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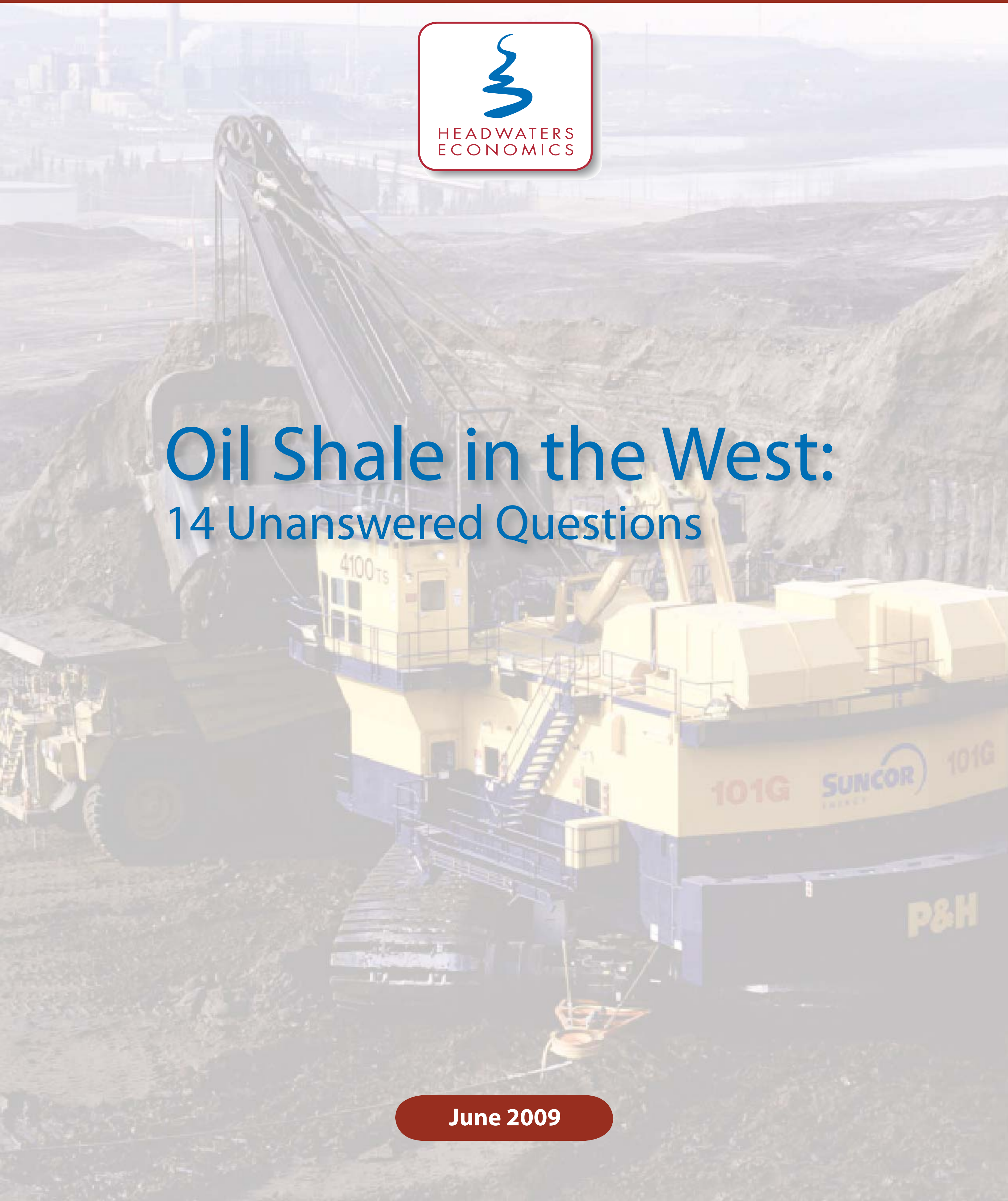

Oil Shale in the West:

14 Unanswered Questions

June 2009

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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

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.

Recent 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 exceed the volume of oil that Saudi Arabia currently produces on a daily basis. 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.

- 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?

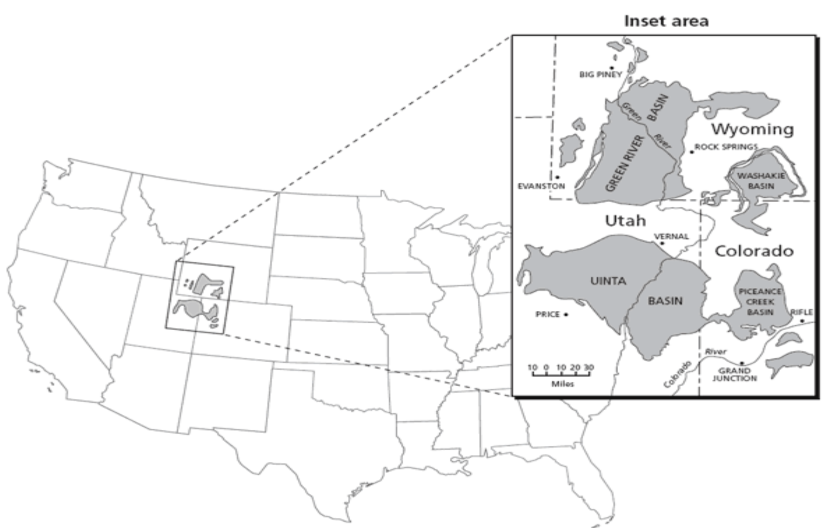
BACKGROUND

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 (OSTS 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 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 Programmatic Environmental Impact Statement (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 OSTS 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.

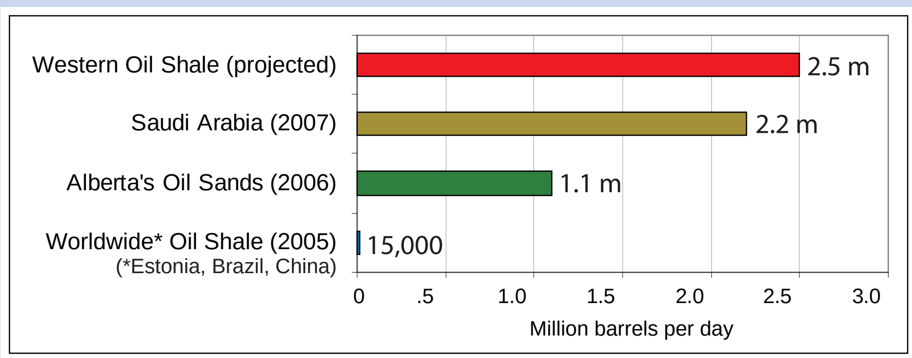
[8] Office of Naval Petroleum and Oil Shale Reserves, U.S. DOE, "Strategic Significance of America's Oil Shale Resource, Vol. II.," 24.

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 that remains the definitive assessment of oil shale at this time. 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. (For comparison, yields from Alberta, Canada's oil sands were 1.1 million barrels per day in 2006 and Saudi Arabia produced a daily average of 2.2 million barrels of oil in 2007.[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 OSTS PEIS, Government of Alberta, and DOE Country Energy Profiles.

[9] The 15-project scenario utilized by the BLM for the 2008 OSTS 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 EPAct. (BLM OSTS 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* options[15]—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-feet 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.

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[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.

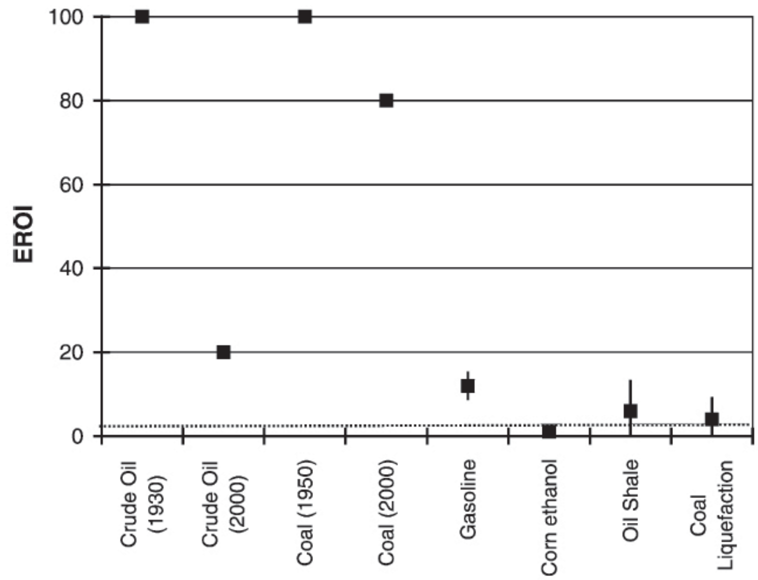
[13] OSEC Press Release, June 9, 2008, http://www.oilshaleexplorationcompany.com/news.asp.

[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." ***Energy*** **30 (2005): 780.**

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 OSTS 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

[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 OSTS PEIS, 4-13.

[21] Tri-State, a Touchstone Energy Cooperative web site, "Craig Station." Accessed 6/10/09,

significant power needs are achievable through a massive expansion of the existing electricity generation 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 OSTS 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

http://www.tristategt.org/AboutUs/baseload-resources.cfm.

22 See BLM OSTS 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.

over time."[26] (For reference, the 3.8 million customers of the city of Los Angeles's Department 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 OSTS 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.

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

[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, OSTS 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]

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[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?

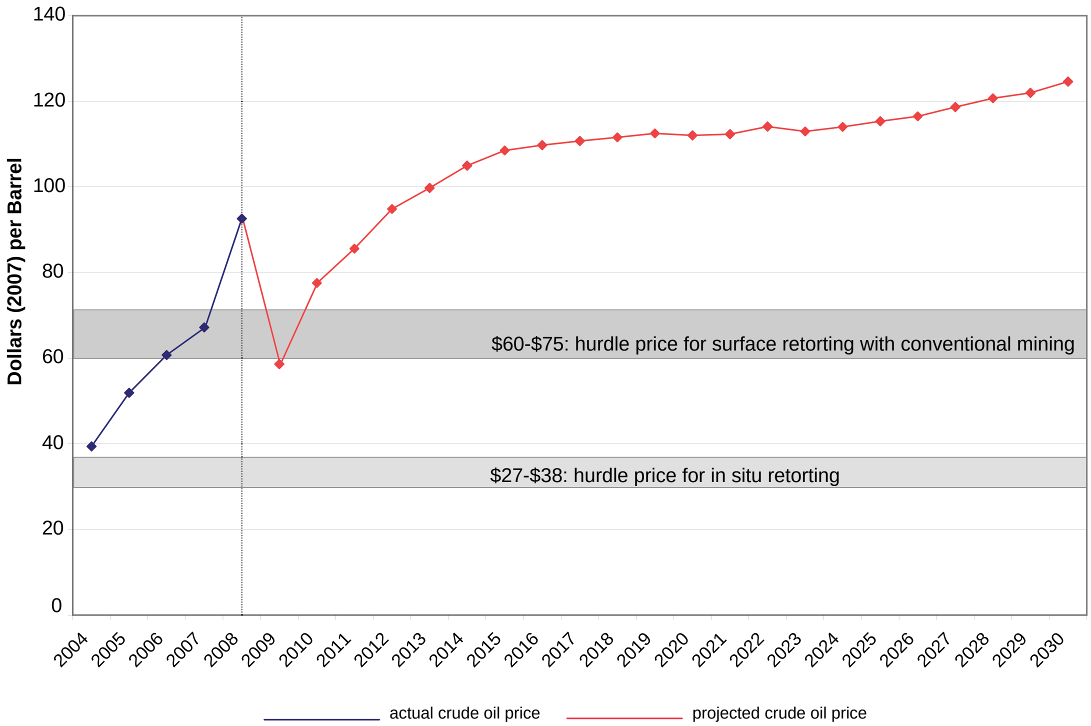
Oil shale cost estimates are complicated and subject to variability due to the many assumptions that inform cost models. Surface retorting is generally assumed to have a higher per barrel production cost than *in situ* retorting. Models also typically assume that the costs of production will be highest 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; 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 5 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, the new 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.

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[43] For a portfolio of key players in the oil shale industry and their current activities, see U.S. DOE/NPOSR, "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.

OPPORTUNTIES 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 OSTS PEIS and promulgate rules for oil shale leasing
- direction to BLM to initiate a research, development, and demonstration (RD&D) leasing program in 2004[49]
- expansion of the maximum lease size permitted under the Mineral Leasing Act[50]
- 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 sponsorhip 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 EPAct 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 EPAct 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% 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 proposed 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]

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[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 exceeding the current average daily crude oil production in Saudi Arabia and 150 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.

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