Oil Shale Development in the United States

Prospects and Policy Issues

James T. Bartis, Tom LaTourrette, Lloyd Dixon,
D.J. Peterson, Gary Cecchine

Prepared for the National Energy Technology Laboratory of the
U.S. Department of Energy

RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT

The research described in this report was conducted within RAND Infrastructure, Safety, and Environment (ISE), a division of the RAND Corporation, for the National Energy Technology Laboratory of the U.S. Department of Energy.

Library of Congress Cataloging-in-Publication Data

Oil shale development in the United States : prospects and policy issues / James T. Bartis ... [et al.].
p. cm.
"MG-414."
Includes bibliographical references.
ISBN 0-8330-3848-6 (pbk. : alk. paper)
1. Oil-shales—United States. 2. Oil-shale industry—United States.
I. Bartis, James T.

TN859.U5O35 2005
622'.3383'0973—dc22

2005022573

Cover photo: A view east, down Ryan Gulch, towards the center of Piceance Basin.
Photographer: Linda Jones, Bureau of Land Management, White River Field Office

Published 2005 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
201 North Craig Street, Suite 202, Pittsburgh, PA 15213-1516
RAND URL: http://www.rand.org/
To order RAND documents or to obtain additional information, contact
Distribution Services: Telephone: (310) 451-7002;
Fax: (310) 451-6915; Email: order@rand.org

Summary

Since the early 1980s, oil shale has not been on the U.S. energy policy agenda, and very little attention has been directed at technology or energy market developments that might change the commercial prospects for oil shale. This report presents an updated assessment of the viability of developing oil shale resources in the United States and related policy issues. The report describes the oil shale resources in the western United States; the suitability, cost, and performance of available technologies for developing the richest of those resources; and the key energy, environmental, land-use, and socioeconomic policy issues that need to be addressed by government decisionmakers in the near future.

The U.S. Oil Shale Resource Base

The term *oil shale* generally refers to any sedimentary rock that contains solid bituminous materials that are released as petroleum-like liquids when the rock is heated. To obtain oil from oil shale, the shale must be heated and resultant liquid must be captured. This process is called *retorting*, and the vessel in which retorting takes place is known as a *retort*.

The largest known oil shale deposits in the world are in the Green River Formation, which covers portions of Colorado, Utah, and Wyoming. Estimates of the oil resource in place within the Green River Formation range from 1.5 to 1.8 trillion barrels. Not all resources in place are recoverable. For potentially recoverable oil shale resources, we roughly derive an upper bound of 1.1 trillion barrels of oil and a lower bound of about 500 billion barrels. For policy planning purposes, it is enough to know that any amount in this range is very high. For example, the midpoint in our estimate range, 800 billion barrels, is more than triple the proven oil reserves of Saudi Arabia. Present U.S. demand for petroleum products is about 20 million barrels per day. If oil shale could be used to meet a quarter of that demand, 800 billion barrels of recoverable resources would last for more than 400 years.

Oil Shale Technology Prospects

Processes for producing shale oil generally fall into one of two groups: mining followed by surface retorting and in-situ retorting.

Mining and Surface Retorting. Oil shale can be mined using one of two methods: underground mining using the room-and-pillar method or surface mining. The current state of the art in mining—both room-and-pillar and surface techniques, such as open pit mining—appears to be able to meet the requirements for the commercial development of oil shale.

The current commercial readiness of surface retorting technology is more questionable. Development of surface retorts that took place during the 1970s and 1980s produced mixed results. Technical viability has been demonstrated, but significant scale-up problems were encountered in building and designing commercial plants. Since then, major technical advances have occurred but have not been applied to surface retorts. Incorporating such advances and developing a design base for full-scale operations necessitates process testing at large but still subcommercial scales.

Cost information available from projects and design studies performed in the 1980s can be escalated to give a very rough estimate of the anticipated capital costs for mining and surface retorting plants. Using this approach, a first-of-a-kind commercial surface retorting complex (mine, retorting plant, upgrading plant, supporting utilities, and spent shale reclamation) is unlikely to be profitable unless real crude oil prices are at least $70 to $95 per barrel (2005 dollars).

In-Situ Retorting. In-situ retorting entails heating oil shale in place, extracting the liquid from the ground, and transporting it to an upgrading or refining facility. Because in-situ retorting does not involve mining or aboveground spent shale disposal, it offers an alternative that does not permanently modify land surface topography and that may be significantly less damaging to the environment.

Shell Oil Company has successfully conducted small-scale field tests of an in-situ process based on slow underground heating via thermal conduction. Larger-scale operations are required to establish technical viability, especially with regard to avoiding adverse impacts on groundwater quality. Shell anticipates that, in contrast to the cost estimates for mining and surface retorting, the petroleum products produced by their thermally conductive in-situ method will be competitive at crude oil prices in the mid-$20s per barrel. The company is still developing the process, however, and cost estimates could easily increase as more information is obtained and more detailed designs become available.

Development Timeline. Currently, no organization with the management, technical, and financial wherewithal to develop oil shale resources has announced its intent to build commercial-scale production facilities. A firm decision to commit funds to such a venture is at least six years away because that is the minimum length of time for scale-up and process confirmation work needed to obtain the technical and environmental data required for the design and permitting of a first-of-a-kind commercial operation. At least an additional six to eight years will be required to permit, design, construct, shake down, and confirm performance of that initial commercial operation. Consequently, at least 12 and possibly more years will elapse before oil shale development will reach the production growth phase. Under high growth assumptions, an oil shale production level of 1 million barrels per day is probably more than 20 years in the future, and 3 million barrels per day is probably more than 30 years into the future.

The Strategic Significance of Oil Shale

If the development of oil shale resources results in a domestic industry capable of profitably producing a crude oil substitute, the United States would benefit from the economic profits and jobs created by that industry. Additionally, oil shale production will likely benefit consumers by reducing world oil prices, and that price reduction will likely have some national security benefits for the United States. A hypothetical shale oil production rate of 3 million barrels per day was assumed for the purpose of calculating consumer benefits.

Economic Profits. If low-cost shale oil production methods can be achieved, direct economic profits in the $20 billion per year range are possible for an oil shale industry producing 3 million barrels per day. Through lease bonus payments, royalties on production, and corporate income taxes, roughly half of these profits will likely go to federal, state, and local governments and, thereby, broadly benefit the public.

Employment Benefits. A manifestation of the economic benefits of shale oil production is an increase in employment in regions where shale oil production occurs or in regions that contain industries that provide inputs to the production process. A few hundred thousand jobs will likely be associated, directly and indirectly, with a 3 million barrel per day industry. The net effect on nationwide employment is uncertain, however, because increases in employment arising from shale oil production could be partially offset by reductions in employment in other parts of the country.

Reduced World Oil Prices. Production of 3 million barrels of oil per day from oil shale in the United States would likely cause oil prices to fall by 3 to 5 percent, but considerable uncertainty surrounds any calculation on how large the effect might be, especially when trying to model the behavior of the Organization of the Petroleum Exporting Countries (OPEC) and other major suppliers far into the future. Assuming a 3 to 5 percent fall in world oil prices, the resulting benefits to consumers and business users in the United States would be roughly $15 billion to $20 billion per year.

National Security. A drop in world oil prices would reduce revenue to oil-exporting countries. A 3 to 5 percent reduction in revenue would not change the political dynamic in those countries a great deal. With regard to enhancing national security, the principal value of oil shale production would be its contribution to a portfolio of measures intended to increase oil supplies and reduce oil demand.

Other claims of the benefits of increased domestic oil production, such as a reduced trade deficits and more reliable fuel supplies for national defense purposes, are not well justified.

Critical Policy Issues for Oil Shale Development

The potential emergence of an oil shale industry in the western United States raises a number of critical policy issues.

Land Use and Ecological Impacts. Of all the environmental impacts of oil shale development, the most serious appears to be the extent to which land will be disturbed. Regardless of the technical approach to oil shale development, a portion of the land over the Green River Formation will need to be withdrawn from current uses, and there could be permanent topographic changes and impacts on flora and fauna. For surface retorting, extensive and permanent changes to surface topography will result from mining and spent shale disposal. In-situ retorting appears to be much less disruptive, but surface-based drilling and support operations will cause at least a decade-long displacement of all other land uses and of preexisting flora and fauna at each development site.

Air Quality. Oil shale operations will result in emissions that could impact regional air quality. Studies in the 1970s and 1980s suggested that air emissions from an industry producing a few hundred thousand barrels per day could probably be controlled to meet then existing regulations. No studies have been reported since, and no studies have considered output on the order of several million barrels per day. Meanwhile, so much has changed in terms of environmental regulations, mining and process technologies, and pollution control technologies that the earlier analyses are no longer relevant.

Greenhouse Gas Emissions. The production of petroleum products derived from oil shale will entail significantly higher emissions of carbon dioxide, compared with conventional crude oil production. If these emissions are to be controlled, oil shale production costs will increase.

Water Quality. All high-grade western oil shale resources lie in the Colorado River drainage basin. For mining and surface retorting, the major water quality issue is the leaching of salts and toxics from spent shale. A number of approaches are available for preventing surface water contamination from waste piles, but it is not clear whether these methods represent a permanent solution that will be effective after the site is closed and abandoned. For in-situ retorting, inadequate information is available on the fate, once extraction operations cease, of salts and other minerals that are commingled with oil shale.

Socioeconomic Impacts. Large-scale oil shale development will stimulate a significant increase in the populations of northwestern Colorado and Uintah County in Utah. Even a relatively small development effort, such as might occur during the construction of a few initial commercial plants will result in a large population influx. Rapid population growth will likely stretch the financial ability of local communities to provide necessary public services and amenities.

Leasing. The richest and most abundant deposits of oil shale are found on federal lands managed by the U.S. Department of the Interior. As such, the course of oil shale development and its environmental impacts will be shaped by federal decisions regarding how much, when, and which specific lands will be offered for lease. At present, the Department of the Interior does not have available a strategic approach for leasing oil shale–bearing federal lands. The Energy Policy Act of 2005 has liberalized the lease ownership provisions of the Minerals Leasing Act of 1920, thereby removing a major deterrent to private-sector investment in oil shale development. If mining and surface retorting turn out to be the preferred approach to oil shale development, the current lease size provisions of the Act will constrain resource recovery and increase per-barrel mining costs and land disturbance.

Production Costs. Oil shale has not been exploited in the United States because the energy industry, after some halting efforts, decided that developing oil shale was economically unviable. Over the past two decades, very little research and development effort has been directed at reducing the costs of surface retorting. For thermally conductive in-situ retorting, costs might be competitive with crude oil priced at less than $30 per barrel, but the technical viability of in-situ retorting will not be fully established for at least six years.

Market Risks. As with many commodities, crude oil prices are highly volatile. To hedge against the possibility of downward price movements, investments in projects with high capital costs, such as oil shale development, tend to be deferred until a sufficient safety cushion builds up between anticipated production costs and what the market is willing to pay. An added degree of uncertainty is associated with the potential response of OPEC nations to various market and technical developments.

Water Consumption. About three barrels of water are needed per barrel of shale oil produced. Water availability analyses for oil shale development were conducted in the early 1980s. These analyses indicated that the earliest constraining factors would be limitations in local water supply systems, such as reservoirs, pipelines, and groundwater development. A bigger issue is the impact of a strategic-scale oil shale industry on the greater Colorado River Basin. Demands for water are expected to continue to grow for the foreseeable future, making the earlier analyses regarding oil shale development outdated.

Future Development Prospects

The prospects for oil shale development are uncertain. The estimated cost of surface retorting remains high, well above the record-setting crude oil prices that occurred in the first half of 2005. For surface retorting, it therefore seems inappropriate to contemplate near-term commercial efforts. Meanwhile, the technical groundwork may be in place for a fundamental shift in oil shale economics. Advances in thermally conductive in-situ conversion may cause shale-derived oil to be competitive with crude oil at prices below $30 per barrel. If this becomes the case, oil shale development could soon occupy a very prominent position in the national energy agenda.

We are rapidly approaching a critical juncture for oil shale development. On June 9, 2005, the Bureau of Land Management released its Call for Nominations of parcels to be leased for research, development, and demonstration of oil shale recovery technologies in Colorado, Utah, and Wyoming. The response to this solicitation will provide a clear signal about whether the private sector is prepared to commit its resources to oil shale development. Government decisionmakers need to wait for that signal. When it is clear that at least one major private firm is willing to devote, without appreciable government subsidy, its technical, management, and financial resources to oil shale development, government decisionmakers should address the core policy issues listed above.

Key Recommendations

Business as Usual. The following are recommended whether or not oil shale is a candidate for early efforts toward commercial production.

- Oil shale should be part of the Department of Energy's research and development portfolio. Significant long-term research opportunities are associated with both surface retorting and in-situ retorting. A benefit of even a small federal program (i.e., a few million dollars annually) would be the continued availability of a small cadre of scientific and engineering professionals who would be deeply knowledgeable of oil shale development issues.
- Consideration should be given to establishing a national oil shale archive that would hold and preserve information on oil shale resources, technologies, and impacts of development. We fear that, with the passage of time, important information will be lost.
- Analysis should be directed at lease program implementation options, such as combining adjacent lease tracts in a lease offering and provisions for ensuring or promoting extensive recovery of resources within lease tracts.

In Support of Commercialization. Once clear indications are in hand that major firms are ready to invest in scaling up and demonstrating oil shale technologies, government attention should be directed at gathering long lead time information required to support future decisionmaking with regard to permitting and leasing. Early action is appropriate for the following:

- Development and implementation of a research plan directed at establishing options for mitigating damage to plants and wildlife and reducing uncertainties associated with ecological restoration.
- Research directed at mathematical modeling of the subsurface environment, combined with a multiyear hydrological, geochemical, and geophysical monitoring program. (This in the event that major industrial investments are directed at in-situ retorting.)
- Research directed at establishing and analyzing options for long-term spent shale disposal. (This in the event that major industrial investments are being directed at mining and surface retorting.)
- Regional air quality modeling directed at determining preferred locations for federal leasing and informing decisions on air quality permits for initial commercial plants.
- Development of a federal oil shale leasing strategy for the Green River Formation, along with appropriate analytic and procedural approaches for timing and selecting sites for lease offerings, establishing lease provisions, and avoiding measures that will constrain future development.

Development at a Measured Pace. Many uncertainties regarding technology performance and environmental and socioeconomic impacts remain unresolved. While the above "early action" recommendations will serve to narrow uncertainties and reduce the risks of making poor decisions, resolution of the most critical issues associated with strategically significant levels of production will not occur until the initial round of large-scale commercial facilities are constructed and operated—a point that is at least 12 years down the road. A particularly pressing issue is the viability of in-situ retorting because this approach may offer a more profitable and far more environmentally benign alternative to mining and surface retorting. The prevailing information shortfalls suggest that oil shale development should proceed at a measured pace.

Public Participation. Because oil shale development could profoundly affect local residents and other stakeholders, their inputs into federal decisionmaking need to be sought and valued early in the process. The same holds true of the affected state governments, tribal governments, and the wider citizenry, including nongovernmental organizations representing citizens supportive of environmental protection, wildlife conservation, and alternative land uses. An opportune time to broaden public involvement is in conjunction with the preparations for a new round of federal leasing of oil shale tracts. Toward this end, the federal government should consider fostering the creation of a regionally based organization dedicated to planning, oversight and advice, and public participation. Various venues are possible for this, including the Western Governors' Association and the Colorado and Utah state governments.