

Overcoming the Barriers to Commercial CO₂- EOR in Alberta, Canada

by

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EXECUTIVE SUMMARY

Six barriers to commercial CO₂ – EOR (Enhanced Oil Recovery) operations in Alberta are reservoir heterogeneity and oil production, new competing technologies, new oil, carbon capture and storage (CCS), CO₂ supply and unitization. This report focuses on the analysis of the first four barriers (related to the technology of enhanced production of oil) and makes recommendations to overcome them. Since CO₂ supply (related to capture and pipeline economics) and unitization (related to policy development) can be a major barrier for a CO₂ – EOR project, they are also briefly analyzed.

Two simple methodologies are extended and are recommended to evaluate CO₂ – EOR prospects at a high level. The first is a technical assessment which relies on reservoir and piloting properties to choose the best candidates for CO₂-EOR. The second is an economic assessment that uses a simple net back calculation to calculate an affordable price for CO₂ purchased at the field site. The first methodology is used to rate the technical aspects of the commercial (Joffre Viking and Weyburn) CO₂ – EOR operations in Canada and the RCP (Royalty Credit Program) and IETP (Innovative Energy Technology Program) piloting CO₂ – EOR operations in Alberta (Swan Hills, South Swan Hills, Judy Creek, Redwater, Enchant Arcs, Zama and the Pembina Cardium). The Enchant Arcs is the only oil pool that doesn't satisfy the technical assessment. The second methodology refers to literature examples for government, capital and operating costs to analyze the affordable price of CO₂ for a commercial CO₂ – EOR project.

The decision is not only which are the best CO₂-EOR projects but they also have to compete against other oil and gas projects, as the oil and gas company has to look at the risks of the project, what the financial returns are likely to be and the “processing rate” (i.e. the short term gains which are important to the stock holder). CO₂ – EOR projects are similar to oil sand projects which have large up front expenses before any return is seen. Up to the year 2000 in Canada, CO₂- EOR projects lost out to the hydrocarbon miscible floods (e.g. Swan Hills) due to the ready availability of light hydrocarbon gases and liquids, whereas CO₂ was only available for nearby niche applications (e.g. Joffre Viking). The one exception was Weyburn where a 300 km pipeline had to be built for a CO₂ miscible flood. Weyburn was helped by the rapid price rise in oil, a champion in PanCanadian who were not afraid of the risk, the pioneering use of horizontal wells in a CO₂ flood and a government in Saskatchewan who were willing to change their royalty regime to have the project.

Since that time new technologies have advanced to the stage where tight oil reservoirs (even including source rocks – e.g. the Duvernay) can be profitable to produce on primary by the use of horizontal wells and multistage fracturing. The tight oil projects have displaced CO₂ – EOR projects because they have a rapid financial return and low investment costs. As some of these tight pools form haloes (e.g. Swan Hills platform and Pembina Cardium fringes) attached to the conventional reservoirs, unitization may become an important issue as the original unit was only confined to the conventional reservoir. On the back side, because they are low permeability reservoirs, they produce only from 3 to 5% of the original oil in place (OOIP) on primary and should be targets in the future for secondary production. Water flooding may yield poor results in these tight reservoirs due to water blocking which opens them up for gas flooding, possible CO₂.

Other new targets for CO₂-EOR exist. Residual Oil Zones (ROZs) formed by “nature's water flood” during uplift and tilting of the Western Canadian Sedimentary may contain huge oil reserves which have not been recognized in the past as the oil will not produce on primary or water flood. Also, recent work on heavy oil suggests that secondary production technology using immiscible gas (preferably CO₂) huff and puff strategy until communication between wells is established (much like the early strategy for the oil sands) is economic

in shallow reservoirs down to API 12° (a gravity much heavier than have ever been considered previously for CO₂-EOR).

Finally, CCS could be considered as an enabler for CO₂ EOR by treating the reservoir as a bank. Roughly, 1/3 of the injected CO₂ remains behind in the reservoir in a CO₂ –EOR project. All the purchased CO₂ is injected into the reservoir (goes into a savings account in the bank) and then is recycled back into the reservoir (a short term CO₂ loan which is paid back). At the end of the project the oil pool is either abandoned (CO₂ stays in savings account in the bank) or blown down and the CO₂ is resold (much of CO₂ is removed from savings account in the bank with only the residual CO₂ remaining). By having a funding program that recognizes the CO₂ storage amounts as they occurs and adjusting the amounts during the process, it would help defray the large capital costs encountered early in the life of a CO₂ EOR project. At the end of the project, a case could be made for the remaining stored CO₂ to be transferred to CO₂ offset credits.

One path forward for overcoming the barriers to commercialization of CO₂ – EOR projects in Alberta is by taking the technologically more attractive CO₂ – EOR pool candidates based on oil pool attributes and piloting results, comparing them against the cost of the CO₂ supply through a netback calculation, and establishing a fund for early recognition of CO₂ storage in CO₂ – EOR commercial projects to address CO₂ price gaps. Other paths forward could be proposed based on utilizing different combinations of the other opportunities previously identified to help overcome the CO₂ – EOR barriers. The most promising path forward could be identified by developing a risk management framework to reach the final decision.

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Table 1c: Properties of Alberta CO₂ EOR Pilots and Commercial in Sandstone Pools

<i>Class</i>	<i>Property (units)</i>	<i>Pemb. Cardium/Penn West</i>		<i>Chigwell/Glencoe Resources</i>		<i>Penn West 1982 - 2002</i>
		<i>Vertical W.</i>	<i>Horizontal</i>	<i>E Viking</i>	<i>I Viking</i>	<i>Joffre Viking</i>
Fluid Properties	Depth (m)	1551	1551	1386	1411	1400
	Pressure (MPa)	20.4	20.4	9.9	7.4	7.7
	Temperature (°C)	46	46	58	59	51
	API (°)	0.83/38	0.83/38	0.86/38	0.84/39	0.82/38
	MMP (MPa)	12	12	14	?	12
	Viscosity (cp)	5.48	5.48	5.56	5.11	5.41
	S_{oil} initial	0.85	0.85	0.62	0.61	0.64
Reservoir Properties	OOIP (10³. m³)	1,488,000	1,488,000	8058	2097	14,120
	Cum. Prod.(10³.m³)	205,996	205,996	476	321	6699
	Thick (m)	7.25	7.25	3.18	1.96	2.73
	Porosity (%)	12	12	13	13	13
	Permeability (md)	30	?	73	44	349
	Aquifer Support	?	?	?	?	?
	Gas Cap	No	?	No	No	No
Pilot Properties	Heterogeneity.	Fractures	Fractures	Fractures	Fractures	No fract.
	Area/Spacing (h/a)	293,534/	293,524	3829/	1499/	7977/
	Infrastructure #well	//6/2	?	61/7//	30/8//	422/20//
	Technology (wells)	Vertical	Horizontal	V + H	V + H	Vertical
	Water inj. (m³)	6145	?	?	?	7,258,322
	Water prod. (m³)	48,510	?	?	?	4,616,952
	CO₂ inj./well (t/d)	100	?	?	?	38
	CO₂ inj. (tonne)	94,019	?	?	?	2,153,064
	CO₂ inj. (fct. HCPV)	0.29	0.08	?	?	0.76
	CO₂ inj. time(days)	1386	?	?	?	X
	CO₂ prod. (tonnes)	10,129	?	?	?	1,290,522
	Incr. oil prod. (bbl)	39,941	?	?	?	3,648,200
	Incr solv prod(boe)	8,153	?	?	?	0
Production -P/W/S/CDH or CDV		P/W/CDH	P/W/CDH	P/CDH	P/S/CDH	P/W/CDH

P=Primary; W=Waterflood; S=Solvent Flood;CDH=Horizontal CO₂ flood; CDV=Vertical CO₂ Flood

Infrastructure = # of wells: by field//by pilot – producers/injectors

Area = area of pool in hectares / Spacing in acres= well spacing of pilot including injectors

? = not available for this report