

Testimony of

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**Subcommittee on Energy and Environment**

On

**TAPPING AMERICA'S ENERGY POTENTIAL THROUGH RESEARCH AND DEVELOPMENT  
ACT OF 2012.**

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## **INTRODUCTION**

Chairman Harris, Ranking Member Miller and members of the subcommittee, thank you for the opportunity to testify before the House Science, Space and Technology Subcommittee on Energy and Environment. Addressing United States (U.S.) energy security is extremely important and establishing an U.S. oil shale research and development (R&D) program is strategic, in my view, to securing our energy future.

My name is Michael Hagood. I am the Program Director for Energy and Environment Science and Technology at Idaho National Laboratory. I am a geologist by training and have worked in the energy and environment sectors for over 30 years.

My testimony will address the following:

- Background on Western U.S. oil shale resources;
- How safe and responsible production of oil shale contributes to U.S. security goals;
- Identification of selected technical challenges and R&D needs;
- Comments on strategy to identify and prioritize R&D;
- Comments on draft legislation titled “Tapping America’s Energy Potential through Research and Development Act of 2012.”

## **OIL SHALE RESOURCE BACKGROUND**

The United States is currently experiencing an increase in domestic oil and gas production, primarily associated with its shale gas and tight light oil (shale oil) resources. Production from U.S. oil shale resources, as well, will likely emerge during the next several years as an important contributor to oil and gas production with the potential to ramp up into a substantial industry during the next few decades and lasting for most, if not all, of this century.

Oil shale is a fine-grained sedimentary source rock, containing organic matter called kerogen, an algae or marine based material that has not yet been converted into oil. When heated using a pyrolysis (retort) process, oil shale can be converted to either crude oil or gas. Crude shale oil is then processed in an oil refinery to produce gasoline, diesel and jet fuels.

Oil shale resources in the United States are immense in size, with most of the resource located in the states of Wyoming, Utah and Colorado. The richest oil shale was deposited in the north-central part of the Piceance Basin in Colorado and in the northeast corner of the Uinta Basin, located in parts of northeast Utah and northwest Colorado (Mercier and Johnson 2012). The Colorado deposits extend from approximately 1,000 feet to as much as 3,000 feet beneath the surface. Within the oil shale column are geologic formations that vary considerably in kerogen content and oil concentration. According to U.S. Energy Information Administration (EIA), the entire column ultimately could produce more than one million barrels oil equivalent per acre during its productive life, compared to Canada’s oil sands deposits which are expected to produce about 100,000 barrels per acre (EIA 2009).

Estimates from recent U.S. Geological Survey studies indicate that between Colorado, Utah and Wyoming, nearly four trillion barrels of oil are estimated to be in place. Most of this resource is located on federal lands. Of the estimated four trillion barrels, it is not known how much oil is potentially recoverable and depends on technical and economic conditions. However, the Rand Corporation (Bartis et al., 2004) estimates that 30 to 60 percent of the oil shale may be recoverable. This is most significant, given that U.S. usage is approximately 6.8 billion barrels in 2011 (18.83 million barrels per day) and projected to be 7.3 billion barrels/yr. in 2035 (19.9 million barrels per day) (EIA 2012).

Oil shale development occurs by either in situ (in place) retorting or ex situ (at the surface) retorting. During the mid-1970s and early 1980s, the petroleum industry focused its efforts primarily on underground mining and surface retorting of oil shale. Today, mining and surface retorting is planned in areas where oil shale is located nearer the surface and more economical to mine. However, the higher concentrations of oil shale resources are located at depths where in situ processes may be more cost effective.

It is more likely that mining with ex situ retort operations will be initiated first by the U.S. oil shale industry and which will be primarily conducted on state and/or private lands. In situ retort operations within the richer formations will likely be initiated later. EIA estimates that the earliest date for initiating construction of a commercial project is 2017 for ex situ process and 2023 probably is the earliest initial date for first commercial production of in situ processes (EIA 2009). However, the Red Leaf Resources Eco Shale process, which is a modified surface retort method, may come on line as early as 2015.

Establishing an oil shale industry is heavily dependent upon economics and the price of a barrel of oil. According to industry representatives (represented by the National Oil Shale Association), it costs somewhere between \$40 and \$80 to produce a barrel of oil from shale, depending on the technology used. The price of oil, currently at ~\$87 a barrel, has risen in the past over \$100 a barrel.

## **HOW DOES SAFE AND RESPONSIBLE PRODUCTION OF OIL SHALE CONTRIBUTE TO U.S. SECURITY GOALS**

A viable oil shale industry would help meet U.S. energy demands and reduce dependence on selected imports and associated costs, as well as reduce the risks associated with potential supply disruptions. New jobs directly related to oil and gas industry and the domestic production supply chain would arise from this industry, including those potentially associated with value-added industries, not yet identified. Development of an oil shale industry will also result in increases in tax and royalty payments to federal and state government for oil production on their lands and contribute to the U.S. gross domestic product (Unconventional Fuels Task Force 2004, 2006; GAO 2012).

Currently, it is not known what production rates may be achieved by an oil shale industry, however DOE provided a vision of a commercial oil shale projects that would range in size from 10,000 to 50,000 barrels per day for surface retorts to as much as 300,000 barrels per day for full-scale in situ projects. For the DOE study, a reasonable development scenario envisioned cumulative production of two to four million barrels per day by 2020 to 2030. The time to market, however, depends on the level of R&D support and other factors.

## **SELECTED TECHNICAL CHALLENGES AND ASSOCIATED RESEARCH AND DEVELOPMENT NEEDS PERTINENT TO CREATING AND SUSTAINING A U.S. OIL SHALE INDUSTRY**

While an U.S. oil shale industry will likely be initiated on a small portion of the U.S. oil shale reserves using current technologies, an aggressive R&D program is required to help tap the largest and most valuable portions of the U.S. reserves. Specifically, R&D is required for in situ processes to explore and advance new approaches and innovative concepts. More research promises to expand technology options, improve operability and efficiency, mitigate potential environmental impacts and reduce costs of producing oil shale (DOE, 2004). Advancement of novel concepts and new approaches requires significant investment in long-term, high-risk R&D to reach proof-of-concept stages of development. Similarly, applied R&D is needed to develop and prove technology at bench or field scale prior to demonstration at a commercial scale (DOE, 2004).

Research and Development has already played a strategic role in the successful development of unconventional fossil energy resources, such the Canadian oil sands, U.S. shale gas and shale oil (light tight oil, e.g., Bakken Formation). All of these R&D programs took many years to bring new products to market. Relative to oil shale, a summary profile of oil shale technology and R&D can be found in various reports (U.S. DOE 2007, 2011; Unconventional Fuels Task Force, 2007). Research emanating from Canadian oil sands development is also an invaluable and relevant source of information, even though focused on a different type of hydrocarbon resource.

Ex situ retort of oil shale has already been deployed commercially, however most of the richer Western oil shale resources are located at depths requiring implementing in situ retort and recovery processes. Although the technical feasibility of in situ retorting has been proved, considerable technological development and testing are still needed. Of particular note, several industry players are conducting demonstration projects as part of the Oil Shale Research Development and Demonstration Leasing Program managed by the Department of the Interior's Bureau of Land Management (Crawford et al, 2012). Particular challenges include improving the economics of these operations by simultaneously attaining greater production efficiencies and mitigating environmental impacts. A number of associated research topics need to be addressed in a federal oil shale R&D program, including increasing the energy return on investment, fracture mechanics and heat transfer for enhancing recovery, materials performance in high-temperature subsurface environments, real-time subsurface process monitoring, water use reduction and post-retort subsurface environmental impact mitigation. Modeling and simulation can assist in addressing many of these topics but computer simulations must be supported by laboratory testing and field validation. In addition, there is significant opportunity for developing novel technology to support "smarter," environmentally-friendly oil shale development.

A number of challenges and opportunities also exist for an emergent oil shale industry as a whole. Collectively there are likely several pathways to develop Western oil shale, which goes beyond addressing individual site operations. Accordingly, it is worthy to consider conducting an oil shale industry fuels logistics analysis which would help better understand options for developing a power, refining and delivery infrastructure, within the context as well of a marketplace. Given the size and longevity of the resource, there is also opportunity to investigate application of hybrid energy systems approaches, including integrating renewable and/or nuclear

energy into oil shale development schemes for achieving greater carbon efficiency and reducing environmental impact. Understanding the development of a U.S. oil shale industry within the context of a greater bi-national regional energy corridor is also essential to enhancing long-term U.S. energy security and the economy. In addition, there will be cumulative environmental and socioeconomic effects in the region that need to be better understood and addressed, including within the context of competing needs (i.e., for agriculture, municipalities, industry, etc.).

Associated with both site operations and development of a larger oil shale industry is a need to ensure that oil shale resources are developed using environmentally suitable approaches. Increasingly, research is playing a role in better understanding the interdependencies between energy development and the environment and the development of innovations that mitigate environmental impacts. This requires significant investments in research to enhance environmental performance associated with water, air quality, wildlife, land (including land reclamation) and greenhouse gases. Water management, as an example, is critical in the arid west and there are concerns that adequate quantities are available to support an oil shale industry and whether there will be impacts on water quality and use elsewhere.

## **COMMENTS ON DRAFT LEGISLATION TITLED “TAPPING AMERICA’S ENERGY POTENTIAL THROUGH RESEARCH AND DEVELOPMENT ACT OF 2012.”**

A federal oil shale R&D program is critical to establishing a viable U.S. oil shale industry, focused on long-term responsible and safe oil shale production. Given the evidence from R&D investments made in similar settings, such as the Canadian oil sands, an oil shale program would provide a high return on investment. A well-organized federal R&D program can provide the backbone for coordinating research across academia, industry, and state and federal laboratories.

The objective of such an oil shale R&D program should be to provide solutions that help achieve specific production and environmental performance goals. It should have a strong strategic plan and a road map to better focus and prioritize R&D investments. Prescribing specific investment R&D directions without sufficient planning can be risky and potentially lead to disconnected R&D efforts that do not effectively achieve the desired end state. A significant body of work produced by DOE and the Task Force on Strategic Unconventional Fuels already exists upon which R&D planning can be built (see references) including a 2008 strategic plan for implementing portions of the Task Force’s recommendations (Task Force’s 2007 program plan), prepared by an Ad-Hoc group of approximately 35 representatives from private industry, academia, community representatives, and local, state and Federal agencies (DOE, 2008).

Stakeholder engagement in an R&D program is very important. Tapping diverse views and champions are essential for innovations in technology. A R&D network promoting “shared research” will improve technology development and have greater impact on technology development than isolated R&D.

The R&D program must consist of investments in both basic and applied research, given the nature of the industry and its longevity. In addition, a strong field demonstration aspect should be required to better facilitate technology deployment. Such a program would provide a greater understanding of the potential benefits and

impacts of oil shale development, while preparing the ground work for, and facilitating, commercialization of America's strategic oil shale resources.

The U.S. Department of Energy and its laboratories are well qualified to provide leadership to deliver a focused, solutions oriented R&D program to address key challenges in realizing a competitive U.S. oil shale industry. DOE is a technical integrator that can bring together needed assets and expertise from both within and outside DOE, including universities and industry, to provide a high-quality R&D program, and as well, act as a needed honest broker of technical information.

Chairmen and members of the Subcommittee, thank you once again for the opportunity to testify.

## REFERENCES

- Bartis, J.T., T. LaTourrette, L. Dixon, D.J. Peterson, G. Cecchine, 2005. "Oil Shale Development in the United States – Prospects and Policy Issues." Rand Corporation - Prepared for the National Energy Technology Laboratory, U.S. DOE.
- Crawford, P.M., C. Dean, J. Stone, J. Killen, 2012. "Assessment of Plans and Progress on US Bureau of Land Management Oil Shale RD&D Leases in the United States."  
<http://www.unconventionalfuels.org/otherreports.html>.
- General Accounting Office, 10 May 2012. "Opportunities and Challenges of Oil Shale Development: GAO-12-740T." General Accounting Office.
- General Accounting Office, 2012. "Unconventional Oil and Gas Production: Opportunities and Challenges of Oil Shale Development GAO-12-7407." General Accounting Office.
- General Accounting Office, 29 Oct 2010. "Energy-Water Nexus: A Better and Coordinated Understanding of Water Resources Could Help Mitigate the Impacts of Potential Oil Shale Development GAO-11-35." General Accounting Office.
- King, C.W., and M.E. Webber, 2008. "Water Intensity of Transportation," *Environmental Science & Technology*, Vol. 42, No. 21, pp. 7866-7872 at <http://pubs.acs.org/doi/abs/10.1021/ec800367m>.
- Mercier, T.J., and Johnson, R.C., 2012. "Isopach and Isoresource Maps for Oil Shale Deposits in the Eocene Green River Formation for the Combined Uinta and Piceance Basins, Utah and Colorado." *U.S. Geological Survey Scientific Investigations Report 2012-5076*, 85 p., 1 pl.
- National Oil Shale Association, May 2010. "Oil Shale Update."  
<http://www.oilshaleassoc.org/documents/FinalUpdateMay2010.pdf>.
- Task Force on Strategic Unconventional Fuels, December 2009. "Annual Report."

- Task Force on Strategic Unconventional Fuels, September 2006. "Development of America's Strategic Unconventional Fuels Resources." Initial Report to the President and the Congress of the United States – Prepared in Response to Section 369(h) (5)(A) of the Energy Policy Act of 2005 (P.L. 109-58).
- Task Force on Strategic Unconventional Fuels, September 2006. "Development of America's Strategic Unconventional Fuels Resources." Initial Report to the President and the Congress of the United States.
- Task Force Strategy and Program Plan, 2007. "America's Strategic Unconventional Fuels." Volume I – Preparation Strategy, Plan and Recommendations, Volume II – Resource-Specific and Cross-cut Plans, Volume III – Resource and Technology Profiles."
- U.S. Department of Energy Office of Naval Petroleum and Oil Shale Reserves, December 2004. "America's Oil Shale – A Roadmap for Federal Decision Making – Sustainable Development of Oil Shale Resources in the United States."
- U.S. Department of Energy Office of Petroleum Reserves Office of Reserve Lands Management, Fourth Edition, September 2011. "Secure Fuels from Domestic Resources: The Continuing Evolution of America's Oil Shale and Tar Sands Industries - Profiles of Companies Engaged in Domestic Oil Shale and Tar Sands Resource and Technology Development: 5th Edition."
- U.S. DOE Office of Naval Petroleum and Oil Shale Reserves, November 2008. "Strategic Plan - Unconventional Fuels Development within the Western Energy Corridor." U.S. Department of Energy, Ad Hoc Unconventional Fuels Working Group: U.S. Department of Energy.
- U.S. DOE Office of Petroleum Reserves, September 2010. "Oil Shale Research in the United States: Profiles of Oil Shale Research and Development Activities in Universities, National Laboratories, and Public Agencies." U.S. Department of Energy Office of Reserve Lands Management. Second Edition,
- U.S. DOE, 2008. Strategic Plan - Unconventional Fuels Development within the Western Energy Corridor - produced by the Ad Hoc Unconventional Fuels Development Working Group.
- U.S. Energy Information Administration Annual Energy Outlook Analysis. AEO, 2009. "Expectations for Oil Shale Production."
- U.S. Geological Survey Oil Shale Assessment Team, 2011. "Oil Shale Resources of the Eocene Green River Formation, Greater Green River Basin, Wyoming, Colorado, and Utah." U.S. Geological Survey Digital Data Series DDS-69-DD, 6 chapters, pages variable.
- U.S. Geological Survey, June 2011. "Assessment of In-Place Oil Shale Resources of the Green River Formation, Greater river Basin in Wyoming, Colorado and Utah." United States Geological Survey, June 2011.

## SUMMARY

The U.S. oil shale resource is immense in size with most of the resource located in the states of Wyoming, Utah and Colorado. Estimates from recent U.S. Geological Survey studies indicate that among these three states, nearly four trillion barrels of oil are estimated to be in place, with a significant portion of this resource projected to be technically and economically recoverable. A viable oil shale industry would help meet U.S. energy demands and reduce dependence on selected imports and associated costs, as well as reduce the risks associated with potential supply disruptions.

An oil shale R&D program can contribute significantly to unlocking some of the richest portions of the western oil shale resource and help achieve this in an environmentally responsible manner. Government and industry R&D investment in the Canadian oil sands and previous U.S. government investment in shale gas and oil development attest to the value of R&D in developing unconventional fossil energy resources.

While an U.S. oil shale industry will likely be initiated with current technology, aggressive R&D is also needed to explore and advance new approaches and innovation. R&D offers to expand technology options, improve operability and efficiency, mitigate potential environmental impacts and reduce costs of producing oil shale. The objective of an oil shale R&D program should be to provide solutions that help achieve specific production and environmental performance goals. Such a program would have a near-term objective of supporting responsible development of an oil shale industry, but also be sufficiently far-sighted to anticipate and promote multiple “next generation” technology advancements.

An oil shale R&D program should focus on challenges that exist at both a site operations scale and those that occur at industry-wide scale, including addressing fuel logistics, integrated energy systems approaches (including renewable and nuclear energy options), and address potential cumulative environmental effects. R&D associated with site operations should include enhancing production efficiency and environmental performance associated with in situ processing. Addressing environmental performance, both at regional and operations scale needs to address surface and groundwater management, air quality, greenhouse gases, wildlife and land disturbance challenges.

An effective R&D program should be guided by a strong strategic plan working with diverse stakeholders and implementing a R&D road map to ensure that the key research needs are identified and prioritized. Such a strategy can be built upon work already completed by the Unconventional Fuels Task Force ([www.unconventionalfuels.org](http://www.unconventionalfuels.org)) and DOE in support of implementing Energy Policy Act 2005, Section 369. Planning should also take advantage of decades of relevant research conducted in association with the Canadian oil sands. This effort should also incorporate assets and expertise that have emerged around western oil shale operations and research, including regional universities, government agencies and laboratories.

The U.S. Department of Energy is a technical integrator that can bring together needed assets from both within and outside DOE to deliver an impactful R&D program and can also act as an honest broker of technical information. DOE is well qualified to provide leadership and to deliver a focused, solutions oriented, R&D program to address key challenges in developing a long-term U.S. oil shale industry.