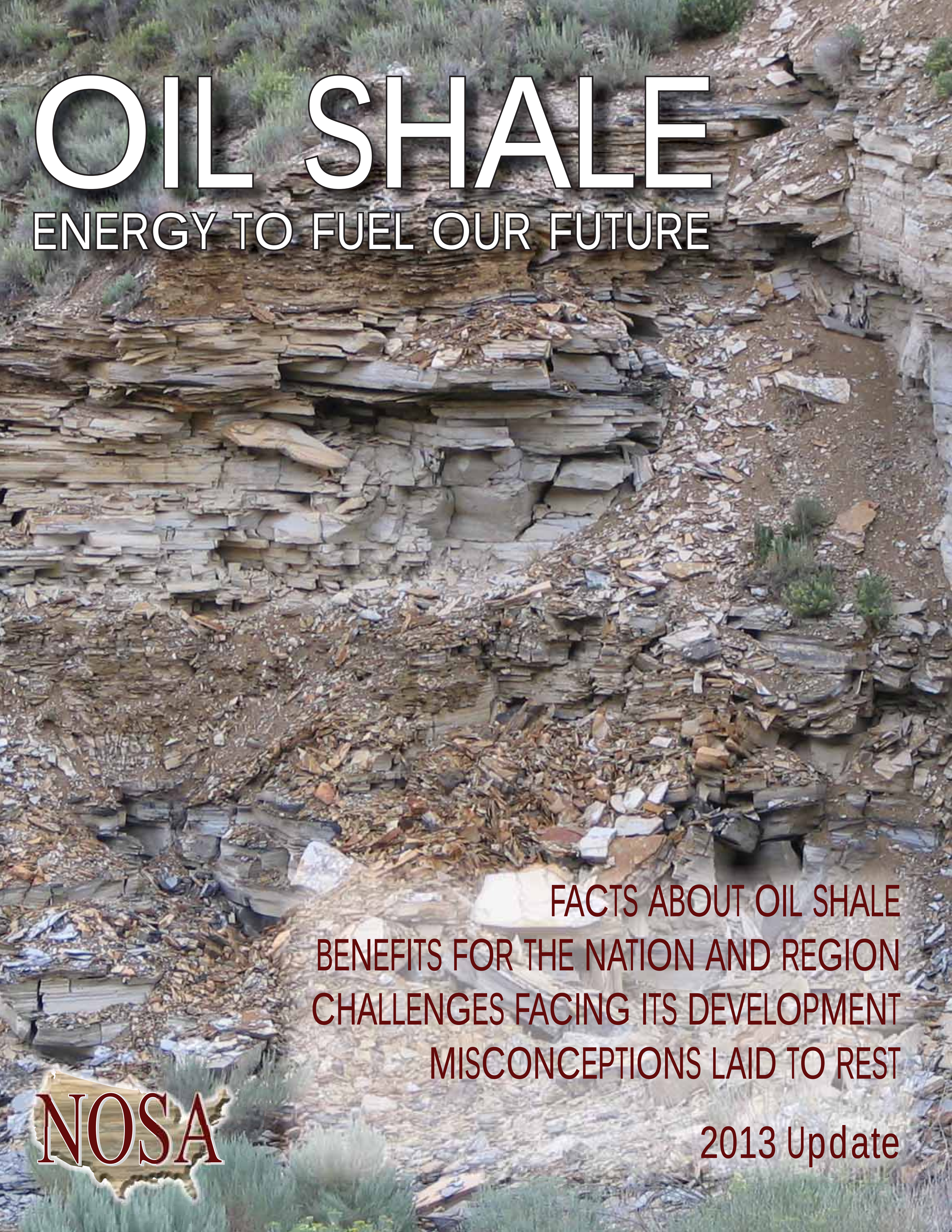


OIL SHALE

ENERGY TO FUEL OUR FUTURE

FACTS ABOUT OIL SHALE

BENEFITS FOR THE NATION AND REGION

CHALLENGES FACING ITS DEVELOPMENT

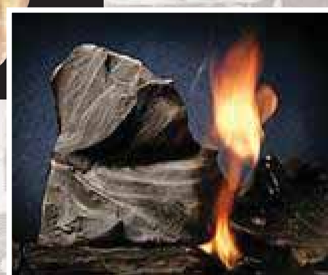
MISCONCEPTIONS LAID TO REST

NOSA

2013 Update

INTRODUCTION

The National Oil Shale Association (NOSA) has produced this brochure to present the facts, benefits, challenges and misconceptions surrounding oil shale development in the United States. It is intended to be a reference document suitable for use by decision makers, the media, educators, the public at large, and interested stakeholders.



Today there is confusion about the definition of oil shale. Some are calling oil shale the impermeable rock from which liquid oil and gas is recovered using horizontal drilling and fracturing (often termed fracing). “Tight oil” or “Liquid Rich Shale” is a more accurate terminology describing deposits like the Bakken and Niobrara shales. This brochure deals only with the oil shale containing solid kerogen that requires heating to produce shale oil and gas.

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A. FACTS

THE BOTTOM LINE

The imperative is great to advance oil shale development, because:

1. There are looming oil shortages, higher gasoline prices and political instability resulting from importing so much petroleum.

2. Oil shale remains a huge untapped domestic resource that can assist the nation in becoming less reliant upon foreign sources of petroleum.

3. Both the military and public will benefit through the stabilization of gasoline prices, the reduction in the trade deficit, the creation of jobs here at home, the tax and royalty income for local communities, and a more secure future for our children and grandchildren.

4. Thus, a U.S. government policy is needed that supports the development of all domestic energy resources, including oil shale.

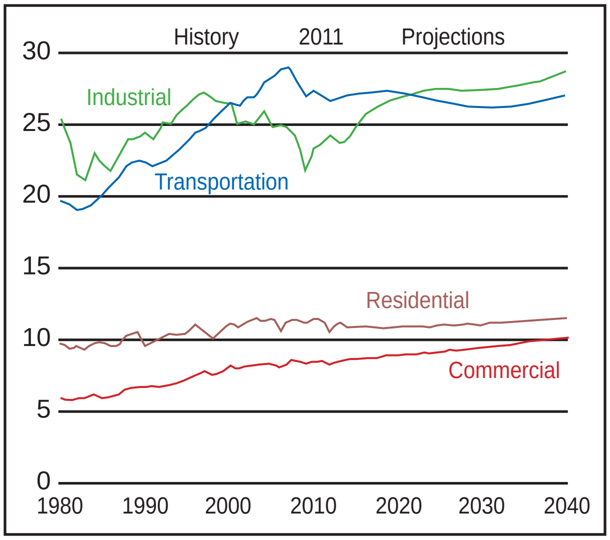
Oil shale can become a sustainable industry after decades of setbacks, because:

1. Knowledge about oil shale processing has improved here in the United States, and from the experience of foreign firms.

2. Despite reports to the contrary, a wealth of information is available to the public and decision makers on water usage, environmental impacts, energy efficiency, socioeconomic impacts and benefits, and climate change implications.

3. Lessons were learned from the past attempts to commercialize oil shale. Today, there are no government mandates and financial incentive for quick production as there were in an earlier boom and bust era.

4. Current research and development projects are taking a methodical and deliberate approach to obtain the detailed technical, economic and environmental answers before proceeding.



Delivered energy consumption – quadrillion BTU
(SOURCE: U.S. EIA AEO 2013)

PETROLEUM SUPPLY/DEMAND

Over 90% of the fuels that power our cars, trucks, trains and planes come from petroleum. The United States imports over 50% of its petroleum from outside its borders. Despite recent increases in domestic production of conventional petroleum (e.g. tight oil and gas liquids), and conservation programs to reduce the amount used, the U.S. demand for petroleum products continues to grow. Both the International Energy Agency (IEA) and the U.S. Energy Information Agency (EIA) predict continued reliance on petroleum for decades.

The U.S. imports petroleum from many countries. Some of these countries are unfriendly to the U.S. This reliance on imported petroleum is a burden on our economy and a threat to national security.

While conservation, renewable energy, and alternatives to transportation fuels, such as electricity, natural gas, and hydrogen, are important to future energy supplies, few predict that these resources will appreciably offset petroleum demand for the next decades. The EIA predicts that the increase in the U.S. population and the growth of our economy will more than offset any decline in petroleum and other liquid consumption through 2035. Fortunately, the United States is blessed with huge reserves of oil shale, coal, heavy oil, tight oil, and oil sands which could be used to produce liquid fuels to help offset the increase in demand. The chart on page 1 shows EIA's projections for energy consumption by sector from 2011 to 2040.

In 2011 the world used about 87 million barrels (42 gallons per barrel) of petroleum per day of which 18.8 million (22%) was used in the United States. The IEA predicts that world oil consumption will continue to increase reaching 100 million barrels per day by 2035. China alone accounts for 50% of the increase.

While the demand for energy continues to increase, the world reserves of conventional petroleum are not increasing proportionately. Production within the United States peaked in 1972, and the nation continues to be dependent on imports. In 2011 domestic production, including Alaska was about 7.9 million barrels per day, which represents about 42% of the nation's needs.

In 2011, the United States imported a net 8.5 million barrels of petroleum and petroleum products per day, which was 45% of its daily consumption. U.S. oil production is raising from sources such as tight oil, biofuels and gas liquids, but the nation continues to be dependent upon other countries to supply its total demand for petroleum.

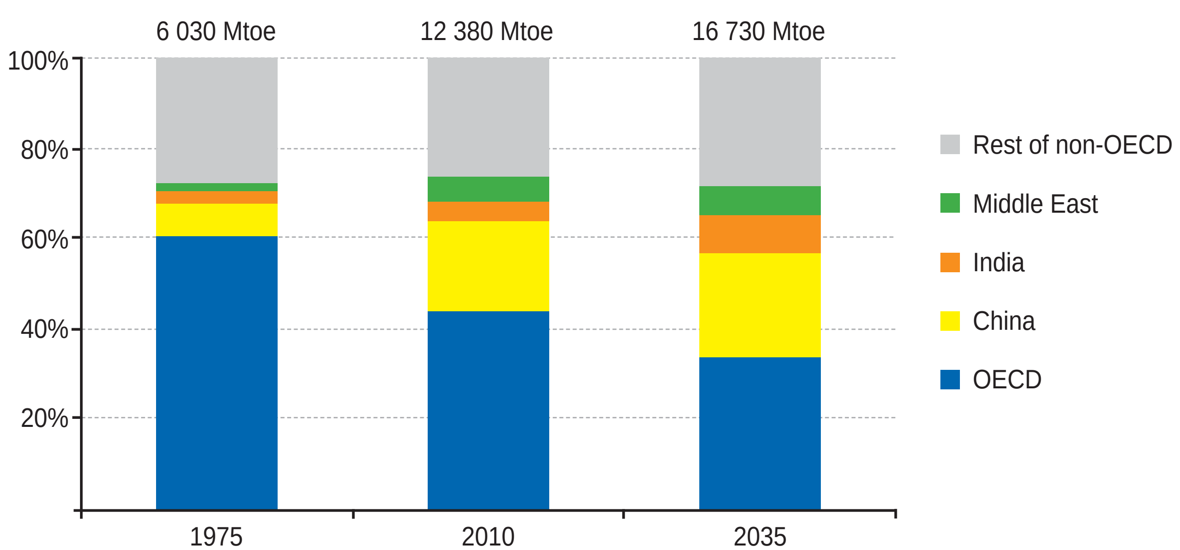
OIL SHALE RESOURCE

Oil Shale is a natural resource that produces petroleum-based fuels that are used in our automobiles, jet planes, trains and trucks. It is a rock that contains a solid hydrocarbon called kerogen. The composition of the rock varies depending upon the geographic location and geologic origin. This brochure deals only with the oil shale containing solid kerogen that requires heating to produce shale oil and gas.

The amount of hydrocarbon products contained in oil shale is determined by assay, and is expressed in gallons of shale oil per ton of oil shale rock (gpt). A ton of oil shale rock in the ground is about 1-cubic yard. Commercially attractive deposits range from 15 to 35 gpt (and even higher at some locations).

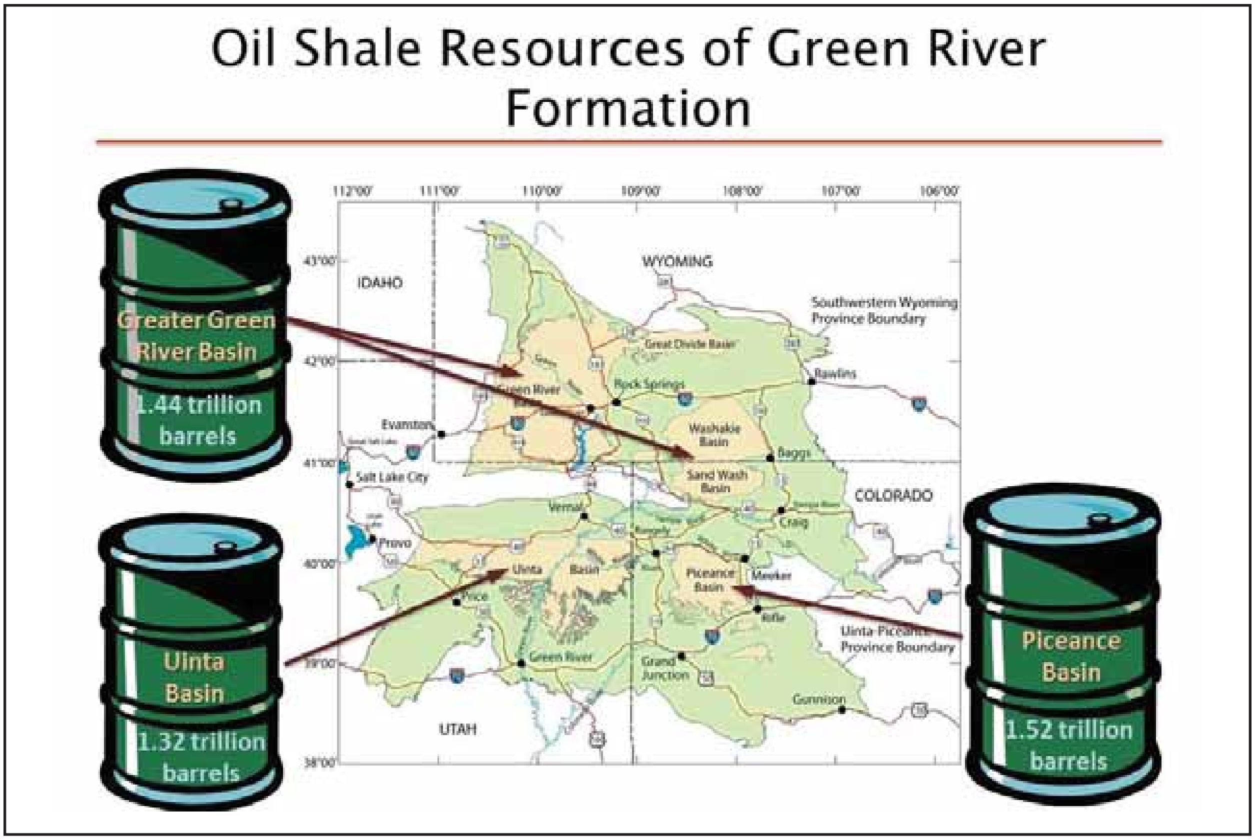
While oil shale is found in many regions of the world, the largest deposits of rich oil shale occur in the United States. There are oil shale deposits in the eastern United States but the thickest and richest oil shale deposits are those

SHARE OF GLOBAL ENERGY DEMAND



Global energy demand rises by over one-third in the period to 2035, underpinned by rising living standards in China, India & the Middle East

(SOURCE: Institute of Energy Research)



(SOURCE: Dr. Jeremy Boak, Colorado School of Mines, citing USGS estimates, 2012)

in the Green River Formation in Colorado, Utah and Wyoming. The U. S. Geological Survey (USGS) has estimated that the Devonian shales in the eastern U.S. represent perhaps 619 billion barrels of resource averaging 15 gallons per ton. The Green River deposits of the western U.S. are estimated to contain up to 4.2 trillion barrels from shale averaging over 15 gallons per ton. The USGS estimates that between 353 and 1,146 billion barrels of the in-place resource have a high potential for development and could be produced from the Green River Formation using current and foreseen technologies; this alone is more than one to six times the total oil reserves of Saudi Arabia and significantly greater than the known U.S. reserves of conventional oil.

The map on this page shows the results of the recent USGS resource estimates.

The U.S. government controls most of the oil shale resource in the western U.S. The richest and thickest oil shale resource in the world is located in the Piceance Creek Basin of Colorado. The U.S. Bureau of Land Management (BLM) controls 70% of this resources and is currently limiting leasing to small tracts for research and development only.

GLOBAL ENDOWMENT

There is an abundance of liquid hydrocarbons in the earth when considering all of the more difficult to extract petroleum found around the globe. For instance, the synthetic crude oil produced from Alberta oil sands is an extremely heavy crude oil prior to upgrading. Today, the oil from Canada accounts for a large percentage of United States petroleum imports. The synthetic crude oil from oil sands is similar in quality to upgraded shale oil.

Many experts believe that current producers of petroleum will not be able to meet growing world demand. When reference is made to this supposition, it pertains only to those conventional crude oil reserves that are recoverable utilizing proven technology, and does not yet apply to resources such as U.S. oil shale. Experts also point out conventional producers may not be able to replace reserves at the rate they are being consumed. When oil shale technologies are proven to be commercially viable, the billions of barrels of shale oil in the U.S. will become proven reserves and add to the remaining years of oil supply in the world.

Oil shale deposits are found in many nations around the world. In 2007 the World Energy Council prepared a preliminary estimate of the oil shale deposits in 33 countries. That estimate totaled 2.8 trillion barrels of shale oil.

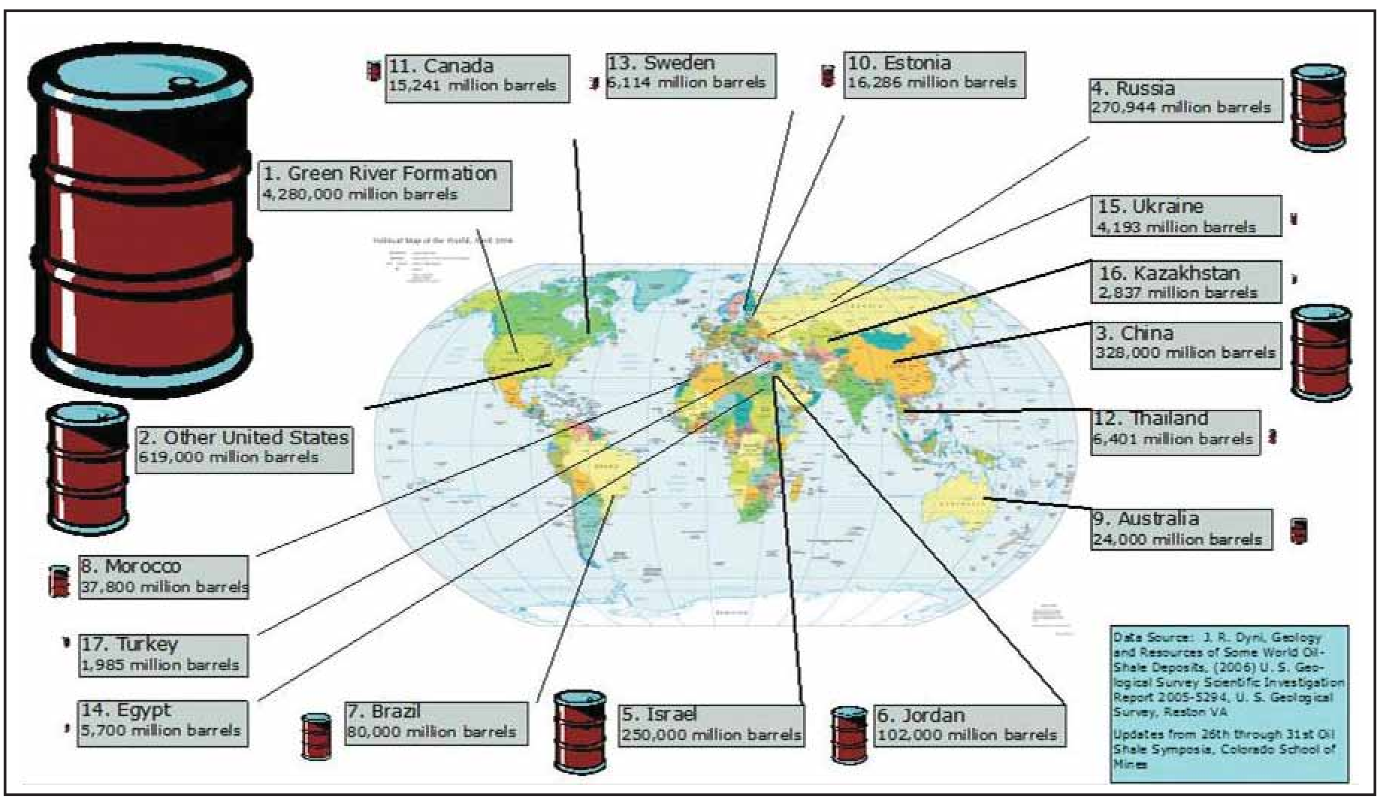
In 2012, Dr. Jeremy Boak, at the Colorado School of Mines further refined the world oil shale resource estimates, and presented the map on page 4 showing the countries with the largest oil shale resources.

Many of the oil shale deposits of the world have not been studied in detail. However, it is safe to say 1/2 of the total is within the United States. The 353 to 1,146 billion barrels of estimated recoverable shale oil in the Western United States is nearly equal to the world's proven reserves of conventional oil, which were reported to be 1.5 trillion barrels by credible sources in 2011.

There has been significant commercial production of shale oil from Estonia, China and Brazil. Jordan, Israel and Australia are countries where significant development is progressing at this time. Many other countries are investigating the potential for production of shale oil.

PROCESSING OIL SHALE

Unlike conventional petroleum, shale oil cannot be pumped directly from the ground. It must be processed by a technique known as retorting, wherein the rock is heated to release crude shale oil, shale gas and water. Processing can be accomplished by mining the oil shale and retorting it on the surface, called ex-situ processing; by using underground methods known as in-situ recovery; or by a combination of the two methods. Crude shale oil is upgraded to remove certain impurities, such as sulfur and nitrogen, and then further processed in an oil refinery to produce gasoline, clean diesel fuel, jet fuel and other petroleum based products.



World Shale Oil Resources
(SOURCE: Dr. Jeremy Boak, Colorado School of Mines, citing USGS estimates, 2012.)

Ex-Situ Processing

Ex-situ processing of oil shale has been practiced for over a century in various parts of the world. Projects based upon this approach have been operating for decades in China, Estonia and Brazil. These processing facilities look much like any modern industrial complex.

First the oil shale is mined by underground or surface mining methods. In Colorado and Utah underground room and pillar mines were opened decades ago and are still in stable condition. Because of the strength of the oil shale beds, large stable rooms can be created supported only by pillars of oil shale and rock bolts placed in the ceiling. This contributed to the excellent safety record for these mines. This is very different than many underground coal mines that have small openings in relatively weak rock. Underground oil shale mines are more like subterranean quarries, and consequently large trucks, loaders and drilling equipment can be used in them to keep costs low.

After oil shale is mined, it is reduced in size in machines called crushers, conveyed to the retorting plant, and converted into crude shale oil, water and shale gas. A number of well-tested ex-situ retorting technologies are candidates for commercial projects, but none are operating at commercial scale in the United States.

The waste rock that results from retorting is known as spent shale. It constitutes about 70-80% by weight of the mined oil shale, and expands somewhat as a result of size reduction in mining and crushing of the mined

Paraho ex-situ retort pilot plant - circa 2007.
(Photo Courtesy of Shale Tech International.)

Ex-situ oil shale plant in Estonia - circa 2009.
(Photo Courtesy of ENEFIT.)

rock. After cooling and conditioning, the spent shale is conveyed to a surface disposal area or back into the mine. At the disposal area spent shale is compacted to assure its stability, covered with top soil and vegetated. Large spent shale embankments created in the U.S. over two decades ago are stable, support vegetation and have not contaminated water supplies. Some amounts of spent shale may find applications in construction materials such as bricks and cement.

In-Situ Processing

In-situ processing employs techniques similar to the drilling and production of conventional petroleum. In this approach, wells are drilled into the oil shale strata, and retorting is conducted in the ground without mining. Other wells are drilled into the same area for production of crude shale oil liberated by underground heating. The method of supplying heat to the underground oil shale varies by technology. A number of research and development projects have been conducted using various in-situ techniques, but none have yet reached a commercial level of production in the U.S. In-situ processing was successfully conducted in Sweden between 1941 and 1960, and experiments were conducted in the United States beginning in the 1970's (e.g. Equity Oil Shale project in Colorado). There are a number of active in-situ R,D&D projects including the

AMSO In-situ Project - 2012

American Shale Oil project in Colorado shown in the pictures on this page.

In-situ technologies are most applicable to thick oil shale deposits where mining is more difficult, such as the center of the Piceance Basin of Colorado where oil shale deposits are about 1000-feet thick and buried under 1000-feet of overburden.

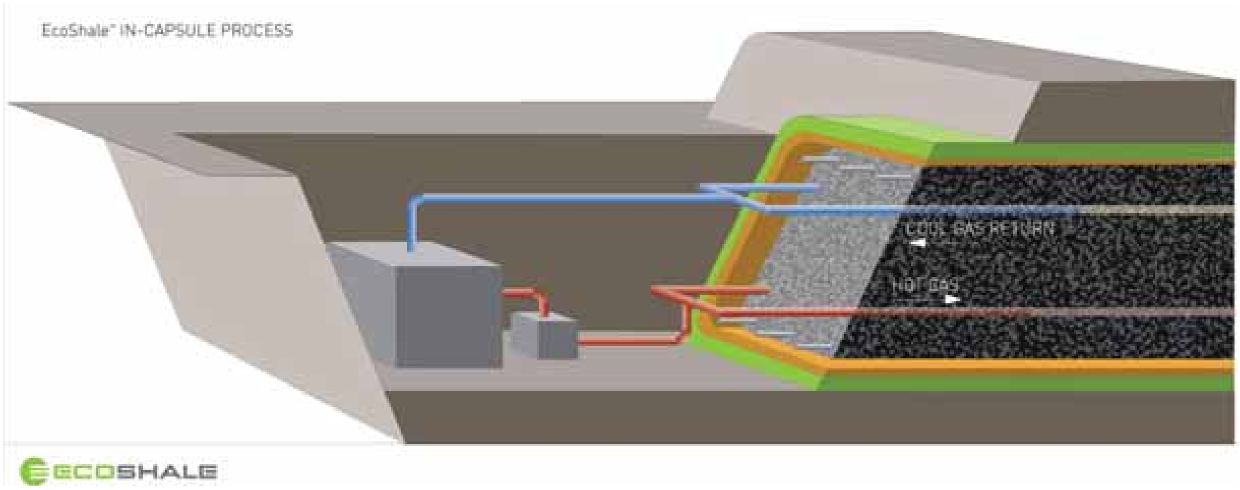
Crude shale oil, shale gas and water are produced from in-situ retorts. The crude shale oil produced is a quality that requires less upgrading than oil from most ex-situ processes. Studies indicate that the shale gas produced is sufficient to supply a large portion of the heat needed for oil shale retorting. Alternatively, the shale gas may be processed and sold as natural gas. Produced water may be used internally by the project or cleaned and returned to the subsurface.

The spent shale resulting from in-situ processing is left underground and need not be reclaimed in the conventional sense. However, ground water in the processing area may be impacted by the spent shale and hydrocarbons left behind if mitigation measures are not taken. Concepts for excluding ground water and mitigating potential impacts to ground water are being developed.

Other Processing Methods

Modified in-situ is an approach that uses a combination of ex-situ and in-situ techniques. In one case some of the oil shale is mined underground to create a cavity for subsequent in-situ retorting. In this approach an underground void is created into which an adjoining mass of oil shale is made into rubble through explosive fracturing conducted in preparation for subsurface retorting. In another approach, the EcoShale technology, oil shale is mined, crushed, and placed into a lined and covered pit equipped with piping for in-situ retorting, as depicted on page 7. Both approaches have been demonstrated at pilot scale in the field. During World War II Germany used a modified in-situ process. Oil shale was mined and placed in excavated tunnels where it was retorted using in-situ techniques to avoid bomb damage to retorts on the surface.

Thousands of patents have been issued for oil shale extraction technologies. They include the retorting methods described above and other concepts that do not use heat as the principal



method of extraction (e.g. extraction of kerogen by methods like flotation, gravity separation, or chemical methods such as dissolution of the oil shale rock matrix). The use of electromagnetic stimulation, electrical conduction, fuel cells, carbon dioxide injection, and biological digestion have also been explored, but none have been tested at large scale.

OIL SHALE HISTORY

Products were being produced from oil shale in Europe and the Eastern U.S. before the first oil well was drilled in Pennsylvania in 1859. A thriving oil shale industry started in Scotland in 1851. Legend has it that a barrel of oil is defined as 42 gallons because whiskey barrels of that size were used in Scotland to transport shale oil. Since these early days, oil shale developers have experienced periods of enthusiasm and consternation as the availability and price of petroleum from conventional sources varied. When oil prices went up interest in oil shale increased, and when they came down developers generally lost interest. Likewise, in times of war and oil shortages, enthusiasm for oil shale peaked, and then waned when the crisis passed.

Early western settlers produced small amounts of shale oil that was used for lubricants and fuel for lamps. Native Americans are believed to have burned oil shale and coined the name “the rock that burns”. The first real attention to western oil shale came with a land rush after World War I. It brought prospectors to Colorado and Utah to claim oil shale lands under the General Mining Act of 1872 as placer claims. The 1920 Minerals Leasing Act brought the claiming to a halt, but approximately 30% of the oil shale resource in the west had come under private ownership. Since 1920, the 70% controlled thereafter by the Federal Government has been withheld from leasing unlike other minerals and oil & gas entrusted to the BLM.

World War II saw another resurgence in oil shale activity when the government became concerned about supplies of petroleum for the military. A research facility was established at Anvil Points near Rifle, Colorado in 1944. A mine was opened, and studies were carried out on several processing technologies. The Nevada-Texas-Utah (NTU) gas combustion retort was chosen and tested at a demonstration scale of 300-tons-per-day capacity. Successful tests were also conducted on the production of motor fuels from shale oil. Operation by the Bureau of Mines at Anvil Points was terminated in 1956, but a group led by the Colorado School of

Old Utah retort - circa 1920’s

UNOCAL demonstration oil shale plant - circa 1980's.
(Photo Courtesy of Roger Day.)

Mines later operated the facility between 1964 and 1968.

In-situ processing of oil shale is not a new concept. Between 1941 and 1960, the Ljungstrom in-situ method operated at experimental and then commercial levels in Sweden. It is estimated that in a three year period over 100,000 barrels of shale oil was produced. The technology utilized electrical heating in vertical boreholes at the corners of a hexagonal drilling pattern. Shale oil was produced through a borehole in the center of the pattern. The shale oil produced was reported to be a high grade producing more gasoline than shale oil produced from ex-situ retorts at the same Swedish site. The information gained from the demonstration of the Ljungstrom technology is believed to have served as a foundation for later in-situ development in the United States.

From the 1950's to 1990's several private firms developed and tested oil shale retorting technologies. They included Union Oil of California, The Oil Shale Corporation (TOSCO), Shell Oil Company, Paraho Corporation, Occidental Petroleum, Superior Oil Co., Equity Oil Co., and Geokinetics, Inc. to name a few. In 1974, Prototype Oil Shale Leases were awarded by the Federal government: two in Colorado (Ca and Cb) and two in Utah (Ua and Ub) to firms that bid a total of $641 million in bonus payments. Bidding came soon after the Arab oil embargo, when the price of petroleum rose dramatically, and long lines at gas stations became commonplace. The prospects for oil shale commercialization were high and companies believed they could develop the leases and go into commercial production in the near term. But, as in earlier cycles, the oil price dropped, the Federal government lost interest, and companies ultimately abandoned the leases.

During the 1970's and early 1980's developers rushed to Colorado and Utah to initiate commercial oil shale projects. Literally billions of dollars were spent by major oil companies and other smaller firms. It was like the rush to an oil discovery well by wildcatters of old. The Federal government created the Synthetic Fuels Corporation in 1980 and allocated billions of dollars to the development of domestic sources of energy. However, in 1982 another oil shale boom ended. The repercussions are still a vivid memory by many in the region because of the loss of jobs, devaluation of property values and loss of tax revenue to local governments. But it should be noted that bonus payments shared with local communities improved services and infrastructure in the region. And the town of Battlement Mesa was build solely with private funds.

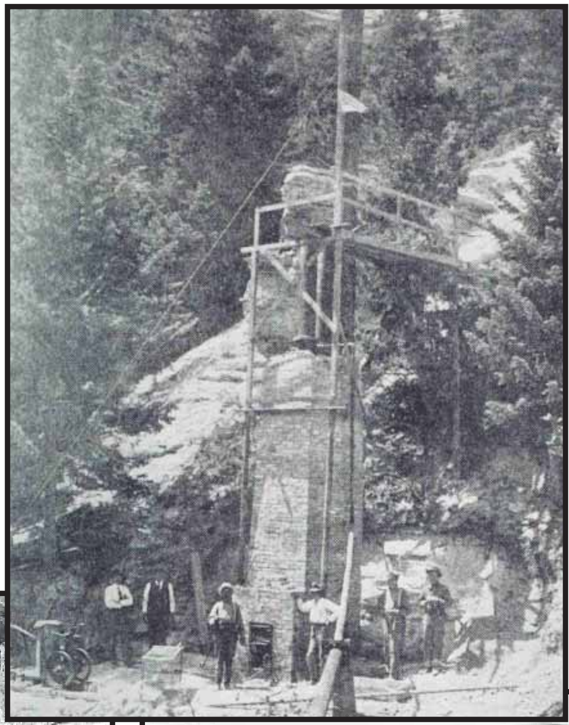
After the 1980's the interest in U.S. oil shale waned. But, Union Oil of California (UNOCAL)

Tosco Semi-Works Plant – circa 1967.

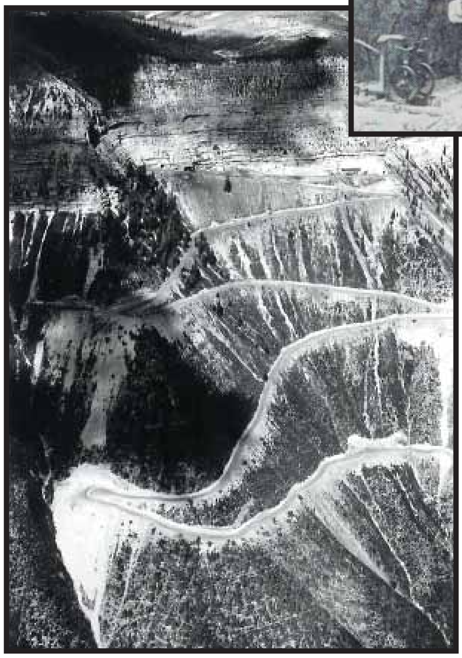
continued operation of its large demonstration oil shale plant near Parachute, Colorado but it too ceased operations soon thereafter in Colorado. During its period of operation UNOCAL produced 5-million barrels of shale oil that was upgraded into transportation fuel products. During the following years, Shell Oil conducted research and development on its in-situ technology on private land in the Piceance Basin of Colorado, and Paraho continued to improve its ex-situ retorting technology.

The U.S. Energy Policy Act of 2005 brought a modest resurgence of interest in oil shale. It directed BLM to begin making preparations to lease Federal oil shale lands for commercial development. The Act also directed the Office of Petroleum Reserves within the U.S. Department of Energy (DOE) to initiate an unconventional fuels program and provide recommendations to promote development of those resources. The Task Force on Strategic Unconventional Fuels was formed in response to the Act, and issued reports to the President and the Congress describing the potential benefits from developing America's strategic unconventional fuel resources.

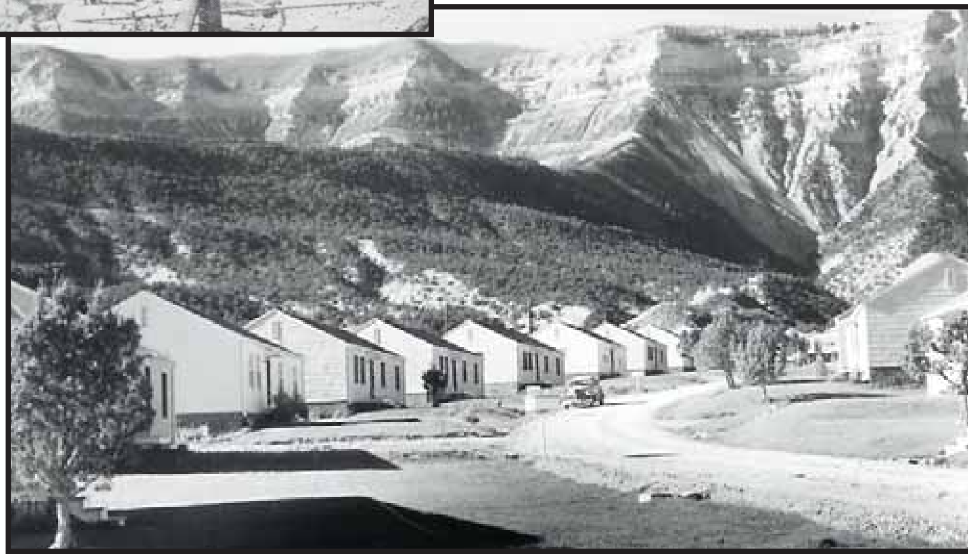
BLM awarded oil shale Research, Development and Demonstration (R,D&D) leases to four companies in 2007. A second round of R,D&D leases was offered in 2009, and two were awarded in 2012. BLM also promulgated regulations for commercial oil shale leasing and completed a Programmatic Environmental Impact Statement (PEIS) for oil shale and tar sands in 2008. However, in 2012 the earlier PEIS was discarded by BLM, and a new version was issued that dramatically reduced the acreage available for application for leasing, and restricted leasing to R,D&D only. No other mineral resource leased by BLM requires performance on R,D&D leases before commercial leasing. Changes to the oil shale leasing regulations were pending as of the writing of this document.



Old Oil Shale Retort - circa 1920's.



Anvil Points Mine - circa 1940's.



Housing at Anvil Points - circa 1940's.

Battlement Mesa, CO - Built with private funds to accommodate oil shale population growth.

B. BENEFITS

ECONOMIC AND SOCIAL BENEFITS

According to the Department of Energy (2004) “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.”

The social benefits of an oil shale industry can be significant, and include the following:

- Economic expansion and diversification for the region
- Educational growth, skill development, and opportunities to educate and train a sustainable workforce
- Increased opportunities for existing local businesses and growth of opportunity for new business development
- Fiscal support for public sector infrastructure including enhancements
- Long-term employment opportunities including high paying jobs in the oil shale and supporting industries

Regional social impacts are described in the Challenges section. Achieving a balance between the social benefits and social impacts of oil shale development is a key objective for industry, government and all stakeholders.

ENERGY AND NATIONAL SECURITY ENHANCEMENT

There are two important concerns related to energy and national security that stem from the nation’s over-reliance on imported petroleum.

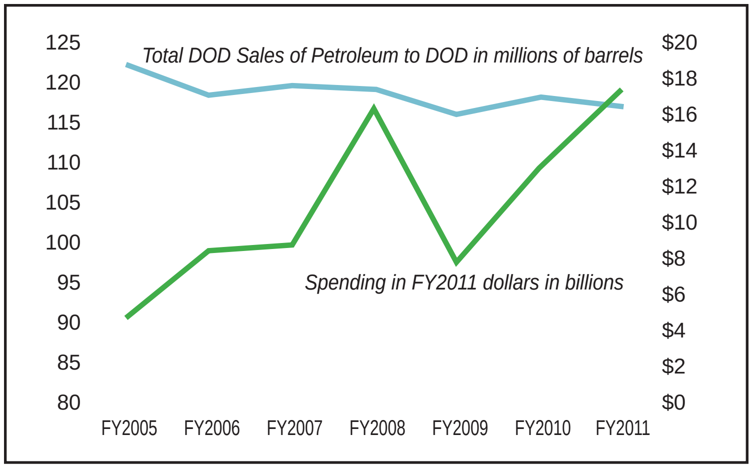
- First, importing so much petroleum has made the United States vulnerable to geopolitical pressures, including the need to station military forces in hostile areas of the world.
- Second, the military requires a secure supply of petroleum products to fuel its ships, vehicles and planes. The production of shale oil and other sources of domestic transportation fuels here in the United States can help to reduce the impacts of both energy and national security concerns.

Until about 50 years ago, the United States was self sufficient in its supply of petroleum, and the price of the gasoline produced from it was stable year after year. However, as domestic supplies of conventional petroleum could no longer meet demand, the nation began to import petroleum from abroad. In the 1970’s, the Organization of Petroleum Exporting Countries (OPEC) cut off petroleum supplies to the United States. It resulted in gasoline shortages and long lines at gas stations. In recent years there have been dramatic swings in fuel prices when petroleum ranged from $30 to $140 per barrel and gasoline cost over $5 per gallon in some parts of the U.S. Price volatility has become a constant factor in crude oil markets.

The United States imports more than 50% of its petroleum. Around 20% comes from

OPEC, and about some 10% comes from Persian Gulf countries. Many of the largest petroleum exporters are unstable or vulnerable to destabilization. Further, many of these countries produce their oil through national oil companies that do not necessarily comply with the requirements of the free market. Countries like China are purchasing international oil inventories before they make their way to the market. And although the United States has consciously tried to position its import portfolio with secure countries, such as Canada and Mexico, world supplies are vulnerable as is price stability.

Today the worldwide operations of the Department of Defense (DOD) are heavily dependent on its fleets of airplanes, ships and ground vehicles. In 2011 the Department of Defense consumed about 320,000 barrels of petroleum fuels per day (about 2% of the U.S. daily demand that year) which cost DOD about $1.8 billion in direct costs. The following figure shows what fuels the DOD purchases and what the costs were between 2005 and 2011.



U.S. Military Petroleum Purchases and its cost.
(SOURCE: U.S. Department of Defense.)

Defense Readiness Concerns include:
- Dependence on foreign oil
- Dependence on foreign refined fuels
- Higher fuel costs

Many military operations have a mission of maintaining political stability in oil producing regions of the world or along the shipping lanes used by oil tankers headed to the U.S. The DOD has long recognized the vulnerability of the oil supplies, which, in reality, represent the lifeblood of both the U.S. military strength and the U.S. economy.

The DOD is striving to develop domestic sources of military fuels to assure a secure supply. While the Strategic Petroleum Reserve is one of the tools, it represents only a relatively short term solution. The DOD's current focus is on biofuels, but needs to include oil shale in its planning, because it is the largest domestic energy resources that could meet the military needs, and the needs of the general public. Deposits of oil shale, coal and tar sands are large enough to produce unconventional fuels in quantities sufficient to meet the needs of DOD and reduce the nation's reliance on imported oil for decades into the future.

Oil tanker headed for the U.S.

ENERGY RETURN ON INVESTMENT

Companies that invest in shale oil production create jobs, provide tax revenues, improve national security, and generally enhance the economic welfare of the nation. Those benefits are realized when there is a positive energy return on investment. More importantly companies do not invest in projects that do not have a positive energy return on investment (unless there is some form of government incentive provided).

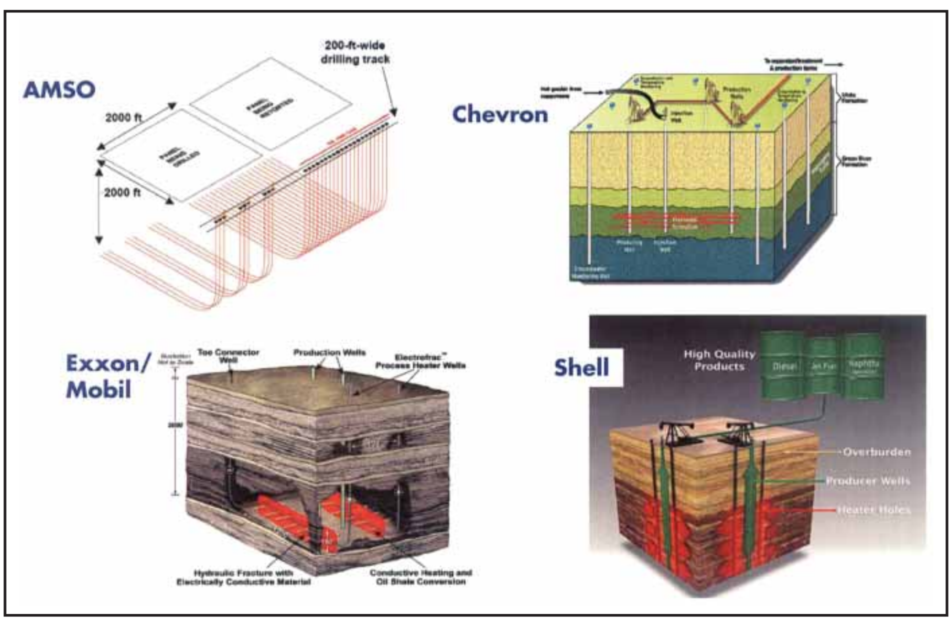
The energy return on investment is positive for producing shale oil. Assertions are wrong that oil shale processing uses more energy than are contained in the products produced.

Energy Return On Investment (EROI) is the ratio of the energy delivered by a process to the energy used directly and indirectly in that process. Multiple studies conducted over the years have confirmed that oil shale processing produces an energy surplus. One recent study by Dr. James W. Bunger is summarized below based upon the ex-situ processing of a 25-gallon per ton western U.S. oil shale.

> *"When oil shale is heated, the energy content of the kerogen is converted 66% to oil, 14% gas, and 20% coke. This distribution has been verified by both laboratory experiments and large scale retorting systems such as the Paraho technology and the decades running Petrosix plant in Brazil.*
>
> *Using well known properties of oil shale, it can be shown that, assuming heat recovery from the products to 200° F, the retorting process requires about half the energy in the coke, and the remaining power needs for operating the plant and mine can be supplied by the other half of energy in the coke. Consequently, essentially all the oil and gas are exportable, and the EROI is 80% / 20%, or 4.0. There is actually some surplus thermal energy, which might be sold under some circumstances, thereby raising the EROI to as much as 4.3.*
>
> *Even more importantly, virtually all of the energy needed is produced from the oil shale itself. One of the historic, attractive features of the vast U.S. oil shale resource is its ability to achieve energy self-sufficiency."*

Different oil shale processes will use energy in somewhat different ways. Nevertheless, EROI for shale oil production is positive and ranges from 3:1 to 6:1 depending upon the technology employed and the richness of the resource.

In summary there is a positive production of energy from nearly all methods of producing shale oil from western U.S. oil shale deposits. Based upon similar experiences with Alberta oil sands projects, there can be a positive economic outcome from the commercial production of shale oil in the United States.



In-situ Technologies – Colorado R,D&D Projects

C. CHALLENGES

ENVIRONMENT

Initial oil shale development activities within the United States will most likely occur in Colorado, Utah or Wyoming, because these states contain the thickest and richest oil shale deposits in the nation. Each of these states have large, uninhabited areas where oil shale projects could be constructed. While this would appear ideal for this new industry, these same areas may be attractive for recreation and sporting activities or they may be environmentally sensitive for any number of reasons. In order to address all of these concerns, proposed oil shale development projects will need to comply with a large number of permitting requirements, and meet public expectations, before any construction is authorized by federal, state and local government agencies.

An oil shale project cannot be built without receiving the required environmental, construction and operating permits. This is true even if the project is built on private land, although the process and the number and type of permits will be somewhat different on public and private land.

Existing Federal and state environmental laws assure that projects comply with strict regulations. Federal environmental laws include: the Clean Air Act; the Clean Water Act; the Safe Drinking Water Act; the National Environmental Policy Act (NEPA); National Historic Preservation Act; and the Resource Conservation and Recovery Act, among others.

Each state has its own rules, regulations and permits. These include the following: ground water discharge permit; dam safety permit; stream alteration permit; water rights permit; drinking water permit; and the permit to mine.

On a local level, counties require that projects secure construction permits, which assure the project complies with local ordinances and building codes. The county may require a project to mitigate environmental or socioeconomic impacts as conditions for issuing permits.

Many of the federal, state and local permits require public hearings and allow for a public comment period. This allows the public to voice concerns, which must then be considered by the agencies. The public input may require that the permits contain special stipulations that address issues raised.

Historic cabin – Piceance Basin, Colorado

So, while an oil shale project will necessarily have environmental impacts on a region, the multiple levels of rules and regulations assure that every project must comply with the environmental laws and employ best practices and technologies to minimize or mitigate those impacts.

LAND USE

In the western U.S. about 70% of the oil shale resource is controlled by the Federal government and administered by the Bureau of Land Management (BLM). The remaining 30% is either privately owned, State controlled or Indian Tribal Lands. In some instances the surface of the land and the oil shale minerals underlying it are controlled by different parties. This is known as a split estate. In the eastern U.S. most of the oil shale lands are privately owned.

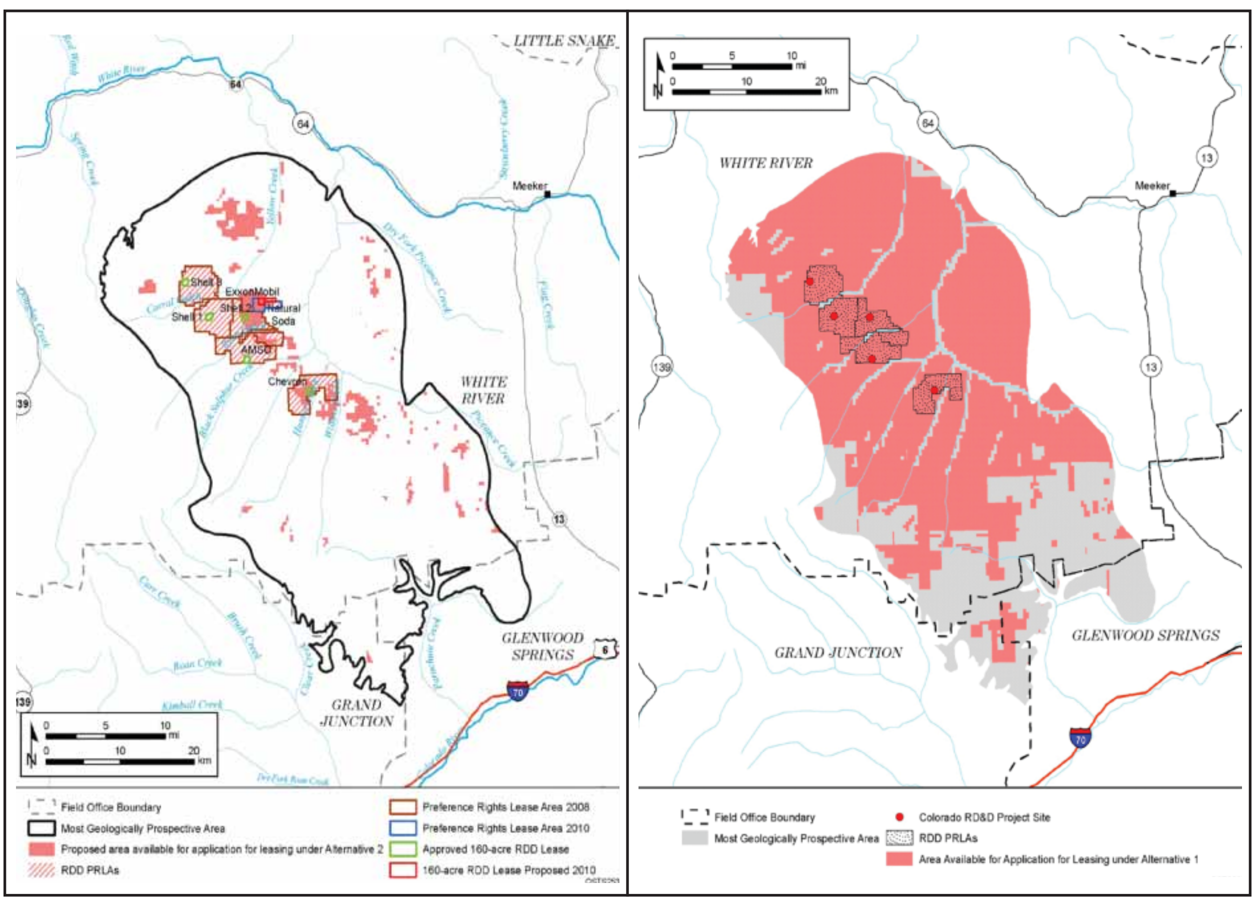
The Lands administered by the BLM are managed under a principle of “multiple use". Uses include mineral development, agriculture, recreation, and preservation. In preparing for leasing oil shale lands BLM completed a programmatic environmental impact statement (PEIS) that considered the multiple uses of the lands, the potential environmental and socioeconomic impacts, and mitigation measures. This 2008 PEIS and leasing regulations were discarded after the Department of Interior was sued by environmental groups, and after a change in the Federal administration. A revised draft PEIS was issued in 2012 to provide guidance to BLM field offices for the lands that could be available for application for oil shale leasing in Colorado, Utah and Wyoming. The latter PEIS reduced the acreage potentially available for leasing in all three states. The BLM preferred alternative recommended R,D&D leasing with no provision for commercial leasing without performing R,D&D on Federal property (see comparison map for Colorado on this page). The acreage reduction by state between the 2008 PEIS and the BLM preferred alternative in the 2012 version is given below:

STATE	2008 ACREAGE	2012 ACREAGE
Colorado	359,798	26,259
Utah	630,971	357,409
Wyoming	1,000,453	293,299
TOTAL	1,991,222	676,967

Colorado acreage took the largest reduction, and industry experts indicated that the parcels that may be made available for application for leasing are too small and/or too widely dispersed to hold much if any interest for commercial development.

Current R,D&D oil shale lease holders are exempt from the reductions so long as they meet BLM requirements to expand their R,D&D leases to commercial leases of up to 5,120 areas.

Oil shale is a highly concentrated hydrocarbon resource. Thus, the land used for its development is less than might be expected. In some areas of the Piceance Basin of Colorado



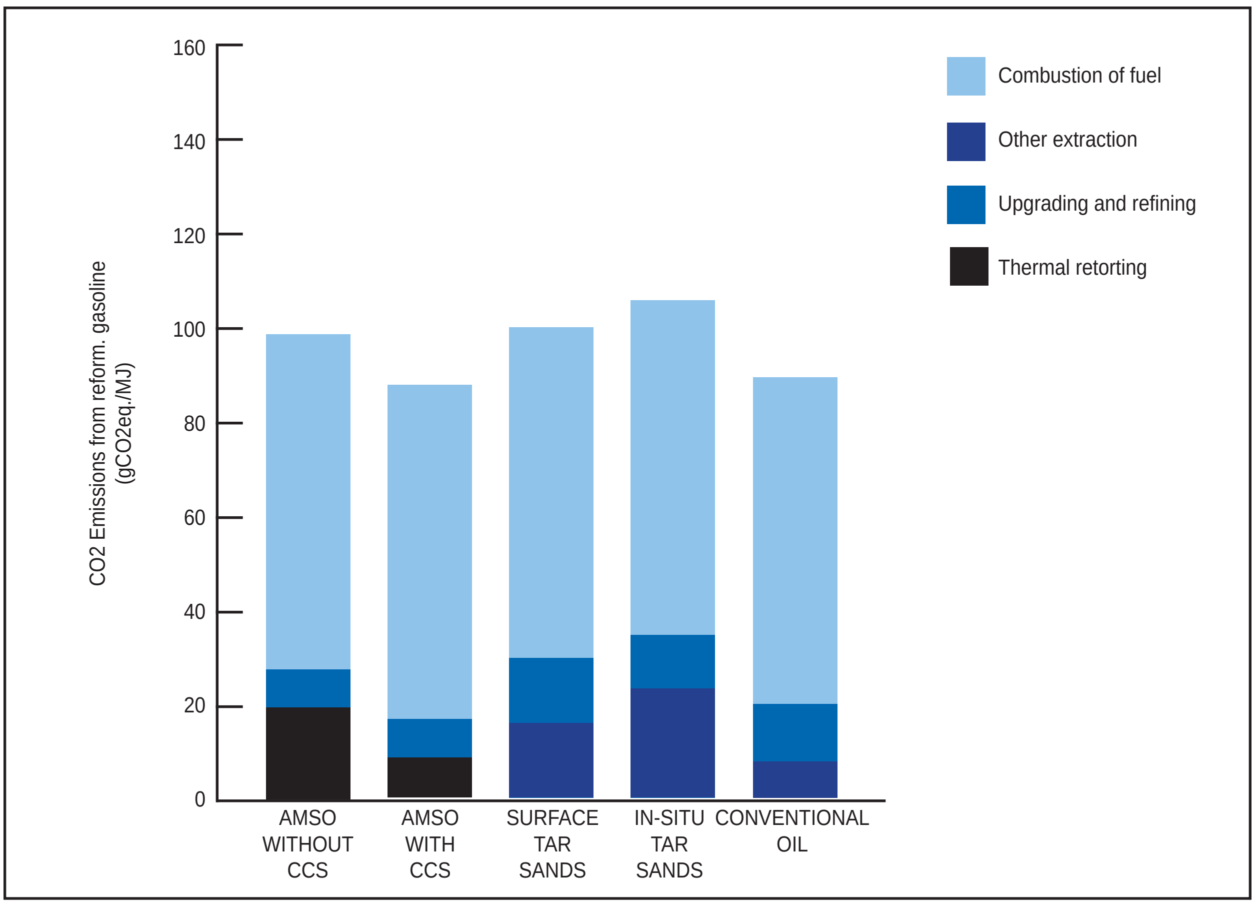
BLM Map Comparison – 2012 vs. 2008 PEIS there is over 1-million barrels of shale oil resource under one-acre of land surface, and this is many times the concentration of a typical oil and gas field or coal deposit. A commercial project on a 640-acre section of land could produce 5,000 barrels per day of shale oil for 20 years. Tracts of up to 5,120 acres are the size anticipated for full commercial development under BLM leases, and could produce up to 100,000 barrels per day of shale oil for decades.

Developers have access to private and State oil shale lands in Utah, Wyoming and Colorado. Development on these lands and on private holdings in other states does not rely on Federal oil shale leasing.

CLIMATE CHANGE

Observed changes in the environment suggest that the global climate is changing. Many experts believe some, if not all, of the change is resulting from human activity. In particular, it is postulated that man-made emissions of greenhouse gases are at least partially responsible for the changes, and that the earth is warming at a faster than expected rate. Other scientists believe that human causes are small if not negligible. The debate in the United States centers on the timing of mandated reductions of greenhouse gases, enacting regulations, and how to assure our economy and standard of living are maintained while the measures are being implemented.

The greenhouse gas of primary interest is carbon dioxide (CO2). This gas is not poisonous and is released every time humans exhale. It is produced whenever something is burned, such as coal, petroleum products and natural gas. For instance, it is produced when these natural resources are burned in a power plant to produce the electricity used in our homes. The same holds true for the production of shale oil because energy in the form of heat is needed to process oil shale. Therefore, shale oil production is not unique in its emission of CO2. The amount of CO2 gas



CO2 Emission Comparison – Source: Alan Burnham, PhD, American Shale Oil (AMSO)

produced depends upon the oil shale resource and the recovery technology. A comparison of CO2 emissions by source is shown on page 15.

There are a number of ways to mitigate the impact of CO2 emissions from oil shale projects. They vary with the retorting technology being employed, and generally include reducing emissions from the source, capturing the CO2 gas, disposing of it, or using the captured CO2 for beneficial use. Reducing CO2 emissions at the source is accomplished by employing energy efficiency measures, and using low retorting temperatures. Capturing CO2 can be accomplished using known technologies.

The isolation of carbon dioxide is known as sequestration. In one form of sequestration CO2 is injected into oil fields to enhance the recovery of petroleum. Alternatively, CO2 may be disposed of by injecting it into subsurface geologic strata. Studies have been conducted in the western United States that indicate there are formations that could accommodate the disposal of large quantities of CO2. Also, one of the current oil shale developers is proposing to use CO2 in its in-situ oil shale recovery technology. Another believes the CO2 may be permanently stored in the spent retorts after the shale oil has been recovered through in-situ recovery techniques.

In summary, CO2 is not any larger a problem for oil shale development than any other carbon emitting industry. The technology to reduce emissions from oil shale processing facilities exists and can be implemented. Nevertheless, it will add to the production costs. The key issue is the regulatory uncertainty surrounding the issue, and how much compliance will cost if standards are ultimately enacted.

WATER

Water is a precious commodity, particularly in the west where most of the U.S. oil shale deposits are located. There are competing water demands in the oil shale region, including the needs of municipal, agricultural, recreational and industrial interests. Compared to many other energy sources, the production of shale oil is not one of the largest consumers of water *(see chart on page 17)*.

Water is necessary for producing shale oil. A recent survey of current oil shale developers conducted by the National Oil Shale Association indicated the average is approximately 1.7 barrels of water per barrel of shale oil (Bbl/Bbl) produced, and some developers believe their technologies will use less, and/or be net producers of water. On balance experts in the field believe a range of 0 to 4 Bbl/Bbl brackets the range of technologies currently under consideration.

Based upon an estimate of 1.7 Bbl/Bbl, a 1.5 million barrels per day shale oil industry would required 120,000 acre-feet per year of water. An acre-foot is 325,851 gallons. For reference, roughly 500,000 acre-feet is diverted annually from the Colorado River for agricultural and municipal uses on the Front Range of Colorado.

The table below came from an independent study completed in 2012 by AMEC for the Colorado, Yampa and White River Basin Roundtables. The results are close to the water consumption estimates by NOSA given above.

TOTAL WATER USE FOR SELECTED SCENARIOS

Scenario	Unit Use (bbl/bbl)	Industry Water Use, acre-feet/year		
		Low	Medium	High
IS-1	-0.22	-16,000		
IS-4	0.77		54,000	
IS-7	1.59			110,000
AG-1	1.45	3,400		
AG-3	2.22		5,200	
AG-6	4.33			10,000
Total		-13,000	59,000	120,000

(SOURCE: AMEC for Colorado, Yampa & White River Basin Roundtables, 2012

White River near Piceance Basin, CO.

Water is required to some degree for all energy production. The information below summarizes the consumption of water by selected users based upon their producing 10,000 BTU's of usable energy from each source. The chart also shows the amount of energy produced for each gallon of water required. The production of shale oil requires the least amount of water of the selected energy producers.

Raw Shale Oil
70,000 BTU produced per gallon water
0.14 gallons of water per 10,000 BTU's

Coal Fired Electric Power Generation
7,000 BTU produced per gallon of water
1.4 gallons of water per 10,000 BTU's

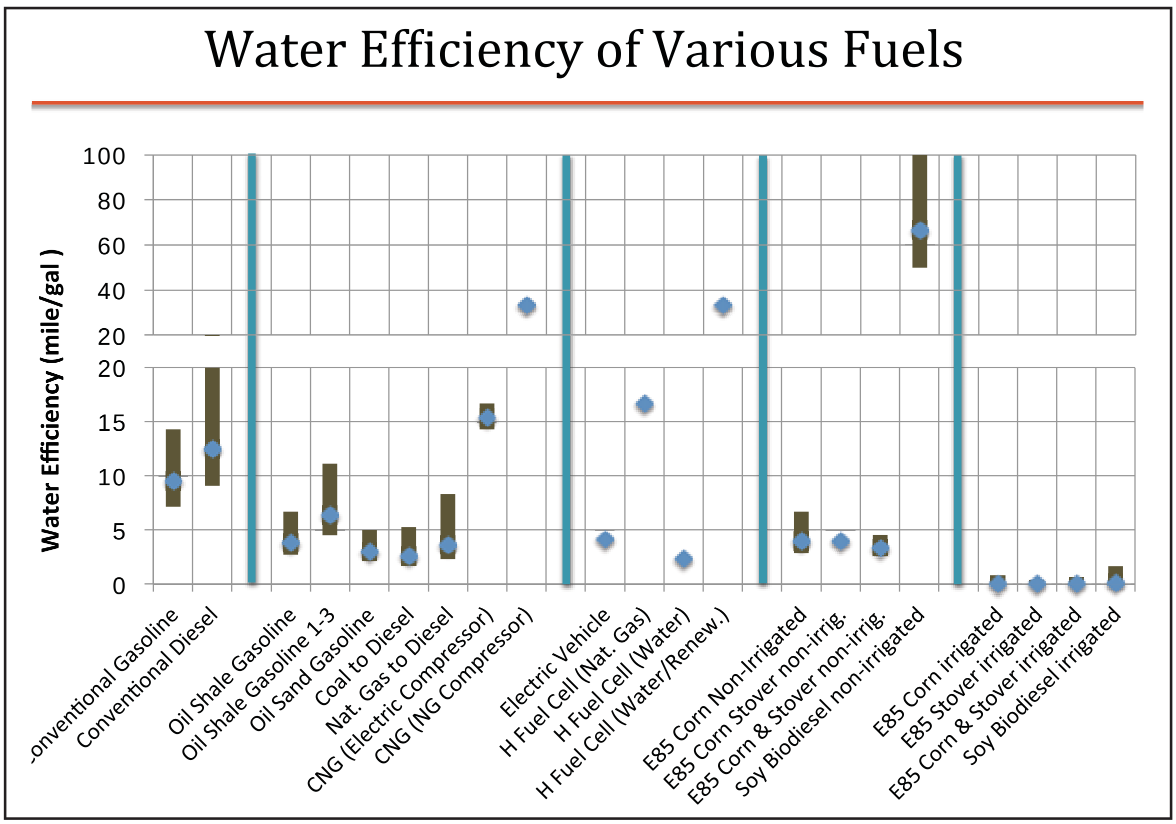
Ethanol From Irrigated Corn
4,200 BTU produced per gallon of water
2.3 gallons of water per 10,000 BTU's

(A BTU is one way to measure energy. It is commonly used to size furnaces and air conditioners. For instance a 70,000 BTU furnace will heat a small home.)

Water for oil shale projects may come from a variety of sources: ground water wells, surface streams and rivers, water produced from oil shale processing, waste waters from other industries or municipalities, reservoir storage, and/or water from other river basins transported to the region by pipeline.

The amount of water a commercial oil shale industry would use is a small fraction of the water flowing in the Colorado River and its tributaries from Colorado and Utah, even if all the required water came from surface rivers and streams. A 1.5-million barrel/day oil shale industry would use only 2 to 3% of the conservatively estimated 8-million acre feet per year of water that flows into Lake Powell in Utah from the Colorado River.

The right to use water from surface streams and rivers is controlled legally within each oil shale state. In the east a riparian doctrine is followed which permits anyone whose land has frontage on a body of water to use that water. Most western states follow a prior appropriation doctrine that follows the "first in time first in right" philosophy. This approach



(SOURCE: King, C.W., and M.E. Webber, (2008) Water Intensity of Transportation, Environmental Science & Technology, vol. 42, no. 21, p. 7866-7872

placed many senior water rights in the hands of the original pioneer ranchers. Many oil shale developers have already acquired water rights that will enable them to satisfy the requirements of their projects.

Water pipelines, storage and treatment facilities will be required to provide uninterrupted and reliable supplies of water to commercial oil shale projects. Due to the arid nature of the west, storage of water during the snow melt period is required to assure a supply during the dry period of the year. Many water experts believe that more multiple use public/private water storage reservoirs are needed, especially in light of some current climate change projections.

With proper management of the water resources, development of water saving technologies, and the development of water storage and diversion projects, there can be sufficient water in the future for all users. The amount of water required for oil shale projects is well known even though it varies with the technology employed and the water content of the resource. Current research, development and demonstration projects will further refine the overall needs for water for each technology.

Water is not the issue that will make or break oil shale development, but misleading information from some groups is leading the public to think it is. Water will be used sparingly, and alternate supplies can be used to reduce the required amount. Water used for oil shale development is a beneficial use that will create jobs, spur economic development, and enhance U.S. energy security.

ECONOMIC AND SOCIAL CHALLENGES

The challenge for an oil shale industry is to demonstrate and utilize technologies that can be economically sustainable and continue to operate through the ups and downs of energy pricing. The question is often asked "at what price of petroleum will shale oil be profitable?" The answer is not clear because most projects are in the research, development or demonstration stage, but recent estimates range from $40 to $80 per barrel. The range is so large because technologies that are under development have not reached a scale of production to sufficiently define commercial plant capital and operating costs, and there are still technological hurdles to be overcome before more accurate estimates can be made.

Oil shale is expensive to extract, and the challenge is for it to become competitive with conventional petroleum. The high end of the shale oil cost estimate range given above is in line with the current estimates for tight oil production, and oil shale can likely compete with projected future international oil prices. When an industry does emerge, it will develop incrementally, likely with multiple technologies, and meeting all regulatory requirements.

The social impacts of an oil shale industry may or may not be significant, depending upon the scale of development, its timing and what other industries have come and/or gone from the region at the time oil shale is commercialized.

The key potential impacts are listed below:

- Shortage of public facilities and services to deal with an influx of oil shale workers, their families, and support businesses
- Lack of upfront funding for infrastructure improvements because royalty and severance tax revenues start after shale oil production begins, while impacts will start during construction
- Inadequate sharing of Federal royalty and State severance tax revenues with local communities
- Degradation of quality of life expectations for residents not involved in the energy sector because the demographics of parts of the region have changed in the last decades
- Affect on real estate prices that may be positive or negative depending upon the location

Significant benefits of an oil shale industry are described in the Benefits section. Achieving a balance between social benefits and impacts is a key objective for industry, government and all stakeholders.

D. MISCONCEPTIONS

Through the years a number of myths and misconceptions about oil shale have been publicized by those that either do not know the facts or intentionally use these misconceptions to mischaracterize the resource. The following sets the record straight on some of the most incorrect and publicized myths and misconceptions.

1. MYTH: Oil shale processing uses more energy than it produces. It would be better to process pop tarts or potatoes.

FACT: Net energy is created though the retorting of oil shale. Depending upon the technology employed and the richness of the resource, estimates range from a ratio of 3:1 to 6:1. Dr. James W. Bunger estimates the ratio at 4.3 for a mining/surface retorting project processing 25 gallon per ton oil shale. The size, concentration and quality of the oil shale resource in the Western U.S. make it an ideal domestic source of gasoline, diesel and jet fuels. An assay of a potato yields 3.5 gallons of oil per ton of potatoes. A typical oil shale yields 25 gallons per ton. Thus the typical oil shale produces 7 times more usable energy than a potato. The same assay revealed that potatoes contain about 200 gallons per ton of water. The chemical properties of oil shale make it an ideal resource for producing transportation fuels.

Oil production from oil shale & potatoes.

2. MYTH: Shale oil is a dirty inferior hydrocarbon fuel.

FACT: Oil shale deposits in the Western United States are the most concentrated hydrocarbon resource in the world. One ton (about 1 cubic yard) of oil shale will produce 25 gallons or more of shale oil that can be upgraded and refined into excellent gasoline, jet fuel, clean diesel and other petroleum products. The shale oil content in a ton of oil shale is 2.3 times greater than the oil contained in a ton of sandstone rock from a conventional oil reservoir, like the oil fields on the north slope of Alaska. The oil produced from oil shale is essentially the same as that from conventional oil wells. The quality of shale oil varies with technology and ranges from 20 to 35 degrees API, with the latter expected from in-situ technologies. *(API gravity is one of the measures of oil quality – as the number increases the density of the oil decreases and the quality improves.)*

3. MYTH: Oil shale development has too many health, wildlife and environmental unknowns, and it is too risky and dangerous, so commercial development must await completion of all research, development and demonstration projects to be completed before proceeding.

FACT: The basic methods of producing oil and gas from oil shale are well known. Shale oil production via ex-situ methods has been successfully carried out in Brazil, China, Estonia and other parts of the world for decades. Large-scale demonstration plants were operated in the United States in the 1960-80's. There is a wealth of knowledge that can be drawn upon by

Shale oil upgrading plant in Parachute, CO - circa 1980's.
(Photo Courtesy of Roger Day.)

engineers and scientists. Testing of the newer in-situ technologies will be required since they have not reached the maturity of some ex-situ processes. The ranges of technical, socioeconomic and environmental factors can be established through this testing so the public and government officials can judge the impacts and benefits of development.

Eventhough additional testing and demonstration is needed for some technologies there is still enough technical and environmental information available to bracket the range of variables so that regulators can make informed judgements. An example is water use. Experts are convinced the range is between 0 and 4 barrels of water required for each barrel of shale oil produced. Estimates outside this range are unreasonable.

4. MYTH: Spent shale is a hazardous material and blows-up like popcorn when produced.

FACT: Spent shale is not a hazardous material. A finding by the U.S. EPA confirms that conclusion. Spent shale embankments resulting from demonstration oil shale operations in the Western United States in the 1960-1980's are stable landfills, support vegetation and have not contaminated surface or ground waters. Techniques developed in that era and experience from similar industries will be employed and used by current developers. Spent oil shale from above ground processes does not expand like popcorn, however it does have a slightly larger volume than the original in place oil shale rock primarily because of voids introduced by mining, crushing and retorting. Spent shale remains underground throughout in-situ oil shale processing.

UNOCAL spent shale embankment, May 2010.

5. MYTH: There is no need to lease Federal oil shale lands since there are plenty of private oil shale lands.

FACT: By far, most of the highest quality oil shale resource in the world is under U.S. Federal ownership in Colorado, Utah and Wyoming. It is this resource that has the best chance of supporting a first generation oil shale industry that is economic and sustainable, if the Federal government provides access to the resource through a commercial oil shale leasing program. No other mineral leased by the Federal government requires R,D&D on Federal land before a commercial lease is awarded, but BLM currently only issues R,D&D oil shale leases. There are oil shale lands in private and State ownership that can support commercial ventures, but they are often less attractive for the in-situ technologies now under development.

6. MYTH: There is no solution to dealing with greenhouse gases (GHG) produced from oil shale processing. Giant coal fired power plants required to support an oil shale industry will be large sources of GHG.

FACT: Greenhouse gases, such as CO2 produced from oil shale processing can be captured, put to beneficial use, or sequestered. Not all technologies under development require large external sources of electric power to supply the heat for retorting. The by-product gas and/or carbon on the spent shale produced during oil shale retorting are sufficient to supply much of the heat needed to convert oil shale into shale oil. Electric power will be required for the non-heating needs of an oil shale industry, and it can be generated from sources other than coal, such as natural gas, solar, nuclear and wind turbines.

7. MYTH: All the impacts of oil shale development are negative and so significant that it should not be allowed to develop.

FACT: An oil shale industry can provide numerous benefits to local communities, states, the Federal government and the general public. These benefits are realized through public sector revenue distribution (e.g. tax, royalty, use and license fee revenues for affected units of government); economic expansion and diversification (e.g. increased opportunities for local small businesses); long-term employment opportunities (e.g. high paying full time jobs in a sustainable industry); education and skill development; and fiscal support for infrastructure improvements (e.g. schools, hospitals, transportation and public services). From a national perspective, a domestic oil shale industry will reduce the trade deficit, improve national security and make the United States less reliant on the importation of foreign petroleum.

8. MYTH: There is not enough water available to support oil shale development in Colorado, Utah and Wyoming. Stream fisheries will be eliminated. Water will become too dangerous to drink because of contamination by elements like arsenic, boron and selenium.

FACT: Water is needed for oil shale processing. The amount varies with technology but is in the range of 0 to 4-barrels of water per barrel (Bbl/Bbl) of shale oil produced, with a reasonable average for current technologies at 1.7 Bbl/Bbl. Unallocated water is currently available within the upper Colorado River Basin to support a commercial industry, and many developers already have rights to use that water. A 1.5-million barrel per day commercial oil shale industry is estimated to use 2-3% of the water in the Basin. It would not dry up rivers or endanger fisheries because water use is strictly regulated by appropriate State agencies. A zero-discharge strategy will be employed wherein contaminated water will be treated and used internally. Contaminated water will not be returned to local streams and rivers.

9. MYTH: We don't need oil shale. We can use renewables and non-fossil fuel alternatives to meet our future energy needs.

FACT: During the next decades the United States will need a secure domestic supply of hydrocarbon fuels especially for airline travel and ground transportation. The demand for gasoline, diesel and jet fuels is continuing to increase and the U.S. will continue to require oil imported from outside our shores. Even with increased conservation, efficiency improvements, and fuel substitution, the percentage of petroleum imported from outside our borders will continue for decades. Growing worldwide demand has been shown to result in higher fuel prices, shortages of world supplies and political instability. Oil shale is one of the domestic bridge fuel supplies that can see the nation through to a society less dependent upon foreign fossil fuels.

Oil Shale Outcrop, Utah.

E. CONCLUSIONS

Oil shale can become a sustainable industry after decades of setbacks, based upon the following.

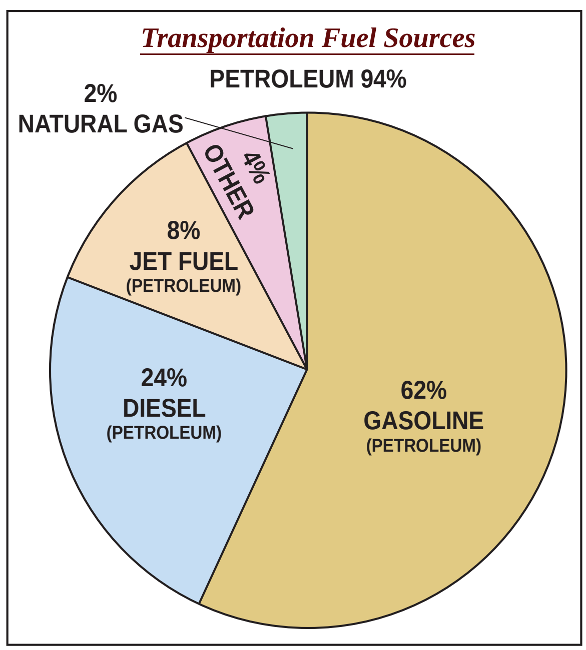
1. Technology has improved in areas of in-situ processing here in the United States, and from the ex-situ technology experience of foreign and domestic firms. Now, these technologies are ready to take the next steps toward commercialization. Technologies under development today have an opportunity to make shale oil production competitive with conventional petroleum.

2. Oil shale remains a huge untapped domestic resource that can assist the nation in becoming less reliant upon foreign sources of petroleum. The estimated recoverable shale oil resource is larger than the oil reserves in the Middle East, and the size of the resource remains a primary impetus for oil shale development in the United States.

3. Lessons were learned from the past attempts to commercialize oil shale. Today, there are no government mandates for quick production. A methodical and deliberate approach is being taken to obtain the technical, economic and environmental answers before proceeding. The Alberta, Canada Oil Sands experience indicates it will take decades for an industry to produce one million barrels per day of shale oil. Partnering with government at all levels, stakeholder groups and the public at large in a transparent fashion is another lesson from the past that is being followed.

4. The imperative is great to advance oil shale development. There are looming oil shortages, higher gasoline prices and political instability resulting from the importation of so much petroleum, especially in an era of rising demand in developing countries like China and India. Over 90% of the fuel we use to power our cars, trucks and planes comes from petroleum (as shown in the attached figure). Reducing reliance on petroleum used to produce these fuels may take decades. Oil shale, along with other sources of domestic transportation fuels and conservation, can assist in the transition to a society less reliant upon foreign sources of petroleum. Many experts believe North America can become energy independent in the near term if development of oil shale, tight oil, gas shales and increased importation of petroleum from Canadian oil sands is encouraged at a national level.

5. A government policy that supports the development of all domestic energy resources, including oil shale, is needed if an oil shale industry is to move forward in the near term. Continuing the necessary research, development and demonstration projects is expensive, and firms need the assurance that their efforts will not be stymied by unwarranted government actions. The leasing of Federal oil shale resources is a necessary step in the process. Firms are seeking a policy that supports the production of unconventional fuels from domestic sources. Both the military and public will benefit through the stabilization of gasoline prices, the reduction in the trade deficit, the creation of jobs here at home, the tax and royalty income for local communities, and a more secure future for our children and grandchildren.



(SOURCE: U.S. DOE.)

ACKNOWLEDGEMENTS AND REFERENCES

The National Oil Shale Association wished to acknowledge the support of all of those who contributed to the production of this document, including the principal authors Gary Aho, Tony Dammer and Glenn Vawter; the Board of Directors and members of NOSA, and Janice Matlock of Jean's Printing, Inc. team in Rifle, CO.

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Piceance Basin, CO.

The National Oil Shale Association (NOSA) is a non-profit organization whose mission is to provide factual information about oil shale in the United States. We advocate the responsible production of shale oil to benefit the energy and national security of the United States. Membership is open to firms, non-profits and individuals. A copy of our bylaws, an application form, and contact information is available on the web site given below. Please contact us if we can answer questions about NOSA or oil shale.

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NOSA