Water use estimate 2014
National Oil Shale Association
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Oil shale developers have re-evaluated estimates of water usage. The National Oil Shale Association has analyzed the new data and produced the following information to better inform the public and decision makers about this important aspect of oil shale commercialization.

Background

Limited amounts of water will be needed to produce oil from the oil shale deposits in the Western United States. The source of the water can be from wells, surface streams and rivers, and sources not subject to appropriation or control by state agencies. The latter includes water produced in oil shale retorting, non-tributary water in the oil shale strata, water from saline geologic formations, and waste water from oil and gas operations.

In 2013 NOSA did an analysis of water usage and determined that on average an industry would consume 1.7 barrels of water per barrel of shale oil produced (Bw/Bo) or 120,000 acre feet of water per year for 1.5 million barrels per day of oil. This information compared favorably with the results of a study conducted by AMEC for the Colorado, White and Yampa River Roundtables. AMEC is an international engineering, project management and consultancy company headquartered in London, U.K. with offices in Boulder, Colorado.

The AMEC estimates were for Colorado projects only and assumed 97% insitu and 3% exsitu projects. The future may hold promise for more exsitu and modified insitu development in Colorado, as well as Utah and Wyoming, especially as we are now seeing progress in Utah with those two process approaches.

In its 2013 study, NOSA acknowledged the fact that water usage is heavily dependent upon the oil shale recovery technology, assumptions about the split between insitu and exsitu processes, and the assumed level of oil production in the future. The estimate was provided to give the public and decision makers a basis for long range planning for water needs in the region.

Some organizations have presented oil shale water usage information without the benefit of actual data from current developers. Some of that data used the extreme upper limits of hypothetical analyses. Other groups used out-of-date information from the 1970's. Lastly some organizations purposely used estimates that were well above ranges available for current technologies and accepted practices in industry to present a much distorted picture of the industry's proposed use of water. The information presented in this report is intended to supplant earlier non-fact based estimates.

New information

New information has emerged in 2014 as oil shale developers have refined their estimates. Projects have matured, and some developers have taken a new look into

technologies that dramatically reduce water needs. However, estimates are still preliminary and may change as projects reach commercialization. Water usage and oil production level estimates were obtained for insitu, exsitu and modified insitu processes in Colorado and Utah. The estimates for insitu projects show the greatest reduction in overall water needs.

Assumptions

Estimates of future oil production from oil shale projects have been reduced from 1.5 million to 500,000 barrels per day in light of a more pragmatic view of what an industry might look like in 50-years for so. Estimating future levels of production is speculative at best, but decision makers need some idea of the potential for an oil shale industry, should it incrementally develop over the next decades. For this report the split of assumed production levels is 45% insitu, 40% exsitu, and 15% modified insitu in the three states.

Water required for shale oil upgrading was included in the estimates for insitu and exsitu projects, but not for the modified insitu projects. Thus 0.6 Bw/Bo was added to the modified insitu estimates given below.

Insitu figures include "intense measures" using break though technologies to reduce water consumption. Exsitu, modified insitu and upgrading estimates include water conservation measures, such as dry scrubbing and air cooling, but not to the same extent as the intense measures for the insitu estimates. Some reduction could result in the exsitu, modified insitu and upgrading figures if these same intense measures were realized. However, some developers are continuing to evaluate their water use strategies and thus a range of values is presented in the table below to reflect those differences.

Break though water use reduction technologies include low NOx burners at power plants that obviate the need for water injection for NOx control, air cooled power plants, the elimination of smaller water based cooling towers that may be distributed in the process, better recycle control, and ever increasing thermal efficiencies in power generation that reduces waste heat and the need for cooling.

Insitu water use estimates given below are for geologic deposits that do not contain mobile ground water and thus do not require water flushing or water required for ground water containment processes such as freeze walls or grouting. If in the future insitu technologies are employed in areas with mobile ground water then an additional amount of water may be required (one estimate places this additional requirement at 1.5 Bw/Bo). Current developers do not believe insitu technologies will be employed in areas with mobile ground water, but technologies are available to accommodate it.

Gross Bw/Bo is the total amount of water used on the project. Net Bw/Bo reflects the net use of water from external sources. The difference between Gross Bw/Bo and Net Bw/Bo is the amount of water produced during processing (or taken from a non-tributary source) and not from any fresh water stream, river or adjudicated well. Net Acre-Ft per year is the

amount of water required from external adjudicated sources for a year of production from plants making a total of 500,000 barrels per day of shale oil at the plant gate.

The number of data points used to develop the following table was limited by the number of currently active oil shale projects.

New data

The following ranges of data are based upon the above assumptions, public documents, and input from developers.

Technology	Shale Oil B/D	Gross Bw/Bo	Net Bw/Bo	Net Acre-Ft/Yr
Insitu	225,000	0.6 – 1.3	0.3 – 1.0	3,180 - 10,600
Exsitu	200,000	2.4 – 2.6	1.4 – 1.6	13,200 – 15,100
Mod Insitu	75,000	0.5 – 1.1	0.0 – 0.9	0 – 3,180
Total	500,000		0.7 – 1.2	16,400 – 28,900

Summary

Different assumption would have resulted in different estimated external water needs for a future oil shale industry. For instance, if the split between technologies was adjusted more toward insitu processing the estimates would go down. Conversely, if exsitu technologies tend to prevail the estimates would go up, but only if based upon current preliminary estimates for those technologies. The intensity of water conservation measures could also reduce exsitu figures, but conversely insitu usage might go up if developers base their use of water based upon its cost and its availability via owned water rights. The need for and water use estimates for upgrading shale oil is another variable. Early projects may find markets for raw shale oil, and some technologies require little or no upgrading before marketing to a refinery.

Oil shale is not yet even a fledgling industry. More precise information will be developed as years go by. But for now a range of Bw/Bo of 0.7 to 1.2 (16,000 to 29,000 acre feet per year for 500,000 barrels per day of marketable shale oil) is considered reasonable. 29,000 acre feet per year of water is less than 1% of the water that flows annually from the Colorado River into Lake Powell, about 5% of the trans-mountain diversion of water from the Western Slope of Colorado to the Front Range.

Actual water consumption, that is only an estimate today, will be well known by the time the industry gets off the ground and production reaches commercial levels. At that time regulators, proponents, opponents, and other stakeholders will be able to judge the overall benefits that will result from the use of water by an oil shale industry. There are many competing demands for the water resources in the western United States, and judging the highest and best use is a challenge for decision makers and the public. However, the benefits of oil shale development include strengthening domestic energy security, providing

tax revenues, developing needed transportation fuels, providing much needed and well-paying long term employment, and providing a strong boost to local and regional economic development.

Industry strives to develop oil shale in economically sound and environmentally and socially responsible ways. The importance of water resources in oil shale country is well-recognized by the companies, who are striving to reduce projected water consumption as they continue development.

The National Oil Shale Association (NOSA) is a not-for- profit organization. Its mission is to educate the public about oil shale, and dispel misconceptions about the resource by presenting factual technical information. NOSA carries out its mission by communicating with the public through a web site (www.oilshaleassoc.org), fact sheets, presentations and position papers. The NOSA web site has a link to a new brochure titled OIL SHALE –ENERGY TO FUEL OUR FUTURE. The site also has a YouTube link to an educational video OIL SHALE - A VITAL DOMESTIC ENERGY RESOURCE.

NOSA supports a U.S. national strategy that encourages responsible development of oil shale and other domestic sources of energy. The membership of NOSA includes companies involved in oil shale development, non-profits and individuals.

Definitions

Oil shale as discussed in this paper is a huge domestic energy deposit in the Green River formation located in the states of Colorado, Utah and Wyoming. Oil shale also exists in many other places in the world. In some countries shale oil has been produced commercially for decades. Oil and gas are produced from oil shale when the rock is heated to from 600 to 900 degrees Fahrenheit. Oil shale is sometimes confused with oil and gas that occurs in shale rocks in a liquid and gaseous form that would better be termed tight oil, liquid rich shale, and gas shale.

Oil may be produced from oil shale by insitu, exsitu or modified insitu methods. Heating is accomplished underground in the insitu method with technologies similar to the recovery of oil and gas by conventional means through wells drilled into the oil shale. Exsitu methods employ mining and surface processing in equipment called retorts. Modified insitu technologies employ mining and then use insitu methods for heating and recovery.

Bw/Bo is a measure of how much water is required to produce a barrel of shale oil at the plant gate of an oil shale production facility. A barrel is 42 gallons. Gross Bw/Bo and Net Bw/Bo are defined in the text above the chart.

An acre-foot of water is a measure of volume used frequently in water parlance and is equivalent to 325,900 gallons, 7,758 barrels or 43,560 cubic feet. 500,000 barrels per day is equivalent to 23, 540 acre feet per year.

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