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Testimony on "American Jobs and Energy Security: Domestic Oil Shale the Status of Research, Regulation and Roadblocks"
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According to the U.S. Environmental Protection Agency, renewable energy comes from sources that "restore themselves over short periods of time and do not diminish" (1). Wind energy is one of the renewable energy sources that the U.S. government has supported through direct spending and tax credits and that states have pushed through renewable energy targets. At the end of 2010, thanks to rapid expansion in capacity, wind power provided 2.3 percent (~40,000 MW of the energy generated in the U.S. (2,3). According to a metals industry analyst, a wind turbine with an electric power generating capacity of 1 MW requires one metric ton of the rare earth metal neodymium for making a permanent magnet (4). That neodymium is most likely mined in Inner Mongolia, a region in China with more than 90 percent of the world's reserves. One of China's most polluted cities, Batou, is located in this region adjacent to a 5-mile wide lake of toxic waste containing acids, heavy metals, and other chemicals left over from the processing of the neodymium ore (5). Studies show high rates of cancer, osteoporosis and skin and respiratory diseases in villages around the lake (5). Does the legacy of this environmental impact diminish the status of "renewable" for wind power?

Another renewable energy source, concentrated solar power, can come with a high price tag for water. Wet cooling, where water is evaporated to remove excess heat, is preferred by developers. Dry cooling, where fans and heat exchangers are used for heat removal, consumes about 90 percent less water but reduces plant efficiency, thus reducing profitability (6). The California Energy Commission has received numerous applications for large-scale solar energy projects in California, and many have large water requirements due to their use of wet cooling technology (7). For example, the Genesis Solar Energy Project would consume an estimated 536 million gallons of water a year for power plant cooling, process water makeup, mirror washing, etc. to produce 250 MW of electricity (8), a rate of 2.1 million gallons of water per megawatt of power generated by this renewable energy source. Is this a sustainable level of water consumption in the arid southwestern deserts where concentrated solar plants are targeted for development?

What about mining and water use impacts from oil shale development? In Utah, the Division of Oil, Gas, and Mining (DOGM) issues permits for oil and gas drilling, coal mining, and minerals mining using guidelines established in the Utah Oil and Gas Conservation Act, the Utah Mined Land Reclamation Act, and the Utah Coal Mining and Reclamation Act (9). Oil shale is regulated as a mineral and is subject to minerals regulatory permits. A large mine, defined as greater than 10 acres, requires a 50+ page application that includes detailed calculations for the bond based upon specific operations. In addition, annual permit fees are required, operation and reclamation plans must be maintained, and approval must be sought for modification (9).

DOGM currently oversees 670 permitted mines in the state of Utah (10). Coal, oil sands, and oil shale mines are particularly controversial. In 2010, after a lengthy appeals process, DOGM issued a permanent program permit to a new surface coal mine, the Coal Hollow Mine, which allows 635 acres of surface disturbance. Earth Energy Resources has applied for a permit to mine 213 acres of oil sands. That permit is currently in appeal (9). Red Leaf Resources is in the process of applying for a large mine permit for development of its oil shale resources.

It is unclear what water consumption rates for oil shale development will be. A recent analysis of previously published estimates shows an average water consumption rate of 2.5 barrels of water per barrel of oil produced (11). An ethanol plant requires four barrels of water to produce one barrel of ethanol, and this amount does not include the water needed for the cultivation of corn (12). How does water usage for oil shale compare to that for the solar energy plant? The energy content of a barrel of oil is measured in units of energy while power plant output is reported in units of power. To compare the two, one must make several assumptions. If one assumes the energy content of a barrel of shale oil to be approximately 1.7 MWh (13) and that it is burned in an engine that has an efficiency of 30 percent, then a 50,000 barrels per day oil shale operation would produce a power equivalent of approximately 1060 MW. At 2.5 barrels of makeup water required per barrel of oil produced, yearly water consumption would be in the 1,900 million gallon range, or 1.8 million gallons of water per megawatt of power produced.

Is oil shale development orders of magnitude worse than any other kind of development that involves extraction or use of resources on a large scale? The above paragraphs address two common critiques used to single out oil shale development, e.g. land disturbance and water usage. There are also critiques related to energy usage, air quality, carbon footprint, capital cost, socioeconomic impacts, etc. All of these concerns are valid given the potential scale of oil shale development in the Uinta and Piceance Basins of Utah and Colorado (see Figure 1). However, there is currently a dearth of data on which to base projections for large-scale impacts because the last active U.S. oil shale facility, the Union Oil operation located in Parachute, CO, was shut down in 1991 (14), and the current round of Research, Development, and Demonstration (RD&D) leases has yet to provide publicly available information on the economic feasibility of various oil shale extraction technologies.

What information on oil shale development and its impacts do we have in the public arena? We have reports and papers from decades of research by academia, national laboratories, companies, and other entities, the experience of oil shale companies currently producing in other countries, and the lessons learned from previous oil shale booms.

The University of Utah has been a contributor to this body of knowledge for many years, beginning with the work of Professor H. Y. Sohn during the oil shale boom of the 1970s and early 1980s and continuing with contributions from Professor J. D. Miller, Dr. James Bunger, and Professor M. D. Deo. In late 2005, the Institute for Clean and Secure Energy (ICSE) at the University of Utah announced the creation of the Utah Heavy Oil Program (UHOP). UHOP's original mission was to provide research support to federal and state constituents for addressing the wide-ranging issues surrounding the creation of an industry for oil shale, oil sands and heavy oil production in the U.S. The scope of the mission was later reduced to focus exclusively on oil shale and oil sands production. The research sponsored by UHOP was broad and interdisciplinary in nature, involving researchers from the Colleges of Engineering, Science, Law, and Business. Funding for UHOP came as the result of a Congressionally Directed Program; the FY2006 budget was $1.8 million. At the time it was funded, there had been no federal support for oil shale/sands research for well over a decade. Part of the renewed interest in oil shale and oil sands was the passage of the Energy Policy Act of 2005 (EPAct 2005).

UHOP was given two directives in EPAct 2005. The first was to prepare an update to the 1988 technical and economic assessment of domestic heavy oil resources (15) and to the 1996 Department of Energy feasibility study of heavy oil recovery (16). UHOP published "A Technical, Economic, and Legal Assessment of North American Heavy Oil, Oil Sands, and Oil

Shale Resources” in 2007. This report evaluated the size of the North American unconventional fuel resource, the production technologies available, the upgrading and refining steps needed, and the economic, social, legal, and environmental issues related to unconventional fuels production (17). The second directive was to sponsor research that related to the objective of Section 369 of EPAct 2005. Four of the sponsored projects were directly related to oil shale and included reservoir modeling for in situ production of oil shale, oil shale pyrolysis kinetics, a analysis of how a federal oil shale program might be implemented, water usage estimates for oil shale development in Utah’s Uinta Basin, and produced water treatment options. A final report was submitted to the Department of Energy (DOE) in early 2010 (18).

ICSE received additional funding in FY2008, FY2009, and FY2010 for the Clean and Secure Energy from Domestic Oil Shale and Oil Sands Resources Program. Current research initiatives include the simulation of a modified in situ production process, the development of improved models for kerogen pyrolysis, the development of a predictive geologic model for the Uinta Basin, an analysis of the geomechanical reservoir state (including subsidence issues associated with in situ production), basin scale simulation of the economic and environmental impacts of oil shale development, and conjunctive management of surface water and groundwater resources in Utah. An economic assessment of various oil shale and oil sands development scenarios in Utah’s Uinta Basin is also being prepared for publication this fall.

Given that we have all this information, what do we need? We need domestic energy resources to fulfill our domestic needs, and the development of all resources should be held to the same high standards. If we don’t like the tailings ponds and open pit oil sands mines in Alberta or the toxic wastes generated by rare earth mines in China for wind turbine components, we need domestic development adherent to more stringent U.S. environmental laws. We need to move all forms of energy development forward so that we don’t miss a solution to the problem. Poor solutions will be eliminated by the market, by the weight of scientific and economic data, or by their failure to meet environmental thresholds set by regulation. We need a regulatory regime in place that will allow oil shale to stand or fall on its own merits. For example, oil shale development is and should be held to the same standard as all other types of mining operations in the state of Utah. It should not be singled out for approval or disapproval just because of the resource type that is being mined. We need opportunities for companies to move their technologies upscale. As a 2005 Rand report on oil shale development notes, “Reliable estimates of water requirements will not be available until the technology reaches the scale-up and confirmation stage” (19). We need companies willing to share information with government and academia. It is difficult to employ tools such as high performance computing that could lead to more rapid deployment of technologies without data for validation and uncertainty quantification. We need a multidisciplinary U.S. oil shale research center. Unforeseen problems will arise, and additional research will be required to address those problems. All of those problems will not have an engineering solution, so such a research center will require experts in the fields of policy, environmental science, law, and economics in addition to engineering and science. Finally, we need research to be moved out of the laboratory and/or the policy think tank and into application. Lessons learned at the larger scale can then be used to refine research directions and initiatives.

ICSE has several models for moving forward with respect to the engineering, policy/legal, and economic sides of oil shale development. On the engineering side, ICSE has partnered with several oil shale technology companies to produce simulation tools with quantified predictivity that can be used by industry to assist in the assessment of the technological, economic and environmental consequences of the production of new gas and liquid fuels from U.S. oil shale/sands deposits. The first model is the application of the simulation tools to Red Leaf Resources’ patented EcoShale process. In this model, Red Leaf is providing temperature data so that the thermal heating of oil shale can be evaluated. The simulation tools will also be used to study product yield as a function of operating conditions for indirectly heated, rubblized oil shale beds.

The second model is a capstone project that is intended to draw together the results of many years of ICSE research to demonstrate computational simulation capability for the assessment and deployment of the shale oil production process commercialized by American Shale Oil, LLC (AMSO). In this integrated project, we are coupling simulation capabilities with experimental data from key small-scale experiments in a formal validation process where the controlling uncertainties are accounted for and quantified. Our goal is to demonstrate that optimal risk assessment and decision-making regarding deployment of this new technology is most efficiently accomplished by this formal validation and uncertainty quantification process. In this model, AMSO is providing funding for the small-scale experiments.

The third model is a joint research project with Los Alamos National Laboratory (LANL) to develop a predictive tool for assessing the basin- or regional-scale environmental and economic impacts of unconventional fuel development. LANL developed a dynamic, integrated assessment tool several years ago that is being updated, improved, and subjected to a rigorous validation and uncertainty quantification process through the cooperative efforts of ICSE and LANL researchers.

On the policy/legal side, ICSE is collaborating with the Wallace Stegner Center for Land, Resources, and the Environment at the University of Utah. Professor Robert Keiter, the director of the Stegner Center, is also the Associate Director of ICSE for Legal and Policy. Together, ICSE and the Stegner Center have hosted the Energy Forum the past two years. The Energy Forum 2011 will feature former U.S. Senator Bob Bennett and former Wyoming Governor Dave Freudenthal in a panel discussion of energy policy challenges including climate change, regional energy demand, natural resources, and national energy security.

Outreach efforts by ICSE also include hosting the annual University of Utah Unconventional Fuels Conference. This year’s conference featured speakers from the Bureau of Land Management Office in Washington, D.C., a member of the Ute Tribe whose lands encompass significant conventional and unconventional fuel resources, representatives from AMSO, Red Leaf, and Enefit, and the director of the Division of Oil, Gas, and Mining for the state of Utah. ICSE has also teamed with the Utah Geological Survey and the Bingham Entrepreneurship and Energy Research Center in Vernal, UT, to lead field trips to oil shale and sands sites in the Uinta Basin.

I will be happy to answer any questions you might have about specific research results, overall program directions, or information contained in our reports at the hearing.

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Figures

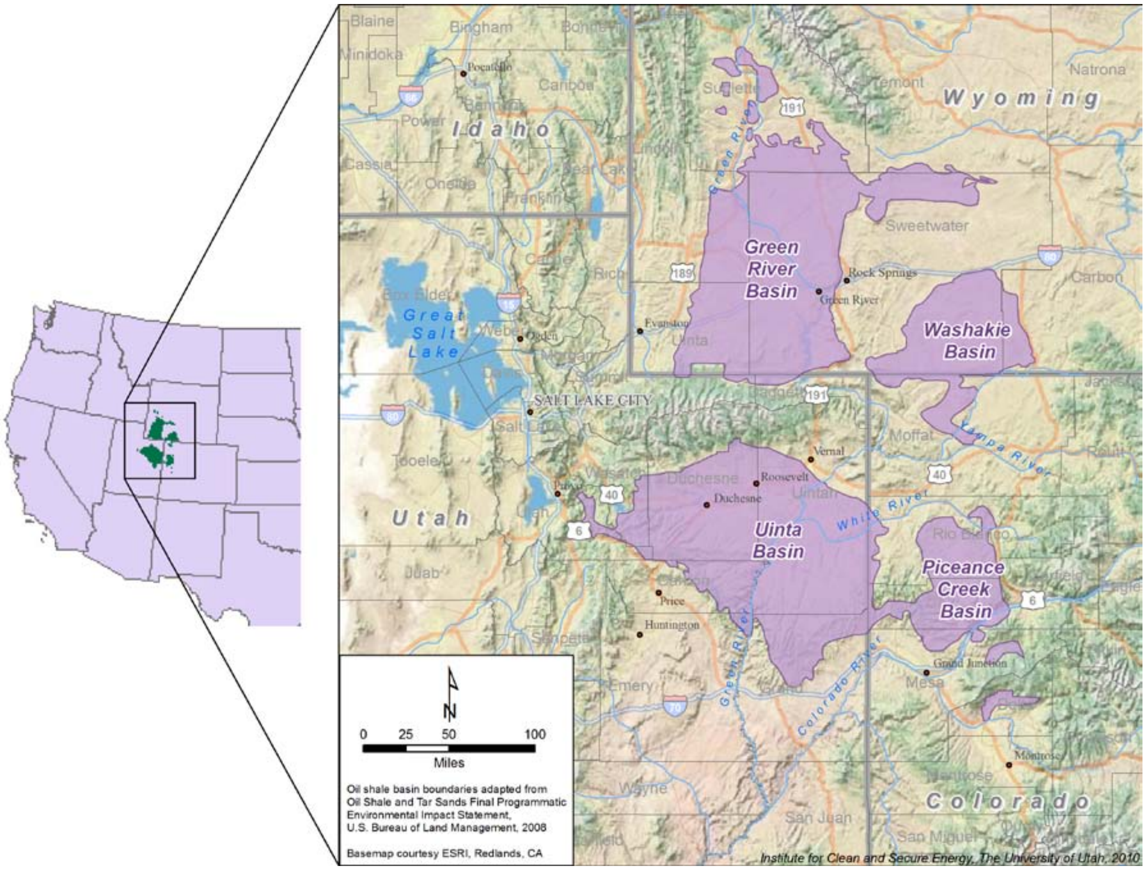

Figure 1: Location of Green River Formation showing main basins in purple.