commercial development of U.S. Western oil shale resources continues to be the risk associated with the price-volatility of conventional petroleum, and the uncertainty of capital and operating costs (including environmental costs) in commercial-scale technologies. These uncertainties need to be resolved to facilitate capital formation and project investments.

Implementation of forward purchase agreements with price floors can be an effective tool for reducing investment uncertainty and improving access to capital.

Policy makers must decide whether and how to reduce economic risks, stimulate capital formation, and provide incentives for private sector investment for the first group of commercial scale oil shale projects. They must not only consider the extent to which incentive options will stimulate commercialization, but also assess their impacts in terms of public and private administrative burden, relative impacts on small versus large companies, impacts on industry competition, and costs to state and federal treasuries.

Economic incentives could take a variety of forms, including: (1) tax credits (R&D, investment, or production); (2) royalty relief for oil shale processed from federal lands; (3) agreements to purchase shale oil or take royalties-in-kind for defense stockpiles or Strategic Petroleum Reserve use at a predetermined, minimum price, (4) price supports and/or (5) loan guarantees (***Table 3***). A comprehensive federal oil shale program plan should be developed that includes a cost-benefit analysis of various policy options and incentives.

6.1.3 Environmental Barriers and Policy Issues

The full environmental impacts of commercial oil shale production are not fully known but are expected to be significant for mined shale facilities and less so for in-situ production. The high areal density of oil shale will result in less land disturbance per unit of production than many other forms of energy production. Volume II discusses this characteristic further.

Table 3. Economic Barriers and Policy Options

Economic Barriers	Policy Options
Capital and operating costs for some processes are uncertain	Analyze and update investment cost estimates for various projects to provide basis for cost-beneficial analyses of policy options and incentives
Capital formation is constrained by high capital costs Higher risk premiums and hurdle rates will be required Capital availability may be constrained if numerous high cost projects initiate simultaneously. Massive investment and long lead times prior to revenues.	Extend R&D tax credit; allow early expensing, or adjusted depletion allowance (including allowance for in-situ) Accelerated depreciation Investment tax credits (Additional X percent) Federal royalty relief Federal loan guarantees Direct Federal loans or subsidized interest loans Price Floors
Market demand for refinery feedstock and chemical byproducts are significant, but not well-quantified	Conduct detailed assessment of shale oil and chemical products demand and logistics in refinery, chemical, defense, or other industries
High / uncertain environmental and regulatory compliance costs	Resolve environmental / regulatory uncertainties
Oil price uncertainty / volatility	Purchase guarantees (such as for SPR or defense reserves) Price Floors Production tax credits ($/ Bbl) Federal royalty relief

Federal standards for air quality, surface and groundwater quality, land reclamation and restoration, and ecological and health effects have matured and stabilized since earlier efforts to develop oil shale. Laws, regulations and practice have resolved much uncertainty in the regulatory arena, with the expected result of reducing the time and expense required to achieve permitted design.

Technical approaches and controls have been developed in coal mining, petroleum production, refining, and chemical industries to comply with stringent environmental standards. Such technologies are being adopted worldwide, yielding extensive industrial experience. These technologies are likely to be directly applicable or adaptable to prevent, reduce, or mitigate environmental impacts of oil shale development. These expectations, however, need to be validated (***Table 4***).

Major uncertainties include potential future changes in environmental regulations as well as lengthy permitting processes that may vary by state or locality. Federal, state, and local regulatory authorities may wish to consider consolidating regulatory requirements and es-

Table 4. Environmental Barriers and Policy Options

Environmental Barriers	Policy Options
Lack of environmental data on oil shale operations at commercial scale	Collect and assess environmental data from pilot projects and recent advances Permit new commercial scale pilots, based on extant standards and use of BACT
Long lead times for project permitting; uncertainty associated with changing regulations and standards	EPA and States can consolidate and streamline the permitting process
Federal standards for air quality, surface and groundwater quality, reclamation and restoration, and ecological and health effects have matured, but continue to change	Grandfather environmental standards to those in effect or publicly announced on date of a filing of project development intention.

tablishing a uniform permitting process to reduce permitting lead times and accelerate industry development. Examples of regulatory streamlining efforts considered by oil and gas-producing states may prove to be of value in accelerating this effort. Clearly, permitting can be accelerated for projects that have demonstrated through commercial practice that environmental impacts can be controlled.

Establishment of a Federal oil shale development activity will likely constitute a "major action" under the terms of the National Environmental Protection Act (NEPA) and require the development of a programmatic Environmental Impact Statement. A substantial and comprehensibe EIS developed for the Prototype Oil Shale Leasing Program is available that could be updated to support this requirement expeditiously.

6.1.4 Socio-Economic Issues

Development of a commercial-scale oil shale industry in the areas encompassing the Green River Formation in Colorado, Utah, and Wyoming could have significant socio-economic impacts on these areas, including increased housing requirements, schools, health care, transportation, utilities, and waste treatment facilities to support the influx of population that will be required to construct and operate oil shale in-situ, mining, surfaceprocessing, and refining facilities (***Table 5***).

These issues and associated costs will influence the timing and scheduling of oil shale plant construction and development. Considerable analysis of these issues was conducted in preparation for the projects expected to be constructed during the 1980s and 1990s by Department of the Interior, by the U.S. Congress Office of Technology Assessment, and by the National Academy of Sciences. These sources can be used to underpin and expedite future analyses and policy decisions.

Federal and/or state financial support may be required to facilitate desired development schedules and to reduce the fiscal impact of investments that will be required well before tax revenues from oil shale operations begin to offset them. Assistance and incentives to states and localities could include block grants, federal loans and land grants among others.

As previously noted, addressing stakeholder concerns will be of major importance. Perhaps a lesson can be taken from the success of the inclusive and deliberative approach taken by the Province of Albetrta in development of its tar sand resources. The Alberta Chamber of Resources refers to the balancing of disparate interests and beneficial management of socio-economic issues as ensuring "permission to practice." Achieving "permission to practice" will be essential to renewed efforts to develop U.S. Western oil shale resources.

6.1.5 Institutional Barriers - Resource Availability and Land Management Issues

About 80 percent of the estimated oil in place in the oil shale resources of the Green River Formation lies beneath public lands administered by the Federal Government. The re-

Table 5. Socio-Economic Barriers and Policy Options

Socio-Economic Barriers	Policy Options
Economic requirements for housing, community infrastructure, and other community support	Make federal lands available for community needs to support development Provide infrastructure development grants for affected communities
Multiple project development impacts	Time leasing of federal lands and project approvals to balance shale oil production targets with appropriate economic growth schedules
Labor force availability	Tax and relocation incentives for workers Training for unskilled workers

maining lands are held by state or private ownership, in large blocks or, more often, in fragmented parcels or isolated sections. In some cases there is on-going litigation over patented mining claims that put resource ownership in doubt. Some companies own awkward parcels of land, which may require exchange of parcels to block up resources into more practical configurations. Additional problems involve conflicting claims on federal oil shale lands with grazing rights and interests in other minerals. Land use issues will need to be solved.

The major institutional requirement will be executive or legislative action to empower the government to reinitiate leasing, increase lease sizes, offer R&D leases, and to help form economic lease blocks for efficient resource development. The BLM has assembled an Oil Shale Task Force to look into the lease policy. They are seeking an indication that industry is interested and willing to pursue leases.

Reasonable land swapping programs can facilitate the fair exchange of public and private lands to achieve this goal.

Federal, state and local land use limitations may also need to be modified to accommodate shale development, mining, retorting and upgrading uses (***Table 6***).

New oil shale technologies have dramatically reduced process water requirements, but stable and secure sources of significant volumes of water will still be required for large-scale oil shale development. The ownership of water in the Colorado River Basin Area, which supplies the U.S. Western oil shale region, has been at issue. However, a recent (October 2003) agreement between the State of California and the upper basin states returns about 0.8 million acre-feet per year to the upper basin states. This additional allocation alone could easily supply the needs of a 2 MMBbl/D oil shale industry. Water use rights will continue to be contested, but disputes can be resolved within existing forums.

6.2 Potential Government Roles

It is appropriate for the government to take substantive action to stimulate or accelerate the development of a domestic oil shale indus-

Table 6. Institutional Barriers and Policy Options

Institutional Barriers	Policy Options
Federal leasing restricted by EO 5237 except for 6 leases opened under Pickett Act in 1973	Initiate federal oil shale leasing program Lease incentives to ensure timely tract development, privatize ownership
Lease area size Limited to 5120 acres; no more than one lease size to any entity	Remove or increaseacreage limitation
Conflicting claims to surface use and mineral rights, including potential oil shale and nahcolite lease conflicts.	Settle claims with Utah and unpatented mining claims; address in lease regulations.
Grazing rights	Resolve issues related to competing surface uses
Water availability is limited and over-claimed.	Resolve disputes over priority rights for water, Minimize water requirements by design changes including recycle, Develop new water storage projects if required
Land use	Amend federal policy to allow surface use of land to accommodate energy development, including rights-of-way and disposal areas
Dispersion of leases	Flexible land / lease exchange program; Block development tracts into economic units

try when national security, economic conditions, or other strategic concerns make accelerated development an urgent national priority or where government policies may have created artificial and/or superficial barriers that constrain industry development.

Policy Role – Consistent with the DOE 2003 Strategic Plan, the government can, and should, articulate and implement a clear statement of policy establishing oil shale as a strategic energy resource that should be developed to mitigate the adverse impacts of changing world petroleum markets, provide for the national defense, and support continued economic growth.

The government should also stimulate an international dialogue on the potential of oil shale resources to meet energy needs and to reduce threats of supply interruptions. International cooperation, information sharing, and collaboration can leverage limited government resources to achieve synergistic benefits.

Organizational Role – Federal responsibility for activities affecting oil shale industry development is dispersed among numerous federal agencies. These agencies include the Department of Energy, the Department of the Interior, the Environmental Protection Agency, the Department of Defense, the Department of Commerce, Department of Transportation, and the Treasury Department, among others. This makes coherent and consistent federal action difficult and complicates efforts of the States and industry to interact with the government on this issue. The government can and should designate a single office to coordinate the interests and activities of the federal government regarding commercialization of a shale oil industry.

Technical Role – Significant public investments in R&D may not be required. Government, however, should encourage and provide incentives for continued and renewed industry investments in R&D and technology advancement. Any federal funded or cost-shared research should be limited to high-risk basic and applied research deemed to be in the national interest, but which would not be performed by private entities in the required time frame without federal involvement or stimulus. Candidates for such R&D activities would be any resource issue, technology hurdle, or product deficiency that could be a 'showstopper' relative to achievement of program goals.

To the extent that oil shale is a global resource rather than a strictly domestic resource, the government should stimulate more aggressive sharing of technology among oil shale companies, as well as with other countries, which, by developing their oil shale resources, could help slow the rate of decline in global liquid fuels supplies.

Economic Incentives – The government can provide temporary incentives to reduce economic risk, stimulate capital formation and investments. These can take the form of deferred revenue and tax credits and accounting changes, such as depletion allowance and allowing expensing in lieu of depreciation for some items. Many of these incentives may be structured to achieve desired outcomes while minimizing the net cost to the government.

An effective means of reducing oil price risk may be to establish forward purchasing agreements from DOD or SPR with minimum purchase prices, perhaps under the existing authorities provided in the Defense Production Act. This resulting price and market certainty would have the effect of lowering hurdle rates that would otherwise be required to compensate for possible revenue risk. The incentives that were included in the Energy Security Act of 1979 should also be reviewed for their applicability today.

Resource Stewardship – In its capacity as administrator of the massive oil shale resources that are located on Federal lands, the Federal government can implement an Oil Shale Leasing Program, expedite resolution of outstanding land claims and mineral rights disputes, and allocate additional public lands as needed to stimulate orderly development. The current limitation of 5120 acres per lease will likely constrain blocking of logical development units and should be reviewed. Efforts already underway by BLM's Oil Shale Task Force should continue to explore options for R&D leases and commercial-scale operating leases. The Government might also consider privatizing some oil shale lands.

Environmental – The Federal Government, in cooperation with affected States, can play a major role in ensuring that oil shale development is conducted in compliance with all regulations and with minimal adverse impact on the environment. Facilitating a collaborative and cooperative regulatory environment and dialogue, stable and consistent rules and regulations, and a streamlined permitting process can help accelerate industry development while protecting the environment and human health and safety.

7.0 Conclusions and Recommendations

Based on the foregoing assessment of the increasing demand for petroleum and the decreasing supply of petroleum likely to face the United States and the global market within the next two decades, and the negative impacts that the expected demand/supply imbalance portends for oil prices, U.S. economic vitality, and secure access to ample fuels for economic and strategic uses, several conclusions and recommendations have been established:

7.1 Conclusions

1. For national security and economic interests, the United States must contain its growing vulnerability attributable to crude oil and refined product imports.
2. The foreseeable peaking and decline of global oil production will reduce the availability of foreign oil supplies to meet U.S. oil import requirements and drive up global oil prices, at a high cost to the U.S. and World economies.
3. Concerns about the reliability and stability of supplies from key oil supplying regions increases the strategic importance of developing secure domestic energy resources to supplement declining oil production, reduce oil imports, defend the Nation, and ensure its ability to meet its global commitments.
4. The United States needs to establish a supply base for its future liquid fuel needs; the two choices of significant magnitude to achieve this goal are oil shale and coal.
5. An estimated 750 billion barrels of shale oil could be recovered from America's massive and concentrated oil shale resource base with currently available technology. Ultimately, more than 1 trillion barrels may be recovered, providing oil for 100 years or more.
6. Existing technologies are available, although not all proven at commercial scale, to convert oil shale to shale oil, fuels, and high value by-products, while protecting the environment. It is possible to initiate an oil shale industry by 2011 with an aggressive goal of 2 MMBbl/D by 2020. Ultimate capacity could reach 10 MMBbl/D, a comparable capacity to the long-term prospects for Alberta tar sand.
7. The national and public benefits resulting from commercialization of a domestic oil shale industry include:
   - Reducing GDP impacts of higher oil prices by $800 billion by 2020.
   - Reduced balance-of-payments deficit, due to increased domestic fuel production, reduced imports, and lower world prices for crude oil.
   - Increasing direct federal and state revenues from taxes and royalties

- Creation of tens of thousands of new jobs and associated economic growth

8. Long lead-times for oil shale projects, ranging from 5 to 10 years from planning to commercial operation for a single project, make immediate public action to stimulate oil shale development necessary.

9. Additional efforts are warranted now in order to provide adequate time for the Federal government and the States to plan for the commercialization of a domestic oil shale industry.

7.2 Recommendations

Based on the conclusions of this analysis and the appropriate roles of the Federal government, described in Section 6 of this report, the following immediate actions are recommended to proceed toward commercialization of U.S. oil shale resources to achieve a 2-million barrel-per-day industry by 2020:

1. Consistent with the National Energy Policy and the U.S. Department of Energy Strategic Plan, the government should articulate and implement a clear statement of policy establishing oil shale as a strategic energy resource to mitigate the potential adverse impacts of changing world petroleum markets, provide for the national defense, and to support continued economic growth.

2. The Administration and Congress should consider designating the Office of Strategic Petroleum Reserves within the Department of Energy to coordinate the interests and activities of the federal government regarding commercialization and strategic reserve potential of a shale oil industry.

   This recommendation is consistent with the Office's current and historic expertise, its direct involvement with international oil shale programs, and its unique position as steward of the largest stockpile of government-owned emergency crude oil in the world and its mission to assure supplies in the event of shortfalls.

3. The Government should immediately commission a detailed study to assess the economic, technical and environmental feasibility of large-scale commercial shale oil development. The study should include an analysis of investment attractiveness and identify those characteristics that may act as impediments to development. This study may be a component of a broader Program Plan.

4. The Government should establish a Program Plan for stimulating oil shale commercialization while protecting the environment. This Plan should establish appropriate metrics to assess program performance relative to specific goals and milestones and should address the costs and benefits of government incentives to stimulate and accelerate industry commercialization.

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Appendix A

Hubbert Modeling and Oil Reserve Growth From Conventional Oilfields

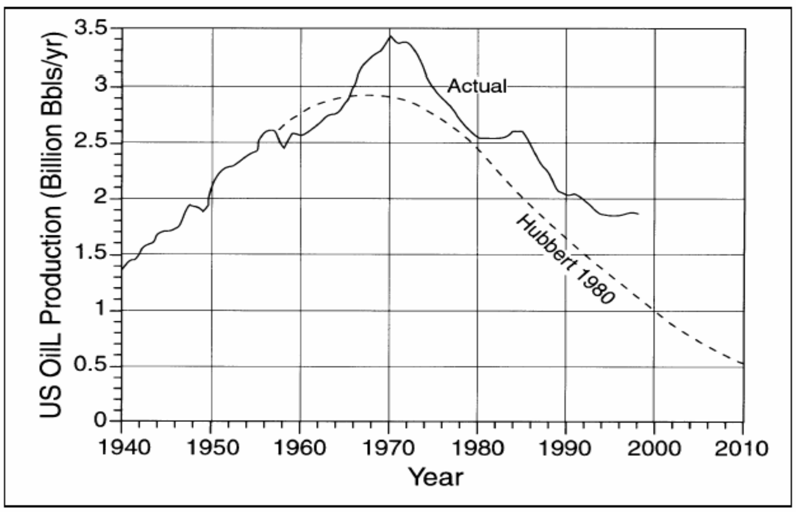
The rate of future petroleum production is the subject of current debate. The root of the supply debate is found in the work of Dr. M. King Hubbert, a Shell Oil geophysicist, who in 1956 modeled annual production in the lower 48 States. At that time Hubbert correctly predicted that U.S. annual oil production would peak in 1970.

Consistent with Hubbert's model, other oil producing areas have also peaked and declined since 1970. According to U.S.GS geologist Thomas Magoon (Ref. 6), this is because:

> *"Production patterns are the same for all oil fields, oil provinces, and countries. They start out with a very rapid rise in production, reaching peak output very soon after they are commissioned. After a while, production levels off and then there is a long period of declining production. This profile of production can be seen in many countries around the world.*
>
> *North America, including the huge Alaskan and Mexican fields, peaked in 1984, the former Soviet Union peaked in 1987, Europe in 2001, Africa in 2001, Asia Pacific region will peak in 2003, South and Central America in 2005, and the Middle East in 2010" (Ref. 6).*

Production in the lower 48 states did peak in 1970 as Hubbert predicted and oil production has continued to fall since that time. However, the production decline has not been as steep as the model predicts (**see Figure A-1**).

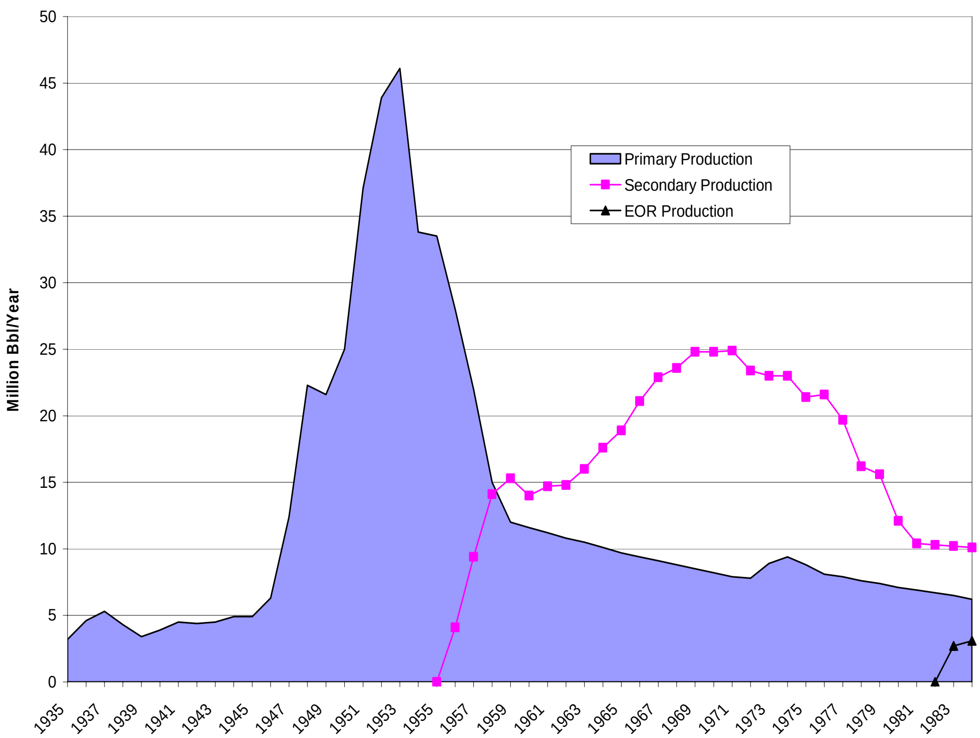
Figure A-1. Hubbert Predictions Useful in Estimating Peak Production (Ref. 26)



A comprehensive analysis of Hubbert's works (Ref. 26) shows that the Hubbert oil production methodology provides consistently low cumulative production results. The primary problem with the Hubbert analyses is reliance on Ultimate Recoverable Reserves (URR) as a single, fixed value. URR is the amount of oil that has already been produced plus the oil that will be produced in the future. In practice, URR continues to increase as oil fields are defined by drilling and as higher prices encourage the application of new recovery technology.

The production history of the largest field discovered in Oklahoma demonstrates the reserve growth process (Ref. 27). Shallow oil production in the Sho-Vel-Tum field was established in 1905. Deeper oil productive intervals were drilled in the 1940's, leading to a rapid increase in primary oil production (**Figure A-2**). Production peaked in 1953 followed by a rapid production decline as the reservoir pressure became depleted. The original URR estimate would consider only the amount of oil to be produced by primary methods.

Figure A-2. Growth of Ultimate Recoverable Reserves in the Sho-Vel-Tum field (Ref. 27)



Water flooding was introduced in 1955 and its application grew steadily. A second oil production peak was reached in 1973 followed by a gradual oil production decline. This second crop of oil is added to the primary production, extending the field URR.

Enhanced oil recovery (EOR) techniques were started in 1982 and oil production began to increase in 1983. Application of these processes will produce an additional crop of oil, further extending the URR.

Oil recovery therefore follows an evolutionary path from primary production to the use of relatively inexpensive recovery methods (water injection that causes physical changes in the reservoir) to the use of more complex and more costly methods (chemicals that cause chemical changes in the reservoir).

Each giant onshore oilfield in the United States was discovered by 1960 (**Table A-1**), and each giant field has already peaked in primary oil production. Sho-Vel-Tum peaked in 1953. The Alaskan fields peaked at 2.017 MMBbl/D in 1988; production in 2001 (0.968 MMBbl/D) was less than ½ of the peak production.

Table A-1. Giant Oilfields Discovered in the United States (Ref. 28)

Location	Giant Field Name	Date Discovered
California	Kern River	1899
	Midway-Sunset	1901
	Belridge South	1911
	Elk Hills	1920
Oklahoma	Sho-Vel-Tum	1905
Texas	Yates	1926
	Wasson	1937
	Slaughter	1937
Alaska	Prudhoe Bay	1967
	Kuparuk River	1969

Each giant U.S. field has been subjected to advanced recovery technologies appropriate to that field. More sophisticated and costly technologies will continue to be applied as warranted by advancing technology and/or higher crude prices.

The United States is a mature oil producing province. Each giant field in the world will go through a production cycle similar to the United States experience. Primary production will peak followed by the application of improved recovery technologies. All predictions (see Section 4.3) show that world oil production will peak in the next few years and production will fall. Falling oil production will cause upward pressure on world oil prices and encourage the application of improved oil recovery technologies. When worldwide demand begins to outstrip supply, energy prices will rise, and with this additional incentive, more in-place resources will become economically recoverable.

Historically, OPEC countries have developed excess capacity and the ability to increase or decrease supply to meet demand has helped moderate oil prices. Even today, oil futures markets are backwarded (future months are cheaper than spot months) because of this excess capacity. But this excess is being lost (see also figure 8). The exact cause of the decline in OPEC excess capacity is not known, but it likely relates to a fall-off in recent investment.

Even if new production investment were to be made eventually, the world's largest oilfields must peak and begin to decline. To illustrate, in 1993, Dr. Ismail of the OPEC Secretariat conducted a comprehensive, field-by-field analysis of capacity expansions that were underway or planned at major OPEC oilfields. In his report, Dr. Ismail noted that production was already declining from the world's largest oilfield, Ghawar in Saudi Arabia:

> *"…part of this capacity addition (in Saudi Arabia) will offset the production decline from old fields, particularly the super-giant Ghawar complex." (Ref. 29)*

Matthew Simmons, president of one of the world's largest energy investment banking groups, observed in 2002 that:

> *"Saudi's Ghawar field, still by far the largest producing field the world has ever known, might last another 100 years. But, the field might also have already peaked. That no public information is available to shed any light on this issue places a giant question mark over the supply from this field." (Ref. 30)*

Simmons suggests that public information related to major OPEC producing fields is simply not available, a situation that casts serious doubt, in itself, on the accuracy of the world oil supply estimates. When Dr. Hubbert made his 1956 prediction, he had access to reliable and accurate field data, which is an established regulatory policy within the United States. Outside the United States, however, such data is not readily available because it is largely controlled by OPEC. This situation hinders accurate forecasting by oil experts and places the oil importing countries at risk.

Oil produced from tar sands and oil shale will become increasingly attractive to supplement conventional crude supplies. Canada has already made the investments needed to build a tar sand oil production capacity approaching 1 MMBbl/day. With the firming of oil prices, some of these resources now qualify as reserves. Reserves associated with this development total 174 billion barrels. This estimate was accepted by the Oil and Gas Journal, vaulting Canada up the ranks of the world's largest producers, ahead of Iraq and just behind Saudi Arabia. For the first time, unconventional oil reserves were used to extend conventional oil supplies.

To put this in the context of the Hubbert models, adding unconventional reserves with conventional reserves makes the URR larger and extends the tail of the curve. It may be too late to avert a worldwide peak in oil production, but bringing tar sand and oil shale into the URR equation promises to extend the tail far beyond what would occur if only conventional petroleum were considered in the model.

Because of its magnitude and richness, oil shale in past years elicited more than a billion dollars in investment. Investment attractiveness is a necessary requisite of future development. The unconventional resources of the U.S. oil shale and Canadian tar sands are larger than total world resources of conventional petroleum. With a resource base of more than 1 trillion barrels, the United States has the richest deposits of oil shale in the world. When developed, shale oil resources will be similar to Alberta tar sand. Between the two Countries, the United States and Canada will be able to claim the largest oil reserves in the world, and these reserves will support secure liquid fuels production for decades to come.

Appendix B

Excerpts of Reviewer Comments

The following comments were derived from written comments provided by reviwers of the draft report as well as from verbal discussions that occurred during question and answer periods and open discussion periods of the peer review meeting. Consistent with the ground rules that were mutually agreed to by peer review participants, comments are not attributed to their specific sources. These comments were organized into several general and specific categories, as follows:

The Problem at Hand

"The central issue is increasing dependence, declining production, and no effective alternative."

"Convincing Government there is a problem may require articulation of that problem to the general public [possibly through the media]."

"Oil shale development will not occur unless Government becomes convinced there is a [supply] problem AND industry becomes convinced there is a prudent investment opportunity."

"Oil shale represents one of only a few options, if not the only option, to relieve our ever-growing dependence on foreign oil, at least in the near term."

Extent and Characteristics of U.S. Oil Shale Resources

"Whether there is 1.5 billion barrels or 1.8 billion barrels of oil shale resource with richness of 15 gallons per ton or better in the Green River Formation doesn't really matter. Either way, more than 700 billion barrels were considered recoverable with technology that existed in the early 1980s. That translates to a lot of oil! Technology improvements since then have no doubt increased the amount that will be recoverable."

"This report should take into consideration Eastern Devonian oil shale. Eastern oil shales also represent important resources for future development, but initial efforts should focus on the kerogen-rich, highly concentrated resources in the West."

"Huge resources exist in Appalachia. Recognition of the diversity of [Eastern] oil shale resources should be made. This resource is large and a considerable portion of it is close enough to the surface and rich enough to mine."

"Eastern oil shale is found on 850,000 acres of land in Kentucky, Ohio and Indiana. 16 billion barrels at an average grade of 25 gal/ton are located in the Kentucky Knobs region. Other commercially attractive formations are the Sunbury shale and Ohio shale. The Eastern oil shale resource could contribute oil in addition to that from Western shale, and shouldn't escape mention."

"Oil shale is a huge resource base and could properly be considered a strategic resource within the mission of the Strategic Petroleum Reserve."

"Competing land use issues need to be resolved. Examples are oil and gas vs. coal bed methane, oil and gas vs. oil shale, competitive vs. non-competitive lease sales, surface vs. subsurface, oil shale vs. nahcolite, etc."

"The currently envisioned BLM short term leasing program, making 40 acres available for research and testing, has merit."

"If expansion of leases beyond the current maximum size of 5,120 acres is required, legislation will be needed [to amend the Mineral Leasing Act]."

"Development will never happen if leases are required. Companies will need private ownership of oil shale lands to remove impediments of leases."

"Tar sand and oil shale are not considered 'unconventional' in Canada anymore."

"The analogy with tar sand should point out some important differences; topographically and geographically, the canyons of Western Colorado [and Eastern Utah] and quite different from the vast barren tundra of Central Canada; there are substantial differences between room and pillar mining and bucket wheel excavators in terms of cost and technology approach; also, the waste disposal issues will be different for spent shale than for tar sand."

Why Oil Shale As Opposed to Other Alternatives or Renewable Resources?

"The purpose for developing oil shale should be to serve as a bridge to meet the Nation's liquid fuel needs until other energy resources and technologies can be developed and commercialized."

"The intent is not to compete with other energy resources but to ensure that oil shale is included in the mix of resources that will be needed to meet America's energy needs as global oil production peaks and declines."

"Compared to the economic and technical viability of numerous renewable energy resources and technology, a Naval Research Lab study finds oil shale to be competitive in in some cases highly favorable to the alternatives."

"By DOE's own targets, the maximum supply from renewables can only meet 5 percent of the need. Renewables are better for conversion to electricity than conversion to liquids. The problem is liquids."

"Anything that can be done with regard to conservation and increase of [domestic] supplies will have a mitigating effect on conditions that occur because of shortages."

Government's Roles

"Government can only create an environment conducive to oil shale investment, the investment must come from the private sector."

"There is no mention of oil shale in the current National Energy Policy. This must have been an oversight that needs to be corrected."

"Given that Government has not been a very reliable partner for oil shale development in the past and that the current political strength is focused on alternatives to fossil fuels, it may not be possible to obtain a policy statement explicitly naming oil shale development as critical to the Nation's security and future."

"What this report does, however, is to establish the basis and rationale for innovative Government policy to contain our vulnerability to increasing oil and gas imports."

"Government policy that avoids responsibility for liquid fuels is dangerous because it presumes that industry will naturally fill the void. Industry has no fiduciary or corporate obligation to make risky investments. This begs the question 'how does industry measure risk' and what implications does the answer to this question have for government policy."

"When Government takes a hands-off approach, rather than a proactive approach, it *increases* the risk of investment."

"Government needs to declare that oil shale is an option and take a leadership role in defining and addressing the public policy issues associated with oil shale development."

"One of the biggest risks to energy security is government's inattention [to realistic solutions]. Government emphasis on high risk, long term solutions may not adequately address more immediate needs."

"Government's policy of getting out of the way of industry [and not participating as an active partner] has led us to the energy dependence we now have."

"Maybe it will take another 'event' before government will act to develop oil shale resources. What can be done to move oil shale forward in a sensible way before such an 'event' occurs?"

"Achieving the goal of 2 MM BBbl/D by 2020 is very optimistic. The socio-economic impacts of 40 50,000 Bbl / D projects will be considerable. The environment on the western slope of Colorado is very fragile. I suggest a target of 200,000 Bbl/d by 2020. If we must tap the [oil shale] treasure to meet the Nation's needs, "Tap 'er light."

"A production goal of 2 million bbls/day by 2020 is probably too ambitious. The resource may support this level, but not in that timeframe."

"It is critical that we keep our eye on the ball and get policy makers to make a decision."

Regulatory and Policy Issues and Options

"Regulatory certainty helps reduce costs and speeds permitting. Poorly conceived regulations can be changed if it can be shown [that the actions they regulate pose] no environmental harm."

"Congress and the Administration should establish legislation capping oil imports and effecting these caps through Trading Allowances Auctions. Such innovation would put market forces to work on the problem of rising imports while using models that are being proven in other industries, namely air emissions in the electric power industry."

"Consideration should be given to renewing U.S. Code: Title 42 Section 13412 that envisioned a 'field testing center for the purpose of testing, evaluating, and developing improvements in oil shale technology at the field test level'. A research and development center, possibly on tract C-a, should be established and made available for design, construction and operation of test facilities to prove recovery and operability. . . This center may concentrate on process mechanisms and economics"

"I firmly believe [that the objectives of the Federal Prototype Oil Shale Leasing Program] were met, with the major and notable exception of developing retorting technology. The environmental and socio-economic baseline conditions were laboriously and credibly established to the satisfaction of all stake holders…..[who] bought off on the Programmatic Environmental Impact Statement as well as the Detailed Development plans written specifically for the Federal leases. .. I fervently maintain that those results should be the foundation of any future work and that no new environmental or socio-economic impact statements be considered."

Gauging and Stimulating Industry Interest in Oil Shale

"A proactive outreach to industry may be desired to identify what industry is willing to do, how industry evaluates risk, and what risks they perceive that can be mitigated by government."

"… Government needs a demonstration of interest and commitment from industry. Government cannot be proactive in a total vacuum, input is needed from those who would invest."

"Why is industry (with the possible exception of Shell) not making oil shale happen today? It is a matter of uncertainty; uncertainties over costs and operability of retorts, future price of crude (risk of depressed prices), lack of Government policy, lack of external incentives, fear of environmental challenges."

"Industry will have to identify a viable economic opportunity in the framework of the energy, economic, and policy environment that results from changes in public policy."

"Most challenging developments begin with smaller first steps. Deep water oil production started on the continental shelf and moved deeper in steps. Unlike development of deep water offshore petroleum resources, industry cannot proceed incrementally with oil shale. That means massive risk and investment that can't proceed without the reliable commitment of the Federal government as a partner."

Readiness of Technology for a U.S. Oil Shale Industry

"Economic failures of the past [oil shale development in the United States] were not the fault of the resource. "

"The biggest uncertainty of oil shale technology remains the operability of the retort."

"Technology advances have made commercial-scale development of oil shale resources economically and technically feasible in several other countries, such as Estonia and Australia"

"What are the potential show stoppers? If there are show stoppers, these need to be articulated."

"In the past it appeared that in-situ processes would be the most difficult to implement and control for technical, environmental, and regulatory reasons. Shell's ICP process may make in-situ projects viable even before any new surface retorting projects."

"In addition to the Shell ICP, there are a number of prior true in-situ efforts, including Equity, Sweden and patent literature dating back to 1918."

"Rotary kiln technology in various forms such as the Galoter (Estonia), Davidson (earlier Estonia), and large kilns used in the cement and limestone industry, in addition to the [Alberta Taciuk Process] ATP, prove the operability of this technology approach."

"Even at commercial scale it would take hundreds of ATP retorts to achieve the goal of 2 MM BBL/D by 2020."

"ATP hasn't been tested using carbonate-based U.S. western oil shales."

"There has been a lot of interest in the past in fluid bed retorting technology because of its high yield and thermal efficiencies (Exxon, Chevron, Lurgi, LLNL, etc.) and it is expected that this technology could re-emerge."

"Foster-Wheeler developed a fluidized bed process for Israeli shales, but Israel chose a non-U.S. firm to fabricate and build its retort.

Consensus Building and Community Outreach

"2 million bbl/day by 2020 will require a common goal with a broad consensus. Can this consensus be built in the absence of crisis? Unlikely, but the ground work can be laid beginning now."

"To build a consensus there must be a recognized need and a common goal. This will require articulating the issues to the public, in addition to government and industry. To obtain 'permission to practice' all interests need to heard. In the end a large resource will be required to fill the need."

"Oil shale will need to attract broad-based support, including buy-in from the environmental community, states, NGOs, and other stakeholders."

"A communications plan can be crafted to draw media attention to the coming petroleum supply problem and to oil shale's potential vis-à-vis other alternatives."

"The public, opinion leaders, and policy makers need to understand oil shale's potential if perceptions are to be changed and policy actions are to be taken. "

"In due time, DOE should consider collaborating with Estonia, Australia and Canada, communicate what unconventional oil resources are, how they relate to conventional petroleum, and what is being done in these other countries to produce energy supply from these resources."

General Comments

"The biggest reason Canada HAS a tar sand industry and the U.S. does not have an oil shale industry is that, unlike in the U.S. where ventures folded when they encountered unexpected costs, in Canada the ventures chose to perservere. … The first-generation plant needed to succeed at the commercial scale to give confidence to second-generation investors. A similar level of first-generation commitment and proof may be needed with oil shale."

"An uninterrupted, steady supply of water will be crucial, requiring senior absolute water rights, and storage capacity to address seasonal availability. Process water consumption may not be as high as previously thought."

"When describing the similarities between oil shale and tar sand it is important to also point out that much of the oil shale will not be accessible by mining, as the tar sand are now, or by low level heating, as is done with SAGD. Recovering oil from oil shale requires more heat and it is not clear if the additional heat requirement is always offset by the additional organic carbon contained in oil shale. This concern may be magnified for those technologies that do not combust the residual carbon for heat, such as might be practiced with in-situ."

How to Proceed – Building a Road Map and a Program Plan

"A "road map" needs to be created to define how to move the oil shale issue and opportunity to the forefront of the energy policy agenda and to overcome the hurdles that prevent public acceptance and industry investment."

"A 'roadmap' may be timely. . . . A roadmap will help identify the issues and reduce the issues to their essential components."

"The value in preparing a roadmap is to make sure you are spending money on the right things."

"A wealth of industry data, government data, and technology information already exists to contribute to developing the road map and making the case for oil shale development."

"Components of a Program Plan may include but are not limited to: Public policy requirements, technology issues (basic and applied research, development, demonstration), environmental issues, investment climate (including relative cost/benefit relationship of various incentives), socioeconomic issues, lessons learned from prior efforts (what is our baseline), special 'first generation' issues, regulatory issues, land management issues, lease conflicts, product markets, legislative needs, and others as the Plan develops."

"Capital investment required could exceed $250 billion barrel to achieve the 2 MM Bbl/D target."

"Given the massive amount of capital investment that will be required to design and develop commercial-scale oil shale projects, government will need to provide incentives or share in funding related research activities."

"There will be a need for basic research to support applied research (to be included in development plan, if program plan is approved)."