

A Synopsis of Recent Literature by



Oil Shale in the West: 14 Unanswered Questions

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Updated

Oil Shale in the West: 14 Unanswered Questions

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ABOUT HEADWATERS ECONOMICS

Headwaters Economics is an independent, nonprofit research group. Our mission is to improve community development and land management decisions in the West.



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Cover photo: Large-scale commercial tar sands mining activity north of Fort McMurray, Alberta, Canada showing a shovel bucket and tar sands processing facility in the background. Surface mining for oil shale would deploy similar technologies. Source: BLM/Suncor Energy Inc. Accessed online, 6/17/09, <http://ostseis.anl.gov/guide/photos/index.cfm>.

TABLE OF CONTENTS

Introduction.	1
Summary Findings.	2
Background	5
Uncertainties Regarding the Mechanics of Oil Shale Development	7
Available Technology and its Constraints	7
Environmental Impacts and Questions about their Mitigation.	11
Infrastructural Hurdles to Oil Shale Development	13
Economic Questions: How and When Will it be Profitable to Develop Oil Shale?	14
Opportunities and Obstacles to Oil Shale Development in Federal Policy	17
Policy Support for Oil Shale.	17
Lingering Policy Obstacles	18
Conclusions	20
Addendum: Research Update. The State of the Industry at the Start of 2010.	21
Bibliography.	27

INTRODUCTION

This report was originally published in June of 2009. An update on recent progress in oil shale research and development was added to this report (see page 21) in January 2010. We have also updated Figure 1 (page 8) in order to correct an error.

This report summarizes recent research and policy documents to provide a brief overview of the current state of oil shale development in the U.S. West.

Recent high crude oil prices, anticipation of a peak oil crisis, and a focus on developing domestic sources of fossil fuel have contributed to a renewed interest in mining and processing the oil shale found in Utah, Wyoming, and Colorado to yield a crude oil substitute.

The development of a commercial-scale industry remains a tenuous proposition due to a number of technical, environmental, regulatory, and economic challenges. The viability of oil shale development relies on major assumptions regarding the industry's ability to overcome these and other obstacles.

Federal policy designed to encourage development of oil shale and the vast scale of the resource mean that oil shale development will remain a possibility in the U.S. West as long as the nation continues to rely heavily on fossil fuels for energy. As a result, it is important to understand the issues that affect the development of a western oil shale industry.

Because the oil shale industry remains a hypothetical prospect, much of what is written about it is necessarily speculative and is published in non peer-reviewed venues. This report highlights the assumptions that inform current assessments about the viability of oil shale production. It identifies a number of questions that need to be answered before the public and policy makers can begin to make informed decisions about the costs and benefits of a commercial-scale oil shale industry in the West.

We conclude there are at least fourteen unanswered questions about the viability of oil shale production at a commercial-scale. There is room for considerable skepticism about most of them, as they involve unproven technologies or what seem now to be political improbabilities. On the other hand, oil shale has clearly gained momentum in recent years and several of the industry's key drivers—fossil fuel dependency, the peak oil challenge, and rising crude oil prices—remain in place.

The body of this report is organized into three sections: an assessment of technological, environmental, and infrastructural challenges to oil shale production; a survey of the economic context; and finally, an overview of the current policy context. A complete bibliography is provided at the end.

SUMMARY FINDINGS

Recent forces are working to move oil shale development forward:

- Recent and projected world oil prices are at or near the “hurdle prices” (ranging from \$30 to \$70 per barrel, depending on technology) at which industry proponents claim oil shale would be cost-effective.
- The potential volume of oil shale’s contribution to domestic fuel supplies is estimated at 500 billion to more than 1 trillion barrels. By comparison, the projected total yield from Saudi Arabia’s oil fields is estimated at 265 billion barrels.
- The BLM has completed the necessary preliminary steps for a national oil shale leasing program.
- Response to recent RD&D (research, development, and demonstration) lease offerings by the BLM demonstrates a high level of industry interest.
- Industry, specifically Shell, has invested large amounts of capital in developing *in situ* retorting (below ground liquefaction of oil shale) as an “environmentally-friendly” and cost-effective approach to oil shale development.

However, significant obstacles to a commercial industry persist:

- Predictions about the commercial viability of oil shale depend on developing an industry at a volume that would rank the oil shale region of the Western U.S. among the top 10 oil producing nations in the world. The vast scale of its operations underlies the many obstacles the industry faces.
- Neither existing production techniques nor new technologies that are in development have ever actually functioned at the scale that industry and government experts predict would be required to make Western oil shale financially viable.
- Predictions of the cost-effectiveness of oil shale assume that crude oil prices will continue to rise and that investment in and development of alternative fuel and energy sources (as well as energy conservation) will not have an effect on fossil fuel dependency.
- Regardless of mining technology, environmental impacts to habitat, ground and surface water, and air quality from oil shale production conflict with existing federal environmental statutes, including—but not limited to—the National Environmental Policy Act (NEPA), the Clean Air Act, and the Clean Water Act.

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- Anticipated new federal legislation capping greenhouse gas emissions would severely impinge on the viability of oil shale by penalizing high carbon energy sources.
 - Creating energy to extract and produce oil shale may be difficult, as coal-fired and nuclear power plants face approval hurdles themselves.
 - Existing refinery and pipeline infrastructure would require major upgrades to accommodate oil shale distillate.
 - The projected water usage demands of oil shale development—hundreds of thousands of acre-feet per year—greatly exceed water availability in the Colorado River Basin, an already over-adjudicated water source of which municipalities as well as agricultural users from across the West are fiercely protective.
 - Affected state agencies in Utah, Colorado, and Wyoming vary in awareness and preparedness for their role in oversight and administration of oil shale leasing.
 - Local governments and communities in northwest Colorado, southwest Wyoming, and northeast Utah are overextended as a result of swings in the current oil and natural gas economy and would likely struggle to accommodate growth on the scale anticipated for a booming oil shale industry.

The Future of a Western Oil Shale industry: 14 Unanswered Questions

Understanding the answers to the following questions will be crucial to making informed decisions about the viability of the industry and the relationship between impacts and benefits.

Regarding mining operations and their impacts:

1. Will mining activities on a scale rivaling the world's largest mines stand up to federal regulatory review such as NEPA?
2. Can new retorting technologies avoid the operational difficulties that plague existing operations?
3. Can a technology that has to date produced only 1,500 barrels of oil scale up to produce 200,000 barrels per day?
4. Can freeze-wall technology be deployed to contain groundwater contaminants effectively during and after production?
5. Will it be possible, from both economic and regulatory standpoints, to construct new power generating facilities to support the substantial electricity needs of this technology?
6. Can as yet unproven technologies realistically expand to produce at a level more than 150 times greater than current worldwide oil shale production?
7. Could the already over-allocated Colorado River Basin could support cumulative new water demands that rival the volume used by the nation's largest cities?
8. Will oil shale, as a significant carbon emitter, be exempt from (possible) greenhouse gas emission legislation?

Regarding economic and structural feasibility:

9. Will (historically volatile) future crude oil prices behave as modeled (rise steadily)?
10. Will economies of scale offset the costs of first-of-a-kind mining operations and processing facilities as predicted?
11. Is government support of oil shale in the form of tax exemptions and generous land leasing terms a better investment than spending comparable money on other fuel and energy alternatives?
12. How will advances in other alternative energy sources affect projected increases in the value of crude oil?
13. Can existing refinery and pipeline capacity be modified and expanded to accommodate oil shale distillate?
14. Do the benefits of oil shale outweigh the social costs to local communities, in terms of pressure on housing, infrastructure, local government budgets, and employment?

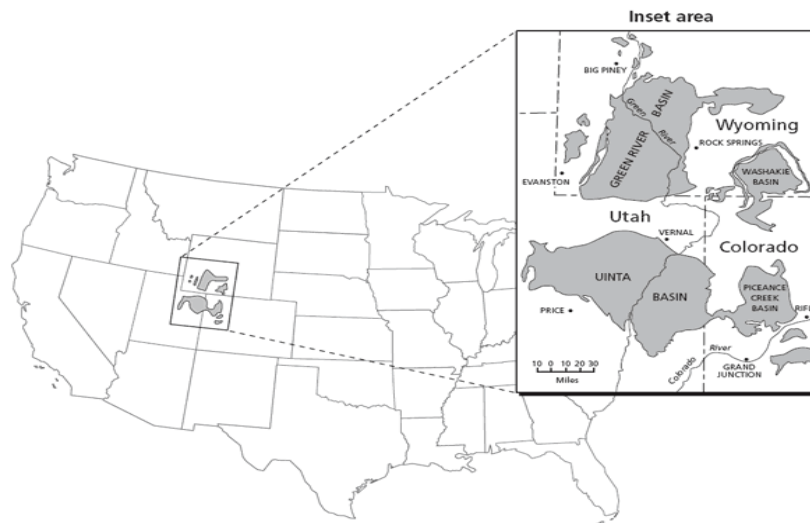
BACKGROUND

The Oil Shale Resource

Oil shale describes a rock layer that contains materials that are precursors to petroleum. When superheated, these materials, primarily kerogen, can be distilled from the rock into petroleum-like liquids. Upgrading and refinement of the distilled liquid is then needed to create usable fuels.

The Green River Formation that lies below Wyoming, Utah, and Colorado contains the largest known oil shale deposit in the world. Green River oil shale can be found anywhere from 500 to 2,000 feet below the earth's surface and varies in the richness of its carbon content. Colorado's Piceance Basin, Wyoming's Green River and Washakie Basins, and Utah's Uinta Basin are thought to have the most accessible and productive resources in the greater Green River Basin.¹ The Bureau of Land Management (BLM) administers roughly two-thirds (2.1 million acres) of the total land area (3.5 million acres) in the Green River Basin containing "geologically prospective" oil shale.² The BLM's 2008 Programmatic Environmental Impact Statement for Oil Shale and Tar Sands (PEIS) designates 1.9 million acres as "available for application to lease" for commercial-scale oil shale development.

Map 1. Location of the Green River Formation Oil Shale



Source: Bartis et. al., 6 (after Smith, 1980).

¹ The BLM's Programmatic Environmental Impact Statement (PEIS) defines "most geologically prospective" as deposits expected to yield 25 gal/ton or more that are 25 feet thick or greater in Colorado and Utah, and in Wyoming, those that yield 15 gal/ton and are 15 feet thick or greater. BLM, "Final Oil Shale and Tar Sands PEIS," 2-11. See also, Bartis et. al., "Oil Shale Development in the United States,"

² Andrews, "Developments in Oil Shale," 2.

Throughout the twentieth century, technological challenges and continued availability of inexpensive crude oil limited the economic viability of oil shale as a fossil fuel. For those reasons, the oil shale in the Green River Formation is considered a contingent, rather than a proved, resource (i.e., one that is economically recoverable based on existing technologies). By all accounts the potential for oil shale is vast. Projections of the resource range from 1.5 to 1.8 trillion barrels, with estimates of what might actually be recovered ranging from 500 billion to more than 1 trillion barrels.³ By comparison, the total potential of Saudi Arabia's oil fields is about 265 billion barrels.⁴

The potential of the Green River Formation's oil shale resources was first formally acknowledged when President Taft set aside federal land in three separate Naval Oil Shale Reserves in the 1910s. Federal support of efforts to develop oil shale has been offered occasionally since then, with flurries of activity occurring during shortages in the nation's fossil fuel supplies, namely World War II and during the energy crisis of the 1970s. Private efforts to develop oil shale stalled after 1982 due to the return of more affordable crude oil prices and subsequent elimination of federal financial support.

Anticipation of future crude oil shortages prompted renewed federal focus on encouraging oil shale development during George W. Bush's presidency. Specifically, the Energy Policy and Conservation Act of 2005 (EPAct) included several provisions designed to encourage the development of a commercial oil shale industry. A key outcome of EPAct was the BLM's release of a final PEIS and promulgation of rules for a commercial leasing program in 2008.⁵

³ Andrews, "Oil Shale," 1, Bartis et. al., 9.

⁴ Andrews, "Oil Shale," 2.

⁵ The rules have been promulgated, however, Secretary of the Interior Salazar has threatened to revoke the proposed royalty of 5 percent according to the Deseret News. Editorial, "Oil-shale decision sensible" Deseret News 3/4/09, <http://www.deseretnews.com/article/1,5143,705288602,00.html>, accessed 5/6/9).

UNCERTAINTIES REGARDING THE MECHANICS OF OIL SHALE DEVELOPMENT

While the concept of rendering oil shale into fuel—basically melting the carbon-rich rock—is relatively straightforward, significant practical constraints stand in the way of bringing large-scale oil shale processing online. Trial oil shale development projects are currently focused on developing economically viable methods for extracting and processing oil shale and on addressing major environmental impacts.⁶ Among the key environmental challenges are issues associated with mining generally, including habitat disturbance, water use, and groundwater contamination, as well as “newer” issues associated with recent and proposed legislation geared toward reducing greenhouse gas emissions. Issues related to linking market demands with existing pipeline and refining capacities also will need to be addressed before a commercial-scale industry can come to fruition.

Available Technology and Its Constraints

Because it is not free-flowing, oil shale necessitates a vertically-integrated production system, meaning that extraction, processing, and initial upgrading of the liquid product occur on the mine site, with further refining taking place at refineries. The method for heating oil shale in the absence of oxygen to extract liquid is called *retorting*, and can occur above ground in large kilns (surface retorting) or below ground. There are existing surface retorting oil shale operations in Brazil, Estonia, China, and possibly Russia. Below-ground retorting is called *in situ* processing and has yet to be pursued at a commercial-scale. If full-scale oil shale mining develops, it is likely that different mining and retorting technologies will be deployed based on the varying depth and concentration of the underground shale within the Green River Formation.

Extracting oil shale for surface retorting can be done by room-and-pillar (conventional subsurface mines) or large scale open-pit or strip mines. Surface mining would maximize recovery of the oil shale, especially in areas where the oil shale seam lies far below the surface. Because of the depth and extent of the resource, oil shale extraction through surface mining would require mines that compare in size to the world’s largest open-pit mines.⁷ The DOE has used a rule of thumb that allots 31 square miles of surface disturbance for every million barrels per day of oil shale produced. This means that a commercial industry operating to produce an average of 2.5 million barrels per day would involve surface mines covering a cumulative area roughly the size of the City of Boston—over 90 square miles—over a lifespan of 30 to 40 years.⁸ This estimate does not include surface disturbance related to the construction of supporting infrastructure such as roads, pipelines, refineries, and power plants.

⁶ A comprehensive review of past and current R&D efforts involving oil shale in Utah, Colorado, and Wyoming is available in Appendix A to the PEIS, The BLM’s inventory of past projects confirms widespread failure of past efforts and describes the goals of current RD&D lease projects. However, no information about the actual level of activity and success on current RD&D projects is provided.

⁷ Bartis et. al., 12.

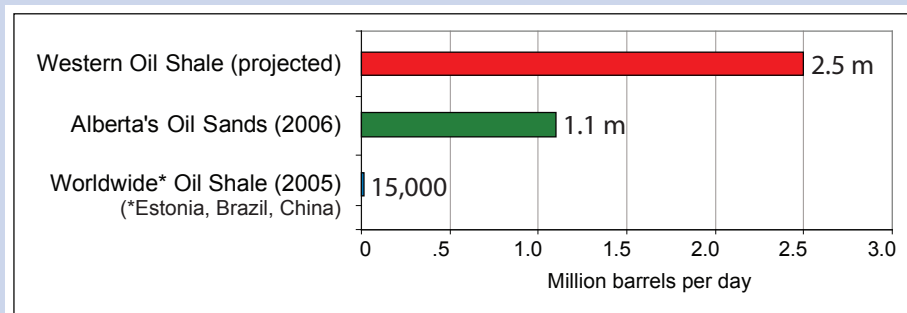
⁸ Office of Naval Petroleum and Oil Shale Reserves, U.S. DOE, “Strategic Significance of America’s Oil Shale Resource, Vol. II,” 24.

The Projected Scale of Oil Shale Development: Necessity and Root Problem

Because oil shale requires massive inputs of energy (see page 10) and resources to develop, spreading those costs across an industry of enormous scale is the only way oil shale development can appear to be economically feasible and can be projected to have a positive impact on domestic fuel supplies. What commercial-scale development actually entails varies by report, but projections by the Department of Energy were carried through in a 2005 study by the RAND Corporation. The reports assume that at peak operations, the western oil shale industry would produce in excess of 2.5 million barrels of crude oil substitute per day.⁹ This is an ambitious projection given that current worldwide production of oil shale is estimated at 10,000 to 15,000 barrels per day. (By 2008 standards, at a production volume of 2.5m barrels/day, the western Oil Shale industry would be the 11th largest oil producing region in the world.¹⁰ See Figure 1.)

If and how an oil shale industry of this scale could actually function, and how scale amplifies the impacts of development activities, are problems at the heart of the technical, environmental, and infrastructural constraints facing the industry.

Figure 1. Projected Capacity and Scale of Western Oil Shale Industry (m/bbls/day)



Source: BLM PEIS, Government of Alberta, and DOE Country Energy Profiles.

⁹ The 15-project scenario utilized by the BLM for the 2008 PEIS assumes all six existing RD&D leases would convert to commercial production and that 3 more leases would be issued in each WY (one *in situ*, one underground with surface retort, one surface mine with surface retort), CO (two *in situ* and one underground mine with surface retort), and UT (one *in situ*, one underground with surface retort, one surface mine with surface retort) per section 369 of EPAAct. (BLM PEIS, 2-16). The PEIS used the assumption that each *in situ* facility would produce 200,000 barrels per day and each surface retorting operation, 50,000 barrels per day. However the PEIS does not look at the cumulative effects of all 15 projects (potentially peaking at 1,050,000 barrels per day), but rather discusses potential impacts of each type of technology in the context of a single plant/facility. For DOE and RAND estimates see: DOE, “Fact Sheet: U.S. Oil Shale Economics” and Bartis et. al., xi.

¹⁰ U.S. Department of Energy, Energy Information Administration, “Country Energy Profiles.” accessed 6/2/09: <http://tonto.eia.doe.gov/country/index.cfm>. Oil sands statistics from Government of Alberta, <http://www.energy.gov.ab.ca/News/oilsands.asp>, accessed 6/2/09.

Surface mines of the scale necessary for commercial development of oil shale would be unlikely to gain approval without significant modification of the suite of environmental and administrative statutes that currently guide federal land management. Thus, a critical assumption in projections of a viable oil shale industry is that extensive surface mines would pass administrative review of environmental impacts under NEPA.

Even existing oil shale retorting technology is far from proven. The RAND Corporation's 2005 research analysis found that conventional mining followed by surface retorting offered technically viable options for developing oil shale, but noted that existing operations elsewhere in the world are producing a small fraction of the total volume that industry and the Department of Energy project for a commercial-scale industry in the U.S. West.¹¹ Other reports cite the operational difficulties that have plagued surface retorts in the past.¹² Another critical assumption regarding development of the oil shale industry is that new technologies or improvements to existing technologies would put an end to functional hurdles that have affected previous efforts to process oil shale.

Despite these obstacles, there are signs of industry determination. In June of 2008 OSEC (Oil Shale Exploration Company) announced its intention to “design, construct and operate the first commercial-scale oil shale facility in the State of Utah” on private land.¹³ The company has a joint venture agreement with a Brazilian firm that allows it to deploy a patented retorting technology called Petrosix.

In situ processing can involve significantly less surface disturbance than would conventional mining with surface retorting and its advocates claim it may be more cost effective than above ground retorting.¹⁴ However, *in situ* processing is currently still at the experimental stage—five of the BLM's six current RD&D leases are focused on testing *in situ* options¹⁵—and involves a staggering amount of energy to operate. Shell's trial *in situ* conversion processing (ICP) site near Parachute, Colorado “involves drilling holes up to 2,000-foot deep, inserting electrical resistance heaters, and heating the shale to 650-700° F over a period of months.”¹⁶ The heated shale releases a liquid substance which can be tapped in a manner similar to a conventional oil well.

Compared to conventional fossil fuels, oil shale requires large investments of energy relative to energy it generates. This ratio is discussed in terms of Energy Returned on Energy Invested (EROI), which relates the unit of energy produced to the unit invested. An EROI of 1 is the point at which energy produced is equal to energy invested, and equates to negligible efficiency (and profitability). Figure 2, reproduced from a 2004 academic study published in the journal *Energy*, compares the EROI for different fuel sources in the United States. It confirms how poorly oil shale compares to conventional fossil fuels.

¹¹ Bartis et. al., 13-14. A World Energy Council survey reports that the volume of oil shale production is declining, largely due to cutbacks in Estonian mining of oil shale. World Energy Council, “2007 Survey of Energy Resources,” 97.

¹² Bartis et. al., 14.

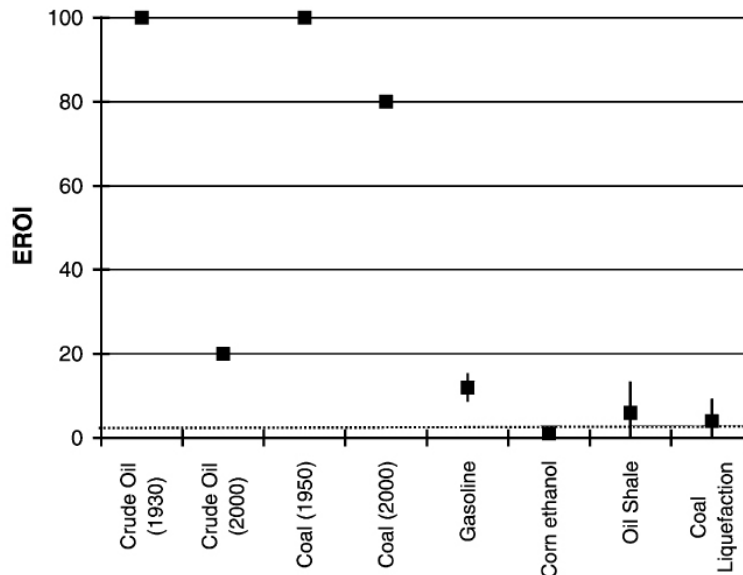
¹³ OSEC Press Release, June 9, 2008, <http://www.oilshaleexplorationcompany.com/news.asp>.

¹⁴ Fletcher, Sam. “Efforts to Tap Oil Shale's Potential Yield Mixed Results,” *Oil and Gas Journal*, April 25, 2005: 26. Quoted in Bartis et. al., 20.

¹⁵ Andrews, “Developments in Oil Shale,” 18.

¹⁶ Andrews, “Oil Shale,” 8.

Figure 2. Energy Returned on Energy Invested (EROI) for Conventional and Alternative Energy Systems



Source: Cleveland, C. J. "Net energy from the extraction of oil and gas in the United States."

The EROI of oil shale has been estimated to lie between less than one and 13, based on models and test runs of oil shale production.¹⁷ Shell claims that the ICP process (for oil shale) the company is currently testing has a ratio of 1:6 of energy used to energy produced.¹⁸ In defense of oil shale's viability, industry proponents note that oil shale's poor EROI is higher than that of tar sands, which is about 3.¹⁹ Tar sands (also known as oil sands) extraction and retorting has been underway on a commercial scale in Alberta, Canada since the early 2000s. Of the 18.5 percent of U.S. crude imports provided by Canada in 2007, approximately half came from tar sands.

Electricity to power retorting processes constitutes one of the major energy investments in oil shale extraction. *In situ* processing is especially expensive from an electricity standpoint: the BLM's PEIS used a working assumption that a single 200,000 barrel/day *in situ* plant would require 2,400 additional MW of electricity.²⁰ Operation of just the five *in situ* plants identified in the PEIS could require the construction of ten power plants the size of the largest coal-fired power plant currently operating in Colorado. (Craig Power Station has a nameplate capacity of 1,400 MW.²¹) An important assumption about a commercial oil shale industry is that the industry's significant power needs are achievable through a massive expansion of the existing electricity generation

¹⁷ Cleveland et. al., "Energy and the U.S. Economy: A Biophysical Perspective," 894.

¹⁸ Bartis et. al., 18.

¹⁹ Cleveland and Saundry, "Ten fundamental principles of net energy." U.S. Energy Information Administration, Country Briefs, Canada. See also Kolbert, "Unconventional Crude."

²⁰ BLM PEIS, 4-13.

²¹ Tri-State, a Touchstone Energy Cooperative web site, "Craig Station." Accessed 6/10/09, <http://www.tristategt.org/AboutUs/baseload-resources.cfm>.

and transmission infrastructure. Such an expansion effort would trigger a number of significant regulatory hurdles.

There is also some disagreement in the literature about the technical feasibility of refining oil shale distillate. The PEIS provides an overview of the numerous obstacles to oil shale distillate's acceptance into the refinery matrix.²² Replacing existing feedstock with oil shale could involve either retrofitting existing refineries or building new facilities. Historically, industry's preference has been to expand existing facilities rather than the more capital-intensive, higher-risk model of building new refineries. The quality and reliability of the new feedstock can affect this choice: in the case of oil shale, neither its quality nor the reliability of that quality is well-established. The development of an oil shale industry assumes that oil shale distillate would compete with other refinery feedstocks at a level that would encourage the investment required to upgrade refinery capabilities.

Environmental Impacts and Questions about their Mitigation

Depending on the technology used, oil shale development will involve significant disturbance and associated risks to terrestrial habitat, ground and surface water sources, air quality, and climate (e.g., greenhouse gas emissions).

Permanent changes to the topography and flora and fauna are expected to result from commercial-scale oil shale development.²³ In the case of surface retorting, spent shale poses a major reclamation and groundwater contamination concern (1.2 to 1.5 tons of spent shale, which has significantly higher salt levels than raw shale and may yield other toxic substances, accompanies each barrel of oil produced by surface retorting).²⁴

In situ processing poses considerable risk to groundwater contamination. One of Shell's experiments on a BLM RD&D lease involves freezing the perimeter of the extraction zone through massive below-ground refrigeration systems. Freeze-wall technology is a proven technique for managing contamination from construction and other surface disturbances, but its use for such large-scale operations and its ability to protect against leakage once the site is abandoned is not well-established.²⁵

In addition to the risk of groundwater contamination, the volume of water necessary to facilitate mining operations has long been known to pose a roadblock to oil shale development. In 2004, the Department of Energy published statistics suggesting that a full-scale commercial oil shale industry could create a total new water demand of .18 to .42 million acre-feet per year and notes that "for a mature industry, substantial water storage and water transfers may be required over time."²⁶ (For reference, the 3.8 million customers of the city of Los Angeles's Department

²² See BLM PEIS, Appendix A, Attachment A1: "Anticipated Refinery Market Response to Future Oil Shale Production" at page A-95

²³ Bartis et. al., 36.

²⁴ Bartis et. al., 36-37.

²⁵ Shell press materials on Mahogany Ridge Research Project, Bunger et. al., and Bartis et. al., 19.

²⁶ DOE Fact Sheet, "Oil Shale Water Resources."

of Water and Power customers used nearly .7 million acre-feet of water in the year 2000.²⁷ Development of the industry, therefore, assumes major adjustments to the administration of the already-strained Colorado River Compact.²⁸ Municipal and industrial consumers seeking to protect their access to Colorado River water could be a major constraint on the scale of oil shale development.

The OSTIS PEIS notes that commercial-scale oil shale development will involve significant emissions that pose air quality concerns from the perspectives of visibility, deposition of particulate matter and the health of animal (including human) and plant populations. Review of the air quality impacts planned oil shale developments will trigger regulations under numerous state and federal statutes. Here again, scale is a critical issue: the level of air pollution will be directly related to the scale of extraction and development activities.²⁹

The goal of reducing and or stabilizing greenhouse gas emissions is slowly making its way into various federal laws and likely poses a significant roadblock to oil shale development. While insufficient data exist to document with precise accuracy the emissions associated with oil shale development, it is generally agreed that greenhouse gas emissions will be significantly higher than those involved in conventional fossil fuels. A 1980 estimate published in the journal *Science* found that surface mining and retorting of Green River oil shale would yield 1.5 to 5 times more greenhouse gas than burning conventional oil to generate an equivalent amount of energy.³⁰ Shell recently reported that a test run of the ICP research site generated greenhouse gas emissions 21 to 47 percent greater than conventional oil production.³¹ Discussing the whole suite of synthetic fuels, an academic study in 2006 noted that greenhouse gas emissions of substitutes for conventional petroleum could be more than twice that of conventional oil per unit of fuel delivered.³² The viability of an oil shale industry assumes some exception for this fuel product in any future regulations regarding greenhouse gas emissions.

²⁷ City of Los Angeles Environmental Affairs Department, http://www.lacity.org/ead/EADWeb-WNR/drinking_water.htm.

²⁸ While the Department of Energy has optimistically stated that the 0.8 million acre-feet/year that was recently re-adjudicated from California to the Upper Basin states could support an oil shale industry (DOE Fact Sheet, "Oil Shale Water Resources"), the political viability of such re-allocation is far from proven. For example, see Jenkins, "How low will it go?"

²⁹ BLM, OSTIS PEIS, section 4.6.

³⁰ Cited in Andrews, "Developments in Oil Shale," 12.

³¹ *Ibid.*

³² Farrell and Brandt, "Risks of the oil transition," 4.

Infrastructural Hurdles to Oil Shale Development

The existing infrastructure in southwest Wyoming, northeast Utah, and northwest Colorado cannot accommodate a commercial-scale oil shale industry. Major adjustments and improvements would be required in terms of roads, bridges, pipelines, and refineries.³³

In addition, the region is ill-prepared for the structural socioeconomic change that is projected to accompany oil shale development, in part because it is already reeling from surges and contractions in oil and natural gas extraction. A 2008 report conducted for the Associated Governments of Northwest Colorado projected that a commercial-scale oil shale industry could add 50,000 residents (about one-quarter the number of the area's current population) and raises major issues in regards to shortages of skilled workers, housing availability and affordability.³⁴ Regional leaders have stressed the importance of coordination with and support for local governments in the event of a move toward commercial-scale oil shale production.³⁵

Under ideal scenarios, the pace and scale of oil shale development could be regulated in order to lessen the negative impacts and secure the greatest benefits of a new energy boom on local communities.³⁶ However, the scale of the capital and investment required to bring new, first of a kind commercial oil shale facilities online puts energy companies under significant pressure to show a rapid return on investment. This suggests that if and when oil shale's "moment" arrives, the pace of expansion and development is likely to be breakneck rather than measured.

The viability of a commercial-scale industry from the perspective of local economic sustainability assumes major expansion of local capacity in terms of population, infrastructure, and governmental capacity. The recent experience of small, rural counties with rapid expansion of natural gas drilling in western Colorado suggests that increased tax revenue based on mineral extraction does not always keep pace with the impacts of mining activities.³⁷

³³ Andrews, "Developments in Oil Shale," 7-8.

³⁴ BBC Consulting, "Northwest Colorado Socioeconomic Forecasts," ES-9.

³⁵ A governmental task force on development of unconventional fuels that included local and state-level representatives noted in its 2006 recommendations to the President and Congress that, "Despite projections of tight world oil supplies and long-term higher prices that would support sustained economic production of unconventional fuels, many communities will be both unable and unwilling to shoulder the financial burden of these requirements without assurances of protection from down-side risk associated with oil price volatility." Task Force on Strategic Unconventional Fuels, "Development of America's Strategic Unconventional Fuels Resources," 13.

³⁶ For a discussion of the impact of rapid energy development on energy-dependent communities in the West, see Headwaters Economics, *Energy in the West*, <http://www.headwaterseconomics.org/energy>.

³⁷ Headwaters Economics, "Energy Revenue in the Intermountain West."

ECONOMIC QUESTIONS: HOW AND WHEN WILL IT BE PROFITABLE TO DEVELOP OIL SHALE?

Oil shale cost estimates are complicated and subject to variability due to the many assumptions that inform cost models. Surface retorting is generally assumed to have a higher per barrel production cost than *in situ* retorting. Models also typically assume that the costs of production will be highest in the start-up phase and will be substantially reduced with experiential learning and refinement of technology over time as well as the distribution of costs over an expanding scale of activities.

A whole suite of economic impacts, opportunity costs, and non-market values must ultimately be factored as part of any assessment of oil shale's real economic viability—and are indeed mandated by NEPA, but no such accounting has been done to date. A more thorough accounting would consider, for example, immediate economic impacts from actions such as shifting existing water uses to oil shale development as well as intrinsic values of leaving the natural areas and the ecosystem services they support intact. We report here only the basic price assumptions offered by industry and the Department of Energy, assumptions that do not include non-market values or externalities. Development of an oil shale industry under proper NEPA procedure assumes oil shale's benefits would exceed costs in any calculus, including one that accommodates environmental impacts as well as non-market, non-use values.

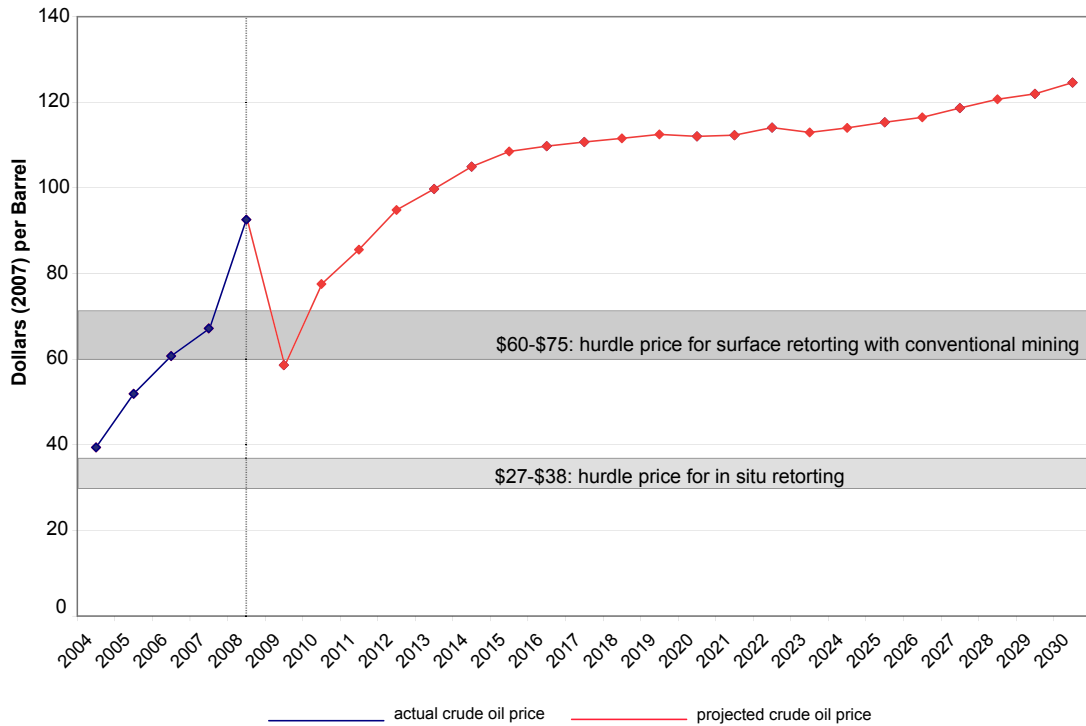
In 2004, the Department of Energy published estimates that a first of a kind mining and surface retorting plant could “eventually be economic” at sustained world oil prices over \$54 per barrel.³⁸ RAND Corporation's 2005 analysis reported that oil prices would need to be at least \$70 to \$95 per barrel for a first of kind mining/surface retorting facility to be profitable, with the possibility that maturity of the plant could create efficiencies that might lower the profitability benchmark to prices between \$35 and \$48 per barrel within 12 years.³⁹ The RAND Corporation's report also restated Shell's claims that ICP could be profitable at prices in the mid-\$20s per barrel, while the Department of Energy has cited \$35 per barrel as the hurdle price for *in situ* processing generally.⁴⁰ All of these projections assume an ultimate economy of scale and also depend on increasing world crude oil prices.

³⁸ DOE Office of Petroleum Reserves, “Fact Sheet: Oil Shale Economics.”

³⁹ Bartis et. al., 16.

⁴⁰ Bartis et. al., 20 and DOE, “Fact Sheet: Oil Shale Economics.”

Figure 3. Price of Imported Crude Oil and Industry Estimates of Oil Shale “Hurdle Price”



Source: DOE/EIA, Annual Energy Outlook (2008 data); Bartis et. al., and Andrews, “Developments in Oil Shale,” 12.

Figure 3 charts trends in the price of imported crude oil against the reported hurdle prices for oil shale (in 2007 dollars).⁴¹ The variability of specific estimates of the oil shale hurdle price notwithstanding, recent world oil price trends and the projected price trends from the U.S. Energy Information Administration suggest that crude oil prices are nearing the thresholds of profitability for oil shale. Nonetheless, past history with oil price volatility has encouraged the oil industry toward a highly conservative approach to high-capital investments like oil shale. As RAND’s 2005 report put it, the “hurdle price’ of crude oil required to trigger capital investment in oil shale development is substantially higher than the crude oil market price that would otherwise be required to motivate investment.”⁴² In fact, a 2004 DOE “road map” on oil shale suggested the federal government subsidize oil shale with a guaranteed purchase price of \$40/bbl. On the other

⁴¹ The prices shown are in 2007 dollars and are based on reported data from the DOE/EIA, U.S. Data Projections, Annual Energy Outlook, Petroleum Prices. Long-term projections for 2009 through 2030 are based on Annual Energy Outlook data accessed 4/29/09, <http://www.eia.doe.gov/oiaf/forecasting.html>, and the actual prices for 2004 through 2008 were obtained from Short-term Energy Outlook data. See notes 30 and 31 for hurdle price sources (adjusted in this chart to 2007 dollars).

⁴² Bartis et. al., 46.

hand, industry watchers consider the strong response to the BLM's RD&D lease offerings (34 applications for five initial leases) indication of realistic interest from the private sector in oil shale investment.⁴³ A 2007 article in *Fortune* noted that oil shale has the largest budget (\$200 million spent to date) in Shell's research portfolio.⁴⁴

Reports typically put the time from the present stage of RD&D to full-scale commercial development (under the right hypothetical scenarios) at a minimum of 12 to 15 and as many as 20 to 30 years away.⁴⁵ The change in administration may have an immediate impact on the timeline for commercial oil shale development. In contrast to his predecessor, Secretary of the Interior, Ken Salazar, advocates a go-slow approach, and recently stated that those who see oil shale as a "panacea for America's energy needs have been living in fantasy land."⁴⁶ Another potential obstacle related to time is the assumption that oil shale will be viable after the next 10 to 15 years of significant investment in competing alternative energy sources.

⁴³ For a portfolio of key players in the oil shale industry and their current activities, see U.S. DOE/NPOS, "Secure Fuels from Domestic Resources."

⁴⁴ "Oil from a Stone," *Fortune*, Nov. 12, 2007 quoted in BBC, "Northwest Colorado Socioeconomic Forecasts." IV-16.

⁴⁵ Bartis et. al., 22. BBC Consulting, "Northwest Colorado Socioeconomic Forecasts," ES-9.

⁴⁶ "Salazar Yanks Oil Shale Leases." *Deseret News*, Feb. 26, 2009. O'Donoghue, A. "Salazar Yanks Oil Shale Leases" *Deseret News* Feb 26, 2009, accessed 5/6/09: <http://www.deseretnews.com/article/1,5143,705287318,00.html>.

OPPORTUNITIES AND OBSTACLES TO OIL SHALE DEVELOPMENT IN FEDERAL POLICY

Renewed interest in oil shale development surfaced during the George W. Bush administration, in the form of congressionally-appointed task forces on fuel sources, Department of Energy reports, and actual legislation in the case of the 2005 EPAct.

Policy Support for Oil Shale

Oil shale supporters within government would like to see the federal government heavily subsidize oil shale development. DOE's Office of Naval Petroleum and Oil Shale Reserves issued a "Roadmap for Federal Decision Making" regarding oil shale in 2004 that was followed up by a 2007 U.S. Task Force on Strategic Unconventional Fuels that provided more specific suggestions for federal action. In the strategy advocated by these reports, the federal government assumes a large burden of the risk associated with oil shale development by funding a large share of demonstration projects and by offering a price guarantee and production tax credits.⁴⁷

The EPAct of 2005 marked a renewed federal interest in developing a commercial-scale oil shale industry. In particular, EPAct sought to encourage the development of a commercial oil shale industry by means of a series of directives that are outlined below.

Oil Shale Development Directives in EPAct:

- creation of the "Strategic Unconventional Fuels Task Force" that consisted of the Secretaries of the Departments of Energy, Defense, and the Interior; the Governors of the States of Colorado, Kentucky, Mississippi, Utah, and Wyoming; and representatives of localities in areas targeted for development.⁴⁸
- mandate for the BLM prepare the PEIS and promulgate rules for oil shale leasing
- direction to BLM to initiate a research, development, and demonstration (RD&D) leasing program in 2004⁴⁹
- expansion of the maximum lease size permitted under the Mineral Leasing Act⁵⁰
- directions to Secretary of Defense to create a strategy to use oil shale when possible for Department of Defense requirements.

⁴⁷ The Task Force suggested incentives that include a minimum guaranteed purchase price of \$40/bbl with a production tax credit of \$5/bbl as well as federal sponsorship of a large share of the costs of RD&D projects.

⁴⁸ The Task Force released a report in 2006 that included optimistic findings about the potential for unconventional fuels to augment domestic fossil fuel production with "aggressive development by private industry, encouraged by government."

⁴⁹ The BLM has awarded six RD&D contracts to date. Among Secretary Salazar's first actions upon appointment was to slow the RD&D leasing process. Department of Interior, "Secretary Salazar to Offer New Round..." Press Release, Feb. 25, 2009. Accessed 5/7/09: http://www.doi.gov/news/09_News_Releases/022509b.html

⁵⁰ Industry has long voiced concerns that the existing size limits on leases acted to constrain investment. The size of individual oil shale lease was expanded from 5,120 to 5,760 acres, but "no one person, association, or corporation shall acquire or hold more than 50,000 acres of oil shale leases" in any one state. 30 USC 241 a.

Lingering Policy Obstacles

There are still serious regulatory constraints to a commercial-scale oil shale industry, and the BLM PEIS does not exempt individual leases from a full NEPA review. Existing federal environmental protection statutes (Clean Water Act, Clean Air Act, NEPA, Endangered Species Act, etc.) pose considerable hurdles to oil shale development, as described above (see page 11).

Policies that focus on reducing greenhouse gas emissions through a “lifecycle” approach to carbon emissions pose a problem for synthetic fuels that entail significant lifecycle carbon emissions. The 2007 Energy Independence and Security Act (EISA, P.L. 110-140) amended the EPCA 2005 to “restrict the federal government’s procurement of alternative fuels that exceed the lifecycle of greenhouse gases associated with conventional petroleum based fuels.”⁵¹ The latter provision (section 526) conflicts with the above-mentioned directives in EPCA for DOD to look to alternative fossil fuels for defense use.⁵²

Resolving a policy conflict between the pursuit of developing synthetic crude substitutes and curbing greenhouse gas emissions is a critical issue facing the federal government at this juncture.⁵³ A recent modeling effort regarding the oil shale industry in Estonia suggests that compliance with current EU directives regarding GHG emissions necessitates a 20 percent reduction in oil shale’s share of that country’s total energy sources.⁵⁴ A carbon tax program such as that under consideration by the Obama administration could seriously undermine the oil shale industry’s potential.⁵⁵

The Environmental Protection Agency has released a finding that would classify greenhouse gases as pollutants under the Clean Air Act. However, the implications of that finding are not yet clear. According to the EPA, “This proposed action, as well as any final action in the future, would not itself impose any requirements on industry or other entities. An endangerment finding under one provision of the Clean Air Act would not by itself automatically trigger regulation under the entire Act.”⁵⁶ When and how the EPA opts to permit GHG emissions will hinge on national and international politics and other hard-to-predict forces.

⁵¹ Andrews, “Developments in Oil Shale,” 12.

⁵² *Ibid.*, 14

⁵³ Farrell, A.E., “Testimony to House Subcommittee on Energy and Air Quality.”

⁵⁴ Roos, I. “Impact of Oil Shale Use on Greenhouse Gas Emission Projections.”

⁵⁵ Broder and Wald, “Big Science Role in Seen in Global Warming Cure.”

⁵⁶ U.S. Environmental Protection Agency, “Fact Sheet: Proposed Endangerment and Cause or Contribute Findings...”

State-level oversight of oil shale leasing represents another set of policy concerns and the three states involved (Utah, Colorado, and Wyoming) have varying levels of preparedness. None of the three states has any policy in place that would significantly constrain oil shale development. An official from the Utah Oil and Gas Commission told Headwaters Economics that the existing regulations for oil and gas leasing are “good to go” and would apply to oil shale development (and do in the case of existing projects). He noted that the state’s Memorandum of Understanding with the BLM has expired and is in the process of being updated.⁵⁷ In Colorado, oil shale oversight is overseen by the Division of Reclamation Mining and Safety (which also oversees coal and mineral mining) rather than the Oil and Gas Conservation Commission. Mining for oil shale will be overseen by Wyoming’s Oil and Gas Conservation Commission, but a representative from the agency was not aware of any rules pertaining to oil shale and said that a review and possible revision of existing statutes would likely be necessary prior to any state permitting of oil shale.⁵⁸

⁵⁷ Paul Baker, Utah Oil and Gas Commission, personal communication, 5/07/09.

⁵⁸ Mark Watson, Wyoming Oil and Gas Commission, personal communication, 5/7/09.

CONCLUSIONS

Many contingent factors will determine when and if commercial oil shale development becomes viable in Utah, Wyoming, and Colorado. Major technical and environmental problems pose obstacles to the industry, but current research and development activity along with projected crude oil price trends suggest reasons to expect more rather than less interest from industry in expediting oil shale development.

This level of interest depends on significant outstanding questions about the viability of oil shale production and the reach of its impacts. The current information basis for making informed decisions about oil shale development is thin at best. This report explores a range of questions about the viability and impacts of an oil shale industry that need to be answered before policy makers and the public can effectively engage in the decision-making process. The answers to these questions will dramatically affect the communities and economies in the West, and the energy future of the country.

One of the most pressing questions about oil shale is scale. Predictions about the commercial viability of oil shale depend on developing an industry at a volume 50 times greater than the combined total of existing worldwide oil shale production. The scale of activities required to achieve such a production volume—and to make oil shale profitable, by distributing its significant costs across a vast economy of scale—would dwarf any industrial land use ever pursued in the United States.

Whether the industry could perform profitably at this scale, and whether the region's social, physical, and biological infrastructure could withstand the associated impacts are as yet unknown issues that cloud a realistic vision about the future of oil shale.

ADDENDUM: RESEARCH UPDATE

The State of the Oil Shale Industry at the Start of 2010

Following the original publication of this “14 Questions” report in 2009, Headwaters Economics was invited by the Colorado School of Mines’ Colorado Energy Research Institute to attend the annual Oil Shale Symposium, an event attended by several hundred industry executives, academic researchers, and government personnel.⁵⁹ Presentations at the October, 2009 symposium were informative and highlighted trends in oil shale technology and research on its impacts. While the conference alerted us to a few emerging issues of note, we concluded that the questions we raise in our June 2009 report remain valid and relevant. This addendum contains an update on recent trends in oil shale technology and refines our earlier observations regarding impacts analysis.

Summary points

- Industry is focused on circumventing environmental constraints and is reporting progress in developing “environmentally-friendly” technologies. Recent and ongoing research demonstrates that the industry and the Department of Energy are taking the environmental challenge seriously, but much of the technology remains in the early stages of development.
- As technological solutions evolve to meet environmental challenges facing oil shale production in the western U.S., the comparisons between the region’s future oil shale industry and that of the 1980s, or Alberta, Canada’s oil sands industry are increasingly remote. This trend raises questions about existing impact analysis based on assumed comparability with oil sands or 1980s oil shale production.
- Fiscal approaches to oil shale development vary significantly across the three state area, leaving questions about how well local governments will be able to respond to quick upturns in development, how well situated state agencies are to perform their monitoring and oversight duties, and how fair the return on public investment will be.

Progress in oil shale research and development

For most oil shale companies, the engineering challenge in oil shale has shifted from how to make production profitable by any means to how to make production profitable and viable under existing and proposed regulatory constraints. Industry leaders are working hard to get ahead of critiques about water use, energy demand, carbon emissions, and waste disposal. The Department of Energy recently updated its profile of oil shale companies to highlight these trends.⁶⁰

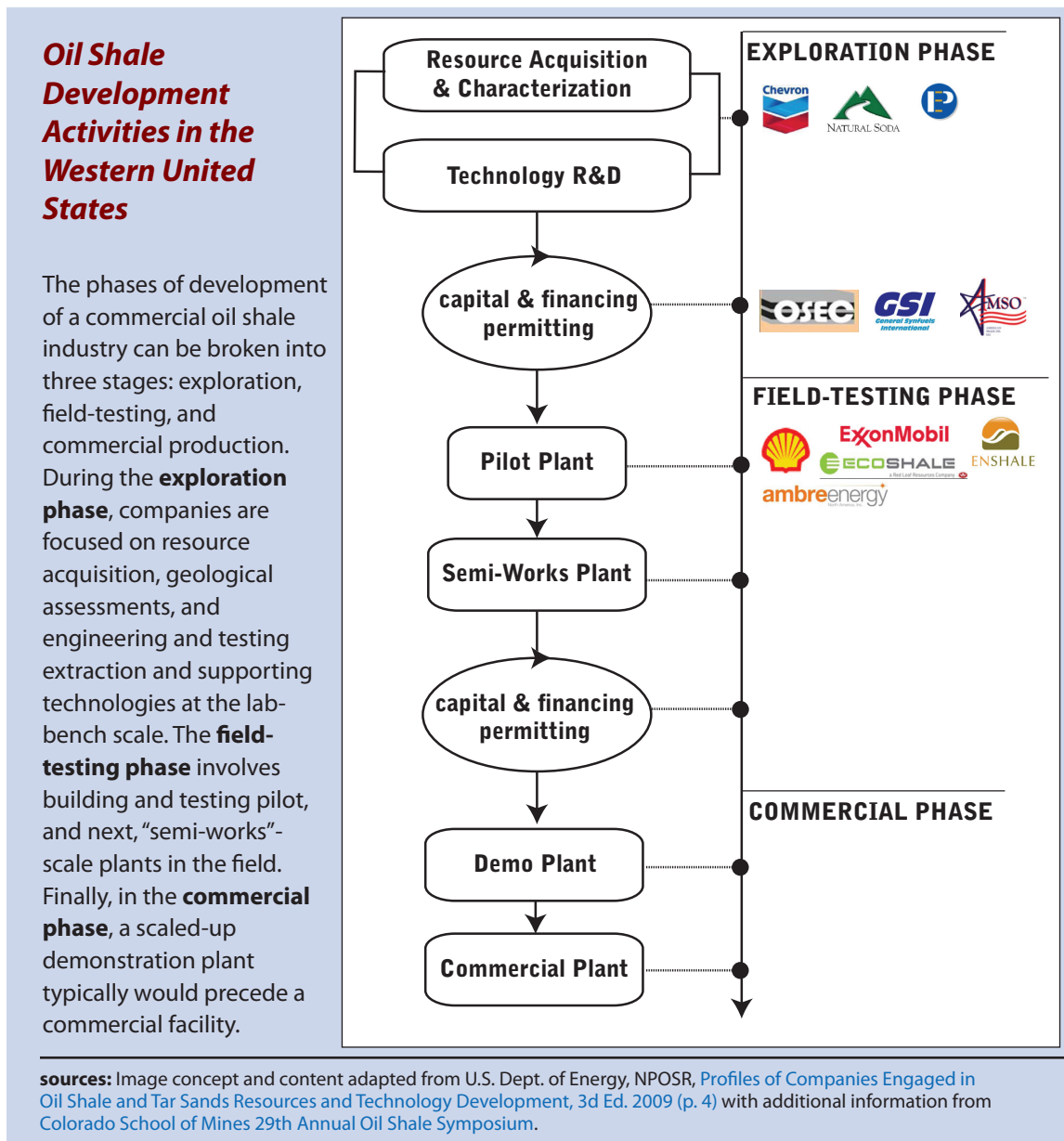
Reports from industry suggest that water and energy demands for both surface and *in situ*

⁵⁹ For conference information including proceedings (forthcoming), see: <http://outreach.mines.edu/content/oilshale/index.html>.

⁶⁰ Office of Naval Petroleum and Oil Shale Reserves, U.S. DOE, “Profiles of Companies Engaged in Oil Shale and Tar Sands Resource and Technology Development.” See also, Crawford, et. al., “New approaches overcome past technical issues.”

production may be less than previously reported. For example, Red Leaf Resources, Inc. reports that their EcoShale “In Capsule” technology—a buried retort using mined and crushed shale—uses less than one barrel of water per barrel of oil produced, has a 1:10 ratio of energy returned on investment (EROI) and has production costs about \$20/barrel based on a pilot field test conducted in 2008.⁶¹ The National Oil Shale Association, an industry group, reports in a flyer distributed in October 2009 that an informal survey of oil shale developers suggests water demands for surface retorting will be 2.0 bbl water/bbl oil, and 1.7 bbl water/oil for *in situ*, assuming off-site upgrading.⁶²

The chart below describes progress in oil shale development in Utah and Colorado.



⁶¹ James Patten, Red Leaf Resources, “Field Test Results: EcoShale In-Capsule Technology.”

⁶² National Oil Shale Association, “Oil Shale & Water Fact Sheet.”

Oil Shale Deposits & Current Development Activities in Western U.S.



Colorado
 Chevron*
 ExxonMobil
 Shell Exploration and Production Co.*
 AMSO (American Shale Oil)*
 Natural Soda, Inc.
 General Synfuels International

Utah
 Ambre Energy
 EcoShale/RedLeaf Resources
 Enshale
 OSEC (Oil Shale Exploration Corp.)*
 Independent Energy Producers
 *Recipient of 2007 BLM RD&D lease

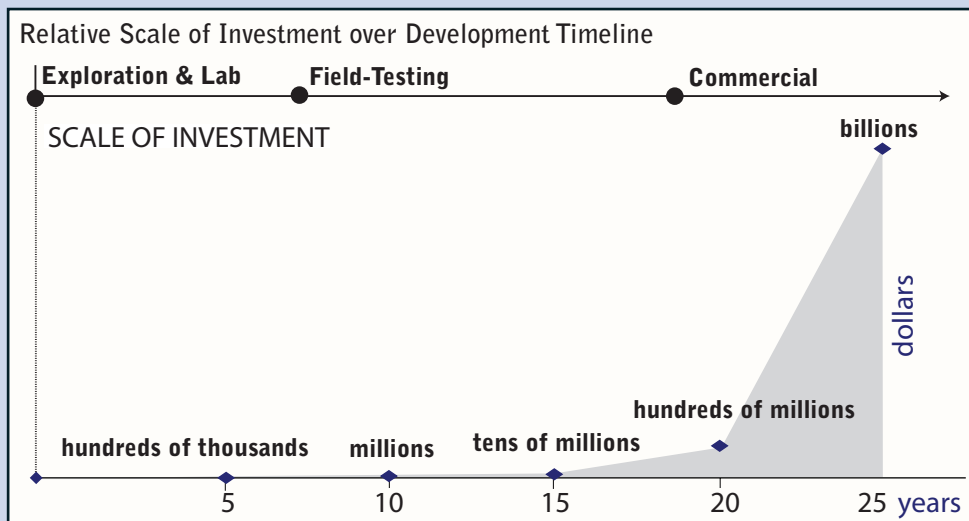
source: BLM PEIS. This and the preceding figure omit approximately 25 companies active in developing oil shale technologies that do not have oil shale resource holdings in the western U. S.

In the early 1980s, the oil shale industry in Colorado reached the cusp of the commercial phase with a single demonstration plant and another semi-works plant before declining world oil prices halted development altogether.

As of late 2009, oil shale development activities remain in the exploratory phases, with a handful of field-trial projects underway. EcoShale, a RedLeaf Resources Company, has plans to move their field-tested technology to the semi-works stage in 2010.

Exploration and field-testing has been concentrated in northeastern Utah and northwestern Colorado on both private and public land.

The scale of investment increases exponentially from one phase to the next, with billions of dollars required to achieve commercial production. As the figure below shows, the leap from trial stages to commercial scale development is significant. Making the leap to commercial-scale production would be very difficult without a sizable public investment.



sources: Image concept and content adapted from U.S. Dept. of Energy, NPSR, [Profiles of Companies Engaged in Oil Shale and Tar Sands Resources and Technology Development, 2009](#).

Trends in impacts assessment

To date, there is little in the way of independently-generated or publicly-available information by which to evaluate the claims about major progress toward environmentally-sensitive approaches to oil shale extraction and processing. To the extent that the market represents a reliable vetting process, the success with which some of the smaller oil shale technology firms attract investment capital will provide some measure of the veracity of their claims from the perspective of the energy finance sector.

There are efforts underway to better assess key impacts of oil shale development, typically at universities with funding from the Department of Energy and in some cases, corporate support as well, including:

Adam Brandt, a Stanford University-based leader in the assessment of greenhouse gas emissions from fossil energy sources, recently co-authored a study stating that the “reasonable estimate of the emissions range [for oil shale from a “lifecycle” standpoint] is between 1.25 to 1.75 times those from conventional oil.”⁶³ Brandt’s research is an important benchmark in understanding the tremendous challenges facing oil shale production in the event that a regulatory policy framework addressing climate change should emerge.

Forthcoming studies (late 2010) from the University of Utah’s Institute for Clean and Secure Energy, funded by the DOE, include considerations of carbon emissions, economic viability, water demand and management, as well as basic science in resource characterization. Initially, these studies are likely to produce white papers for the DOE. The studies will focus primarily on the Uintah Basin in Utah. These reports are poised to be important contributions, particularly with regards to impacts assessments as they will be based on the most recently-available baseline data on production techniques and associated input and output values.⁶⁴

Also of note is the State of Colorado’s ongoing effort to evaluate water demands relative to supply, including the potential demands of fossil fuel extraction in northwest Colorado through its HB 05-1177 water planning process.⁶⁵

These are important research efforts, but critical holes remain especially in the areas of air quality and other cumulative environmental impacts.

Changing technology means changing information needs

The lack of data from a commercial scale oil shale industry is an ongoing problem when it comes to anticipating and planning for the social, economic, and fiscal dimensions of a possible oil shale industry. Existing studies have turned either to the past (1970s-1980s era oil shale development)⁶⁶ or to the oil sands industry in Alberta for estimates.⁶⁷ Neither is an especially apt source for comparisons due to significant differences in the mining and processing activities involved.

⁶³ Brandt et. al., “Carbon Dioxide Emissions from Oil Shale Derived Liquid Fuels.”

⁶⁴ A link to the Institute’s research on oil shale is available: <http://www.heavyoil.utah.edu/>.

⁶⁵ Colorado Water for the 21st Century web site: <http://ibcc.state.co.us/>.

⁶⁶ BLM PEIS, Bartis, et. al., NPOSR DOE, National Strategic Unconventional Resources Model.

⁶⁷ BBC Research and Consulting.

Emerging oil shale technologies are purportedly more efficient than those deployed in the 1970s and require less extensive surface mining than in the past, or in Alberta. An implication could be fewer long-term jobs in mining and upgrading than suggested by existing models. The move toward co-generation of the energy required for oil shale processing (as opposed to the construction of numerous new power plants) may have a similar dampening effect on jobs projections. Pipeline capacity, however, remains a serious constraint for oil shale. A commercial industry would likely involve a major investment in pipeline construction with a related short-term demand for labor.

A related concern is that the BLM has been all but silent in reporting on RD&D progress, leaving observers to wonder whether there is any significant RD&D progress and whether the agency has any coordinated to system to learn from and review that research progress.⁶⁸

Greater transparency from industry, on both a voluntary and mandatory basis, is an important step in resolving information shortages. From the perspective of state and local agencies entrusted with regulating and responding to the direct and indirect impacts of an oil shale industry, routine updates to forecasts regarding anticipated labor, energy and water, and infrastructure demands are important.

Fiscal situation poorly understood

There has been little to date by way of a comprehensive look at the fiscal regimes at the local, state, and federal level as they apply to oil shale development. This issue is important because an energy taxation regime has a large influence on how local areas, states, and regions experience the benefits and impacts of energy development.

Tax regimes and related incentives are important techniques to promote and regulate development. An effective tax structure accommodates energy development by providing resources to regulate, mitigate, and facilitate development and provides a fair public return on investment from the permanent depletion of non-renewable resources.

Research on fossil fuel development suggests that severance taxes—which come only after the resource is known and technology is available to extract it—are a poor vehicle for stimulating production.⁶⁹ They have a very small impact on where producers operate, but severance taxes do have a dramatic affect on the amount of revenue returned to the public.⁷⁰

Research shows that direct incentives to exploration, technology, and research have a large effect on production.⁷¹ States that choose to encourage oil shale development will benefit by providing assistance early on through tax breaks, grants, and/or public private partnerships while maintaining a high severance tax and royalty on production—sufficient to both cover the cost of

⁶⁸ The agency's existing RD&D reporting is available online:

http://www.blm.gov/wo/st/en/prog/energy/oilshale_2/research_development.html.

⁶⁹ Kunce, et. al. "State Taxation, Exploration, and Production in the U.S. Oil Industry."

⁷⁰ Headwaters Economics, "Energy Revenue in the Intermountain West."

⁷¹ Kunce, et. al.

mitigating the impacts of development and provide for investment in a post oil shale-economy. A tax incentive structure oriented toward facilitating research and development rather than production ensures the best incentive for industry to develop commercial scale production in the state and ensures a true partnership where industry and the public shares in profit—if and when prices, technology, and mitigation are sufficient.

Oil shale is not a mobile industry: investors and industry cannot choose among oil shale locations. The resource is fixed in the Greater Green River Basin, and demands geographically-specific technical approaches.

To date, all of the incentives specifically offered to oil shale producers at the state level focus on production tax credits. In 2006, Utah legislators approved a severance tax exemption to oil shale that is good through the year 2015. Colorado has a 4 percent severance tax on oil shale, but offers discounts for the first three years of commercial production. Wyoming makes no special distinction for oil shale in its severance tax program.

Federal tax incentives specific to oil shale include RD&D leases with preferential commercial leasing clauses and a production tax credit (currently under litigation).

At both the state and federal level, oil shale producers will benefit from a plethora of standard business and corporate income tax credits, including a recent change in SEC laws that allows publicly-traded energy companies to count oil shale as proven reserves in their holdings, with a potentially substantial effect on their balance sheets.

As the economic and impact profile of an industry built on new technologies becomes better known, it will be important to review existing fiscal policies with an eye on their appropriateness to the nature of the industry and its impacts.

BIBLIOGRAPHY

Reports and government documents

- Allen, R. et. al. "A technical, economic, and legal assessment of North American heavy oil, oil sands, and oil shale resources: In response to Energy Policy Act of 2005 Section 369(p)." Prepared for the U.S. Department of Energy by the University of Utah, Institute for Clean and Secure Energy, Utah Heavy Oil Program, September, 2007. Available online: <http://ds.heavyoil.utah.edu/dspace/handle/123456789/4921>.
- Andrews, A. "Developments in Oil Shale: Report for Congress." Congressional Research Service. Nov. 17, 2008.
- Andrews, A. "Oil Shale: History, Incentives, and Policy." Congressional Research Service. Apr. 13, 2006.
- Bartis, J. T. et. al. "Oil Shale Development in the United States: Prospects and Policy Issues." Report prepared for the National Energy Technology Laboratory of the U.S. Department of Energy. Washington, D.C.: RAND Corporation: 2005.
- BBC Research & Consulting, "Northwest Colorado Socioeconomic Analysis and Forecasts." Prepared for Associated Governments of Northwest Colorado. Rifle, CO: 2008. Available online: <http://www.agnc.org/reports/08-socioeconomic/>.
- Farrell, A. E. "Testimony to House Subcommittee on Energy and Air Quality." April 18, 2007. Accessed online, 4/26/09: http://erg.berkeley.edu/people/faculty/farrell_publications.shtml.
- Headwaters Economics, "Energy Revenue in the Intermountain West: State and Local Taxes and Royalties from Oil, Natural Gas, and Coal." Accessed online, 6/15/09: <http://www.headwaterseconomics.org/energy>.
- Gerking, S. et. al., "Mineral Tax Incentives, Mineral Production and the Wyoming Economy." Report prepared for the Mineral Tax Incentives Subcommittee, Wyoming State Legislature (2000) Published online: <http://eadiv.state.wy.us/mtim/StateReport.pdf>
- U.S. Bureau of Land Management, "Proposed Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocations in Colorado, Utah, and Wyoming and Final Programmatic Environmental Impact Statement." Washington, D.C.: GPO, Sept. 2008.
- U.S. Task Force on Strategic Unconventional Fuels, "Initial Report of Findings and Recommendations: Development of America's Strategic Unconventional Fuels Resources." Report prepared in response to Section 369(h) of the Energy Policy Act of 2005 (P.L. 109-58). Accessed 4/29/09, <http://www.unconventionalfuels.org/publications.html>.
- U.S. Department of Energy, Energy Information Administration, "Country Energy Profiles." Accessed 6/2/09: <http://tonto.eia.doe.gov/country/index.cfm>.
- U.S. Department of Energy, Office of Deputy Assistant Secretary for Petroleum Reserves, "Strategic Significance of America's Oil Resource, Vol. I: Assessment of Strategic Issues." Washington, D.C.: U.S. Department of Energy, March 2004. Accessed 5/7/09: http://www.unconventionalfuels.org/publications/reports/npr_strategic_significancev1.pdf.
- U.S. Department of Energy, Office of Deputy Assistant Secretary for Petroleum Reserves, "Strategic Significance of America's Oil Resource, Vol. II: Oil Shale Resources, Technology and Economics." Washington, D.C.: U.S. Department of Energy, March 2004. Accessed 5/7/09: http://www.unconventionalfuels.org/publications/reports/npr_strategic_significancev2.pdf.
- U.S. Department of Energy, Office of Naval Petroleum and Oil Shale Reserves DOE/NPOSR, "Secure Fuels from Domestic Resources: The Continuing Evolution of America's Oil Shale and Tar Shale Industries, Profiles of Companies Engaged in Domestic Oil Shale and Tar Sands Resource and Technology Development." Washington, D.C., U.S. Department of Energy, 2007. (Third Edition, Sept. 2009) Accessed 5/7/09: http://www.fe.doe.gov/programs/reserves/npr/Secure_Fuels_from_Domestic_Resources_-_P.pdf.
- World Energy Council, "2007 Survey of Energy Resources." London, U.K.: World Energy Council, 2007. Accessed 6/2/09: http://www.worldenergy.org/documents/ser2007_final_online_version_1.pdf.

Journals and other peer-reviewed materials

- Brandt, A. R., Boak, J., and A. K. Burnham, "Carbon Dioxide Emissions from Oil Shale Derived Liquid Fuels," Book Chapter In Press (2010).
- Cleveland et. al., "Energy and the U.S. Economy: A Biophysical Perspective." *Science* 225, 4665 (1984): 890-897.
- Cleveland, C. J. "Net Energy from the Extraction of Oil and Gas in the United States." *Energy* 30 (2005): 769-782.
- Farrell, A.E. and A.R. Brandt. "Risks of the Oil Transition." *Environmental Research Letters* 1 (2006): 1-6.
- Kunce, M., et. al. "State Taxation, Exploration, and Production in the U.S. Oil Industry." *Journal of Regional Science* 43 (2003):749-770.

News and other periodical sources

- Broder, J. M. and M. L. Wald, "Big Science Role is Seen in Global Warming Cure." *New York Times*, Feb. 11, 2009.
- Bunger, J. W., et. al. "Is Oil Shale America's Answer to Peak-Oil Challenge?" *Oil & Gas Journal*. Special Reprint from Aug. 9, 2004 edition. Accessed 4/29/09: <http://www.fossil.energy.gov/programs/reserves/publications/Pubs-NPR/40010-373.pdf>.
- Cleveland, Cutler (Lead Author); Peter Saundry (Topic Editor). 2008. "Ten fundamental principles of net energy." In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth January 4, 2007; Last revised September 23, 2008; Accessed 6/10/09: http://www.eoearth.org/article/Ten_fundamental_principles_of_net_energy.
- Crawford, P. M., et. al., "New approaches overcome past technical issues." *Oil and Gas Journal* (Jan. 26, 2009): 44-48.
- Jenkins, M. "How low will it go? Colorado may face a dry and difficult future of fighting for water" *High County News* March 02, 2009. Accessed 5/7/09: <http://www.hcn.org/issues/41.4/how-low-will-it-go>.
- Kolbert, E. "Unconventional Crude." *The New Yorker*. Nov. 12, 2007.

Industry information

- Oil Shale Exploration Company. Press Releases: <http://www.oilshaleexplorationcompany.com/news.asp>
- Shell Oil. Mahogany Ridge Media Materials: http://www.shell.us/home/content/usa/aboutshell/shell_businesses/upstream/locations_projects/onshore/mahogany/mahogany_media.html.
- National Oil Shale Association, Fact Sheets and Position Papers. No dates. Accessed January 2010: http://www.oilshaleassoc.org/oil_shale_factsheet.html.
- Patten, J. "Field Test Results: Eco-Shale In-Capsule Technology." Conference Presentation. Colorado School of Mines 29th Annual Oil Shale Symposium. Golden, CO, Oct. 2009. Abstract available: http://mines.conference-services.net/resources/328/1729/pdf/OSS2009_0044.pdf.
- Roos, I. "Impact of Oil Shale Use on Greenhouse Gas Emission projections from Energy Sector in Estonia." Abstract of presentation to Oil Shale Symposium, Tallin, Estonia, 2009. Accessed 6/10/09: http://www.oilshalesymposium.com/fileadmin/user_upload/documents/ROOS.pdf.

Web sites

- US DOE/EIA, Forecasts & Analyses: <http://www.eia.doe.gov/oiaf/forecasting.html>
- US BLM, with Argonne National Laboratory, Oil Shale and Tar Sands Programmatic EIS Information Center: <http://ostseis.anl.gov/guide/oilshale/index.cfm>
- DOE Oil Shale Fact sheets: <http://www.fe.doe.gov/programs/reserves/npr/>
- DOE/NPOS, Strategic Unconventional Fuels Task Force Publications: <http://www.unconventionalfuels.org/publications.html>
- EPA Greenhouse Gas Fact sheet
(Fact Sheet: "Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases under the Clean Air Act": <http://epa.gov/climatechange/endangerment.html>

Publications of Prof. Alex Farrell, UC-Berkeley Energy and Resources Group:

http://erg.berkeley.edu/people/faculty/farrell_publications.shtml

Publications of Prof. Adam Brandt, Stanford Univ.: http://pangea.stanford.edu/~abrandt/oil_substitutes.html

Colorado Water for the 21st Century web site: <http://ibcc.state.co.us/>

University of Utah, Institute for Clean and Secure Energy, Heavy Oil Program (including a repository of digital resources): <http://www.heavyoil.utah.edu/>.

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