The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Weyburn, CO2 Injection and Carbon Sequestration

Posted by Dave Cohen on December 14, 2005 - 11:46pm
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Tags: carbon sequestration, co2 injection, eor, weyburn [list all tags]

Tip of the hat to Engineer Poet for introducing me to this interesting and important story.

Recently, a little publicized meeting called the EOR Carbon Management Workshop, was held at the Petroleum Museum in Midland, Texas.

> Michael Moore, director of the workshop, noted that the developing technology of capturing carbon dioxide (CO_2) emissions, sequestering them geologically or utilizing those emissions in enhanced oil recovery has received government approval.
>
> Holding up a recent announcement from U.S. Secretary of Energy Samuel Bodman about the successful sequestration of 5 million tons of CO_2 into the Weyburn field in Saskatchewan, Canada, he declared, "the government says it works!"
>
> The Weyburn Project, funded by the U.S. Department of Energy, captured CO_2 from a coal gasification project in North Dakota and transported it over 200 miles to the Weyburn field for sequestration and enhanced oil recovery. The DOE estimated the field's oil recovery rate was doubled and, if the methodology was applied worldwide, would eliminate a third to a half of CO_2 emissions over the next 100 years while helping recover billions more barrels of crude oil.

In this post, we'll examine the claims about Weyburn's success to cover two important related subjects.

1. CO_2 injection for EOR (*enhanced oil recovery*)
2. CO_2 sequestration as a solution to climate change

What did Weyburn actually demonstrate? What is the longer term meaning of the Weyburn project? Let's take a look.

To emphasize the importance of all this, here's what Qatar's representative at the Petroleum Museum workshop had to say.

> Explained Hamal Salah al-Baker of Qatar Petroleum, "our wells are flowing and we're just now putting some on waterflood. But there are **predictions of declines by 2020**," at which time, he said, Qatar's oil output would be "**zero**."
>
> "If we can use CO_2 (to increase oil recovery), we can prolong production 20 years," he continued, adding that his country also has a number of natural gas facilities that have

> produced an excess of CO2 as a byproduct.
>
> "**Because of environmental regulations, we have to get rid of it**," he said.

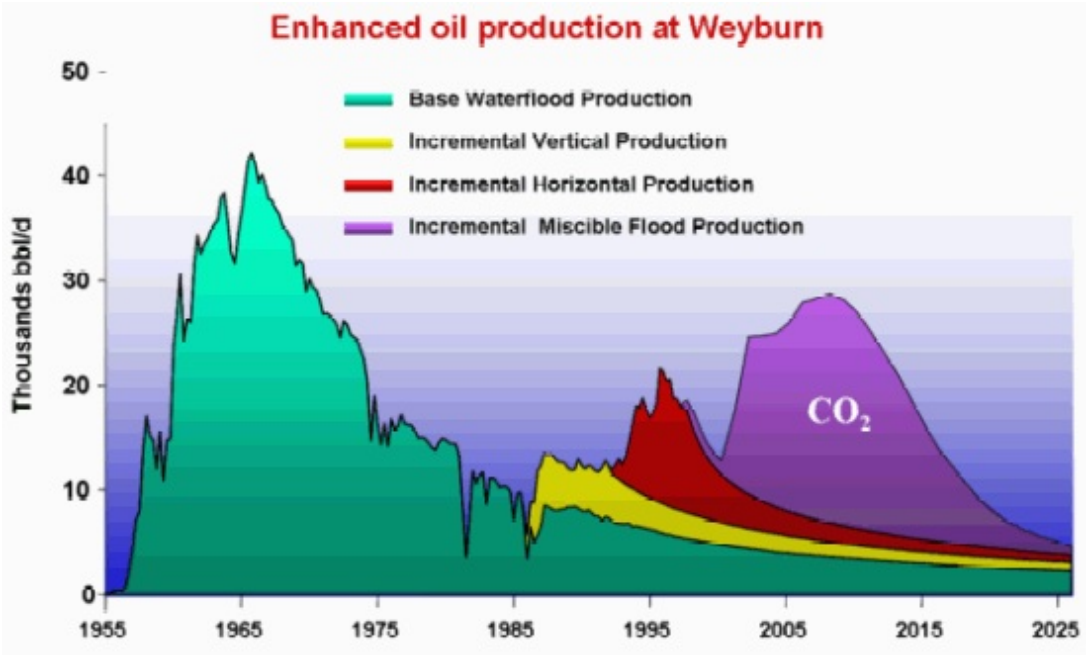
On the other hand, there are only really two strategies for mitigating climate change--switching to alternative energy sources (nuclear, wind, solar, biofuels) that emit little or no carbon into the Earth's atmosphere or sequestering carbon underground as we continue to use fossil fuels.

CO2 Injection for EOR

As reported by the DOE, CO2 Injection into oil fields is a tertiary recovery technique first tried in Scurry County, Texas in 1972.

> Since then, CO2 injection has been used successfully throughout the Permian Basin of West Texas and eastern New Mexico (where about half of all the CO2 floods in the world are located). The technology has been pursued to a limited extent in Kansas, Mississippi, Wyoming, Oklahoma, Colorado, Utah, Montana, Alaska, and Pennsylvania.

As applied to Weyburn, this graphic makes clear the role of CO2 injection in the production lifetime of an oil field.



Examining the Weyburn EOR graphic, water injection was used first, later some new vertical wells were drilled (yellow area), followed by horizontal infill drilling (the red area) in the 90's to offset declines after production had considerably fallen off. Finally, CO2 injection was tried beginning in the year 2000. As in all tertiary recovery, this technique was used to amplify and extend the tail of an oil field's production to extract "stranded" oil in place. As TOD contributor westexas can no doubt tell you, use of tertiary recovery generally has not fundamentally altered the shape of the Hubbert Linearization for lower 48 US oil production but has marginally increased that production by extending the tail of the linearization curve into the future. As the DOE reports (link above), "Today, less than 700,000 barrels per day of oil is produced in the United States by EOR processes (compared to about 6 million barrels per day of total domestic production). Thermal techniques [another tertiary EOR strategy] account for over 50 percent of

U.S. EOR production, primarily being applied in California; gas injection [CO2 in this case] accounts for nearly 50 percent." For Weyburn, CO2 was determined to be the "solvent of choice" and is only used in those parts of the oil field where this is the case. See Role of Enhanced Oil Recovery in Carbon Sequestration--The Weyburn Monitoring Project, a case study (pdf).

CO2 Capture and Storage (CCS) *aka* Carbon Sequestration

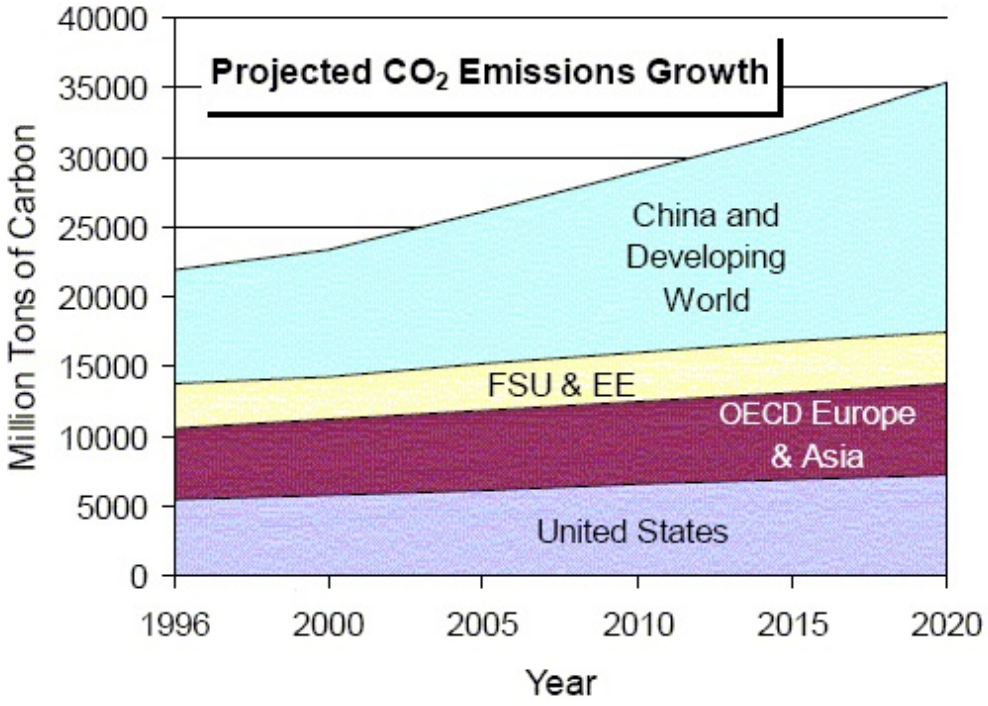
> Carbon sequestration is the capture, from power plants and other facilities, and storage of carbon dioxide (CO2) and other greenhouse gases that would otherwise be emitted to the atmosphere. The gases can be captured at the point of emission and can be stored in underground reservoirs (geological sequestration), injected in deep oceans (ocean sequestration), or converted to rock-like solid materials (advanced concepts).
>
> Fossil fuels will remain the mainstay of energy production well into the 21st century. Availability of these fuels to provide clean, affordable energy is essential for global prosperity and security. However, unless energy systems significantly reduce the carbon emissions to the atmosphere, increased atmospheric concentrations of CO2 due to carbon emissions are expected.

What we are primarily interested in here is *geological sequestration* as used at Weyburn. As this New Scientist article states (not freely available), the possibilities for storing the carbon include

- deep unused saline reservoirs
- active wells for EOR (as at Weyburn)
- depleted oil & gas reservoirs
- deep unmineable coal seams
- CO injection to drive out coal bed methane
- other options (basalts, oil shales, cavities)

So, what are the problems with CO2 sequestration? Well, the first and most obvious problem is *once you put it down there, will it stay there*? This is why there is a Weyburn CO2 Monitoring Project. The second obvious problem has two parts: 1) finding low-cost ways to capture the carbon at its source (eg. coal-fired power plants) and transporting it to a place where it can be buried and 2) burying the carbon once it has arrived there. At Weyburn, which is experimental, this was done in a way shown by the picture shown here in which the "CO2 used is piped in from the Great Plains Synfuels Plant near Beulah, ND, and is a byproduct of the plant's coal gasification process."

Weyburn is an ideal experiment. Not only do such carbon capture processes *not exist* at all current and planned industrial production sources (again, for example, new coal-fired power plants in the US or China) but also, even if they did, there are no programs for transporting the CO2 to places where geological sequestration could take place if the infrastruture were in place to do so. These are the problems the world faces in implementing universal carbon capture and storage. You will want to read Robert Socolow's Can We Bury Global Warming? from Scientific American (July 2005) for more details (unfortunately, not freely available online). For our edification, here is the world's projected CO2 emissions growth out to 2020.



Weyburn and Overall Anthropogenic Carbon Emissions

On November 15th, 2005, Samuel Bodman's office announced Successful Sequestration and Enhanced Oil Recovery Project Could Mean More Oil and Less CO2 Emissions with the subtitle **"Weyburn Project" Breaks New Ground in Enhanced Oil Recovery Efforts**.

> Enhanced oil recovery (EOR), the technique used in the project, has the potential to increase an oil field's ultimate oil recovery up to 60 percent and extend the oilfield's life by decades. Scientists project that, by using knowledge gained from the Weyburn Project, the Weyburn Oilfield will remain viable for another 20 years, produce an additional 130 million barrels of oil, and sequester as much as 30 million tons of CO2.

Now, the obvious problem was pointed out by Jamais Cascio in his post (Engineer Poet's link) Seeing the Forest for the Trees: Sequestration and Oil Production.

> I'm quite certain that you folks have already picked up on the key underlying problem. The additional barrels of oil put out carbon dioxide even while the sequestration buries it. In fact, as I show in the extended entry, **the additional oil puts out more CO2 than is buried**. The Weyburn sequestration model is a study in the need to pay attention to the trade-offs involved in quick-fix solutions to big problems.

Cascio did some very rough back of the envelope calculations to try to prove his claim but I decided to be more precise. Here's how I did that. Based on the year 2001, the US Emissions from Petroleum were 2418.6 teragrams CO2 Equivalent. See Table 2-3. One teragram = 1 million metric tons (mt). EIA's 2001 data indicate that total oil consumed in the US that year was 7.17 billion barrels (19,449/kbd). For the US, this turns out to be 0.337 mt CO2 emissions/barrel of oil consumed.

As applied to Weyburn, an additional 130 million barrels of oil will produce 43.8 million mt of CO2 emissions. On the other hand, if 30.0 million mt are sequestered, only 13.8 million mt will be emitted. This is obviously greater than zero. And in fact, the Weyburn case study says as much regarding their pilot project.

> For the produced oil, on a life-cycle basis, it has been estimated that CO2 production at end use will be **two-thirds that of oil produced in a conventional fashion** [meaning using CO2 injection without sequestration].

According to my calculations, the ultimate CO2 emissions are reduced by 0.68% (about two-thirds)--this is in accord with their numbers, thus substantiating their claim and this analysis. Here's a small Q&A on the meaning of it all.

1. Does the Weyburn experiment extend to new (primary or secondary) oil production, deepwater or land-based? -- *No*.
2. Is carbon capture (as in the Beulah coal gasification facility upstream from Weyburn) viable yet? -- *Yes, technologically, but really no, not without laws mandating that CO2 emissions be penalized to justify the higher costs of capturing the carbon, costs which will be passed on to consumers. See the Socolow article in Scientific American cited above.*
3. Is carbon capture of fossil fuels industrial production sites better than using a natural CO2 source? -- *Sure. Here's from Cascio again.*

> As Watthead correctly points out, the use of CO2 as a means of enhanced recovery from oil fields is not new; the difference in the Weyburn project is that the CO2 used comes from industrial output, and would previously have been released into the atmosphere (past CO2-based recovery used carbon dioxide removed from naturally-occurring underground pockets). If the choice is between sequestering some atmospheric CO2 for

> oil recovery versus no sequestration (but continued enhanced oil recovery), sequestration is clearly a better result. But as the DOE release points out, the use of natural pockets of carbon dioxide happens at "considerable expense" -- oil companies would almost certainly start using industrial/atmospheric CO2 regardless of the environmental benefits (such as they are) for cost reasons alone.

4. Does the Weyburn process reduce future CO2 emissions even if universally applied? -- *Only in those special cases where CO2 injection is appropriate for EOR at the tail end of an oil field's production. This will depend on the field's geological characteristics.*
5. Does the Weyburn process (universally applied) have a large impact on reducing total anthropogenic emissions from fossil fuels? -- *Absolutely not but it does create a very small % reductions in emissions.*

Finally, where does that leave us? Plainly, it leaves us with 130 million barrels of new oil (6.5 days of US consumption) and 13.8 million mt of new CO2 emissions (with a lifetime in the atmosphere of about 100 years), proving that **you can not have your cake and eat it too** or, to put it another way, **there is no free lunch**. There are three doors here, as when Monty Hall says Let's Make A Deal. Behind door #1, we can mitigate climate change by not producing the additional Weyburn oil at all, cutting demand and switching to alternative energy sources, thus reducing overall anthropogenic CO2 emissions and allowing, we hope, a reasonable future life without major recessions or (God Forbid) dieoffs. Or behind door #2, we can produce the oil with a tiny cut in the CO2 emissions growth rate in a business as usual scenario with growing demand. This staves off scarcity that would produce worldwide recessions in the near term but will certainly exacerbate climate change and energy depletion in the longer term, thus postponing the suffering until later. Behind door #3, we can implement energy alternatives now, reduce demand *and* produce the oil with sequestered CO2 as at Weyburn. This would be best if carbon capture and storage programs could be greatly explanded worldwide. However, successful pilot programs like Weyburn, while a small step in the right direction, are not going to cut the mustard if we're going to achieve the CO2 emissions reductions necessary to avoid catastrophic climate change.