Petroleum News -- April 29, 2005

Recovering another 43 billion barrels of oil from six U.S. areas

With crude oil prices sky-high and the U.S. trade deficit at record levels, U.S. oil reserves have assumed a critical role in the U.S. economy. The search for new reserves usually involves exploring for new fields. But vast amounts of stranded oil lie underground in aging U.S. oil fields. The oil is stranded because there's been no way of bringing it to the surface.

Maybe that situation is about to change — on April 20 the U.S. Department of Energy released a series of reports suggesting that as much as 43.3 billion barrels of this stranded oil could technically be extracted from oil field reservoirs.

The key
A technique known as carbon dioxide enhanced recovery that can greatly extend the capabilities of conventional enhanced oil recovery methods such as waterflood, gas lift and the use of miscible injectant.

Carbon dioxide has been used in the past to recover oil by flooding reservoirs. But new state-of-the-art techniques using large volumes of carbon dioxide have substantially increased the ability of carbon dioxide to recover oil.

Two techniques
Carbon dioxide enhanced recovery involves flooding a mature oil reservoir with large volumes of carbon dioxide. But there are actually two distinct recovery techniques using carbon dioxide — miscible recovery and immiscible recovery.

The miscible technique works with high-gravity oil. Carbon dioxide from an injection well mixes with water and oil in the reservoir to form a single, relatively low viscosity fluid phase that flows out through a production well.

The immiscible technique applies to reservoirs with relatively low gravity oil or with low reservoir pressures — in these situations the carbon dioxide does not mix with the oil but, instead, reduces the viscosity of the oil through swelling of the fluid. The pressure of carbon dioxide forces the oil out through the production well.

Selecting oil fields
Analysts from Advanced Resources International Inc., the company that prepared the carbon dioxide enhanced oil recovery reports for DOE, looked at six U.S. oil regions — onshore California, onshore Gulf Coast, offshore Louisiana, Oklahoma, Alaska and Illinois. As a first pass at selecting oil fields in these regions to apply the modern enhanced recovery techniques the analysts used reservoir temperatures and oil composition data to determine the minimum pressure at which carbon dioxide would mix with the oil. If this minimum pressure was less than the maximum injection pressure of a field reservoir, that field became a candidate for miscible carbon dioxide enhanced oil recovery.

The analysts also assessed whether any reservoirs might support the immiscible technique.

Then the analysts used a computer-based carbon dioxide oil recovery model to estimate how much oil might be recovered from each of the selected fields. Adding up these volumes for all of the selected fields resulted in a technically recoverable oil volume for each region. Add all of those numbers up across all of the regions and you get a total volume of 43.3 billion barrels of technically recoverable oil.

Economics

The next step of the analysis involved plugging estimated volumes of carbon dioxide and recovered oil for the selected fields into an economic model that calculated rates of return for different economic scenarios. The economic modeling took into account costs that included drilling new wells, constructing the necessary industrial plant and constructing carbon dioxide delivery spur lines. Local tax and royalty rates were used. The model considered oil prices at $25 and $35 per barrel; carbon dioxide prices that related to local supply possibilities; and rates of return of 25 percent and 15 percent before tax.

For each of the target regions the analysts then identified the fields for which carbon dioxide enhanced recovery would be economically feasible under scenarios appropriate to the region — scenarios assumed different price levels for carbon dioxide and some included the potential for incentives such as tax credits and royalty reductions. By adding up the estimated recoverable oil from each viable field it's possible to derive an estimate for economically recoverable oil.

Onshore California

There is believed to be a total of about 57 billion barrels of stranded oil in onshore California oil fields and 5.2 billion barrels of this oil could probably be recovered using state-of-the-art carbon dioxide enhanced oil recovery.

The analysts looked at four different scenarios for the use of carbon dioxide in the regions. The first of these scenarios involved using traditional carbon dioxide techniques and resulted in virtually no economically recoverable oil. Another scenario that assumed the use of modern, high carbon dioxide volume techniques with relatively expensive carbon dioxide resulted in economically recoverable reserves of 1.8 billion barrels.

Factoring tax credits and royalty reductions into the economics produced a recoverable volume of 3.5 billion barrels. And the availability of low-cost carbon dioxide from industrial plants would further increase economically recoverable reserves to nearly 4 billion barrels.
Onshore Gulf Coast

Onshore Gulf Coast oil fields are thought to contain about 36 billion barrels of stranded oil. Carbon dioxide enhanced oil recovery could probably render 10.1 billion barrels of this oil technically recoverable.

Very little of the stranded oil could be recovered economically using traditional approaches to carbon dioxide enhanced oil recovery. However, the use of state-of-the-art carbon dioxide techniques could result in an economically recoverable volume of 1.8 billion barrels. Factoring in tax credits and royalty reductions increases economically recoverable reserves to 4 bil-

1544 Sawdust Rd, Suite 100, The Woodlands, TX 77380 Tel: (281) 367-0386 Fax: (281) 596-7212

lion barrels. Supplies of relatively cheap carbon dioxide from various future industrial sources could increase the economically recoverable volume to 4.3 billion barrels.

Offshore Louisiana
Current estimates indicate that 15.7 billion barrels of oil lie stranded in offshore Louisiana oil fields; 5.9 billion barrels of this stranded oil might be recoverable using modern carbon dioxide techniques.
The use of carbon dioxide enhanced oil recovery will only result in economically recoverable oil in offshore Louisiana if tax incentives and royalty reduction are applied. In that case there might be 1.3 billion barrels of economically recoverable oil. With reduced carbon dioxide costs in addition to the tax and royalty incentives 3.6 billion barrels could become economically recoverable.

Oklahoma
Oklahoma oil fields are thought to contain about 45 billion barrels of stranded oil. Of this volume 9 billion barrels may be technically recoverable using modern carbon dioxide techniques.

Because of limited use of secondary oil recovery techniques in the past, traditional carbon dioxide flooding techniques could probably enable about 940 million barrels of the stranded oil to be recovered. The higher efficiency of state-of-the-art carbon dioxide techniques coupled with tax credits and royalty reductions could make the recovery of another 4.6 billion barrels economically recoverable. This volume would increase to about 4.7 billion barrels if there were plentiful supplies of carbon dioxide.

Alaska
Current estimates indicate that without further oil recovery techniques 45 billion barrels of oil will remain stranded in Alaska. About 12 billion barrels of this stranded oil could technically be recovered using carbon dioxide.

The supply of carbon dioxide in Alaska would present a major challenge in applying state-of-the-art carbon dioxide enhanced oil recovery. So the analysts assumed a relatively high carbon dioxide price.

Under this scenario there are no economically feasible reservoirs in Alaska. However, if you bring exploration tax incentives and royalty reductions into the economic equation the Alaska oil fields could yield 7.3 billion barrels of oil from carbon dioxide oil recovery. A reduction in carbon dioxide costs to 70 cents per mcf by obtaining future supplies from industrial plants in Alaska increases the economically recoverable reserves to 7.7 billion barrels.

Illinois
Illinois oil fields probably contain 5.7 billion barrels of stranded oil. Modern carbon dioxide oil recovery techniques would probably render 0.7 billion barrels of this oil technically recoverable.
None of the technically recoverable oil can be recovered economically using traditional carbon dioxide flooding techniques. The use of state-of-the-art techniques ought to make about 370 million barrels economically recoverable. Tax incentives and royalty reductions could increase the economically recoverable reserves to 470 million barrels. Ample carbon dioxide supplies