The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Oil Shale and the future

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Topic: Supply/Production
Tags: ground freezing, in-situ retorting, israel, oil shale, rand, shell [list all tags]

I mentioned in an earlier post that there have been over 2,000 patents filed on different ways to best extract oil from oil shale. Before going on to close this series with a discussion of the Rand report, and the Shell process, I thought I would draw a little attention to a new method being proposed in Israel. According to the report

> Older technologies squeezed oil out of shale by putting the crushed rock under enormous pressure at high temperatures. But the process developed by Gvirtz costs far less. The shale is mixed and coated with bitumen, a remnant of normal oil refining, then put through a catalytic converter under relatively low pressure. The output is synthetic oil that can be refined into gasoline and other products. . . . . . That will entail construction of a pipeline from the Ashdod refinery located 80 kilometers (48 miles) to the north that would be used for transferring the necessary bitumen needed for the production process. A parallel pipeline would transport the synthetic oil back to Ashdod for refining. . . . . . . "The cost of producing a barrel of oil using the process would be around $17 a barrel," estimates Amit Mor, managing director of Eco-Energy. At that price, the proposed plant would be a veritable gold mine, with annual profits between $188 million to $317 million. Mor notes that the projections are based on the U.S. Energy Dept.'s forecasts of an average oil price of $45 to $50 a barrel in the coming 25 years.

The process is anticipated to produce 3 million tons of oil from 2 million tons of bitumen and 6 million tons of oil shale. While the idea apparently has some merit, perhaps in that it recovers otherwise unattainable oil from the shale, I think that I would need to know a fair bit more about this before I could make sense of it. Perhaps someone with more of a bent to EROI than I can comment.

And speaking of sense, it is time to wrap this series up, at least in the immediate short-term. As I mentioned, last year the Rand Corp reviewed the oil shale industry and (via the site) a free pdf of the report is available. In the report (and given the restriction I will only quote from the press release) the potential growth of the industry is estimated.

> The benefits of a competitive oil shale industry are substantial. For an output of 3 million barrels per day, the study estimates direct economic benefits of about $20 billion per year. Federal, state and local governments would receive about half of this amount in the form of lease payments, royalties and taxes.
>
> Production at 3 million barrels per day also could likely cause oil prices to fall by 3 to 5 percent, saving American oil consumers roughly $15 billion to $20 billion annually,

> according to the report. A multimillion-barrel per day oil shale industry could also create several hundred thousand jobs in the United States.

However, as I have tried to point out in my earlier posts, they see some significant costs to the process, particularly if it is carried out by mining the shale, and then using surface retorting to recover the oil. Part of the problem comes from the fact that not all oil shales are equal, and thus some are not "well behaved" in the retort, to allow the simple separation that I described earlier. So, as a result, they are not convinced that the problems of scale-up from the initial demonstrations of surface retorting have been fully addressed, even though the technology has advanced some. As a result

> It indicates that oil production based on older oil shale mining and processing technologies would not be profitable unless crude oil prices consistently stay above at least $70 to $95 per barrel. . . . . . In addition, significant adverse environmental impacts are associated with oil shale mining, above ground processing and disposing of spent shale.

However, in developing these costs they appear to have only considered room and pillar mining (and this was really the only option I discussed) even though there are known mining techniques using caving methods that could be more productively used in extracting the shale.

The authors then looked at the process that Shell is developing, and anticipate that the costs will be in the $20 - $30 per barrel range, and that there is a potential for a supply of 3 million barrels a day. They see the cost of the oil being in the range of 250 - 300 kwh per barrel, producing a pumpable clean crude.

However they follow the thought of my one month pregnancy argument, and if I can quote from that post

> I remember Dixie Lee Ray being asked about this during the last crisis and she pointed out that even if that miraculous silver bullet technology (the candidate at the time may have been cold fusion) had already been validated in a test tube in some laboratory, that it would take over 20 years before it would have any significant impact on US energy supply. The reason is that initial experiments have to be validated, then designed for, and approved at a larger - bench scale, and run at that scale, and then the process must be repeated at a prototype scale with permits being obtained and construction approved, and funding found, and then again the proces smust be run for some time to ensure it works at that level. Then an initial pilot plant must be developed through the same process, and then the first full-scale plant. If each of those processes takes a finite number of years, you may understand how quickly she reached the 20-year time to significant impact.

As Rand notes, and Shell have been quite candid about, we have the same situation here, in that the experiment has to be validated through the stages, and thus the permitting, running and evaluating the next stage may take six or more years, and the next step an equal interval, so that it may well be 20 years before we reach the 1 mbd point, and 10 more years before the 3 mbd level. (Although it appears that Rand don't seem to buy into imminent Peak Oil in their evaluation).

With all this discussion, what is this Shell process? It has been described in varying levels of detail. The Shell site is not as easy to find information at. In essence holes are drilled down through the overlying rock (which may be a thousand feet thick) to the oil shale, and then through it. Heaters are then placed in alternate holes, and raise the temperature of the rock to over 700 degrees F. At present the heaters are electrical - though there has been a suggestion that if they were natural gas, then they would need only half the gas that conversion to electricity would use. (But in 30-years where would the gas come from?)

If the heating holes are placed at a spacing of around 20 to the acre then it will take about 2 - 3 years to heat the rock the point where it is fully producing. A recent test was successful.

> On one small test plot about 20 feet by 35 feet, on land Shell owns, they started heating the rock in early 2004. "Product" - about one-third natural gas, two-thirds light crude - began to appear in September 2004. They turned the heaters off about a month ago, after harvesting about 1,500 barrels of oil. (article in Sept 2005)

Note that this does not require any additional water, or removal of the rock, leaving it in place as well as the overburden.

There is a major concern with the water, since, although the oil shale is relatively impermeable, as the oil is able, it will be drawn off, leaving voids and an increased permeability. There is a certain amount of water there already, and if this were allowed to migrate through the area, it would interfere with the process, and also potentially carry contaminants away from the site.

The answer that Shell has is to surround the area with a ring of tubes that are used to freeze the water in this barrier, to create an ice wall around the site. For those who don't know creating ice walls to depth is quite well established. It is used, for example, to create a temporary barrier around mine shaft locations as they are sunk to depth. It has the advantage that it freezes all the water despite the rock condition, and is temporary, so that after the process is complete the freezing flow can be turned off, and the ground restored to close to its original condition. It was used in the installation of at least one shaft at one of the potash mines in Saskatchewan, though before the days of the internet, (they go to 3,000 ft) and at Boulby in Yorkshire (same depth) and for the Voerde mine in Germany.

In essence the technology is quite simple. Small holes are drilled down through the earth, generally to an impermeable layer. They must be kept very straight, a problem in earlier times, but now fairly easy to achieve. Because they are small, it is likely that they can be drilled using a coiled tubing rig . Historically an outer, sealed pipe is first set in the hole, and then a smaller return pipe is fitted within it. Chilled brine is then pumped down the outer tube and chills the surrounding ground. More recently magnesium chloride brine has proved more popular. The need for the outer sealed tube is because, if there is a leak, it is not possible to freeze brine with bring.

Modern technology, using plastic pipes, makes it a much more reliable technique than in those early days, and it can be used to only freeze the zones that are critical as was done, I believe at Bevercotes in 1958 by the National Coal Board.

It is easier to carry out, and be effective, if you are not removing the rock on one side of the icewall, as usually happens, since freezing is used to seal and strengthen weak and water bearing rock, before excavating through it. For the EROI folk it takes roughly 2,600 x the water content as a percentage in Kcal/cu.m. to freeze the ground,, and heat can be extracted at the rate of around 100 to 200 Kcal/hr/m of pipe.

One of the other interesting developments of recent years, however, has been what is known as in-situ evaporation. In this a liquefied gas is used as the refrigerant and is pumped into the site, where it evaporates to cool the surrounding rock. Two liquids can be used, liquid nitrogen, and liquid carbon dioxide. Liquid carbon dioxide was used, for example, to freeze the ground for parts of the Helsinki metro, I believe. Consider the benefits, the gas not only helps with the oil recovery, but can then be left sequestered in the rock. Ground freezing can, therefore, be relatively fast and effective and can solve a number of issues.

But to return to the extraction of the oil from the shale. After the ice wall has been formed (and its integrity can be checked since there is a difference in sonic speed between wet rock and frozen rock) the process moves on. The water within the ice wall is then pumped out, for the duration of the oil recovery, and afterwards they use some of it to clean up after themselves.

> Then you pump the water back in. (Well, not necessarily the same water, which has moved on to other uses.) It's hot down there so the water flashes into steam, picking up loose chemicals in the process. Collect the steam, strip the gunk out of it, repeat until the water comes out clean. Then you can turn off the heaters and the chillers and move on to the next plot (even saving one or two of the sides of the ice wall, if you want to be thrifty about it).

This process is known as "pump and treat". Interestingly, at this stage, the water cleaning of the shale residue can be operated by wind energy and would not necessarily need the heaters to remain in operation. This would also allow the leaching of the shale to be completed in a controlled condition, so that the shale could ultimately become a clean aquifer. Since the oil is produced in a pumpable form, it could also be piped to a refinery in an area where water quantity was not an issue (perhaps at an existing but less-used refinery as world supplies draw down).

In short it is an idea that, while still being investigated, looks as though it may provide us with some oil though not immediately, and not in enough quantities, by itself, to satisfy the gap that will soon be developing. On the other hand, once validated it is sufficiently relatively simple (not saying that it is simple but only relatively) and addresses a sufficient number of concerns that it may, in time, become one of the key players as supplies elsewhere decline, making those nations with oil shale happier campers than they are at present.

Well this is probably the last major item that I will post on this for a bit. Because of the vacation Prof G moved some of the initial posts around, to give us, potentially, a slightly larger audience, so the links may no longer be accurate. But the series should include in order:
Where it is
Mining the shale
the nuclear option
nuclear field tests
in-situ retorting

Thank you for your patience and help. Not only with this topic, but also for all the input that has helped to educate us all.