PRELIMINARY CARBON UNTILIZATION AND STORAGE SCREENING OF OIL FIELDS IN SOUTH SUMATRA BASIN

Sugihardjo, Usman, and **Edward ML. Tobing**
"LEMIGAS" R & D Centre for Oil and Gas Technology
Jl. Ciledug Raya, Kav. 109, Cipulir, Kebayoran Lama, P.O. Box 1089/JKT, Jakarta Selatan 12230 INDONESIA
Tromol Pos: 6022/KBYB-Jakarta 12120, Telephone: 62-21-7394422, Faxsimile: 62-21-7246150
First Registered on July 27th 2012; Received after Corection on August 15th 2012
Publication Approval on : August 31st 2012

ABSTRAK

Penggunaan karbon di lapangan minyak sebagai projek pengurasan tahap lanjut (*Enhanced Oil Recovery*) telah menjadi isu penting dewasa ini. Oleh karena itu seleksi awal CO_2-EOR telah dikerjakan untuk beberapa lapangan minyak yang terletak di Basin Sumatra Selatan, dimana emisi CO_2 dapat dijumpai dari beberapa aktivitas produksi di daerah Sumatra Selatan. Sekitar 103 lapangan minyak yang terdiri dari 581 reservoar minyak telah dilakukan analisis untuk diseleksi dari lapangan lapangan tersebut yang memenuhi kriteria untuk diinjeksikan CO_2. Kriteria seleksi didasarkan pada naskah terbaru kriteria seleksi EOR yang ditulis oleh J.J Taber dkk. 1977. Hasil dari seleksi dapat dikategorikan sebagai terbaur, tidak terbaur, dan gagal untuk diijeksikan CO_2. Selanjutnya, kapasitas simpan CO_2 dan kenaikan perolehan minyak karena injeksi CO_2 dihitung dengan menggunakan persamaan yang dipakai pada industri perminyakan. Kenaikan perolehan minyak karena injeksi CO_2 diasumsikan sebesar 12% dari OOIP pada proses terbaur dan hanya 5% untuk proses tidak terbaur. Perhitungan Kapasitas simpan CO_2 didasarkan pada jumlah perolehan minyak pada tahap primer ditambah peningkatan perolehan minyak dengan injeksi CO_2-EOR. Kedua proses perolehan minyak pada tahap primer dan tersier telah digunakan sebagai dasar perhitungan kapasitas simpan CO_2. Hasil dari seleksi apakah dikategorikan sebagai reservoir tidak terbaur, terbaur dan gagal untuk memenuhi criteria injeksi CO_2 dapat disarikan sebagai berikut: 18 lapangan tidak terbaur, 77 terbaur, dan 7 gagal. Estimasi kenaikan perolehan minyak total dari CO_2-EOR sekitar 480,5 MMSTB. Sementara estimasi kapasitas simpan CO_2 total sekitar 70 MMton sebagai pengisi pori yang ditinggalkan minyak pada produksi minyak tahap primer dan 22 MMton pada perolehan-EOR, jadi kapasitas CO_2 total sekitar 92 MMton.

Kata Kunci: Seleksi-EOR, injeksi CO_2, kapasitas simpan CO_2, Basin Sumatra Selatan.

ABSTRACT

Carbon utilization in oil fields as EOR project has becomes main issue nowdays. Therefore preliminary CO_2-EOR screening has been done for the oil fields laid on South Sumatra Basin, where CO_2 emission arise from a number different sources of activities in South Sumatra area. Around 103 oil fields and consisting 581 reservoirs have been analysis to select which of those fields fulfill CO_2 injection criteria. The criteria applied of the selection are based on EOR Screening Criteria Revisited papers introducing by J.J Taber at. All. 1977. The results of the screening are categorized as miscible, immiscible and failed for CO_2 injection. Afterward, CO_2 storage and incremental oil recovery due to CO_2 injection were calculated using equation normally used in the oil industries. The incremental oil recovery due to CO_2-EOR has been assumed as high as 12% of OOIP at miscible process and only 5% for immiscible displacement. The calculation of CO_2 storage is based on the ultimate primary recovery for each field in addition of the additional recovery due to CO_2-EOR. Both primary and tertiary recovery have been used as the basic of calculating the CO_2 storage. The results of the screening whether reservoir categories in immiscible, miscible injection and failed to fulfill EOR-CO_2 injection criteria can be summarized as follow: 18 fields immiscible, 77 miscible, and 7 failed. Total incremental oil recovery estimate from CO_2-EOR is approximately 480.5 MMSTB. While the total CO_2 storages estimate are about 70 MMton for voidage replacement due to production at ultimate recovery and 22 MMton at EOR-recovery, so the total CO_2 storage is approximately 92 MMton.

Keywords: *EOR-screening, CO_2 injection, CO_2 storage, South Sumatra Basin*

I. INTRODUCTION

Most of oil fields in South Sumatra basin have been categorized as mature fields, since the primary stages of the oil production nearly finish. Therefore EOR technology is the only option to rejuvenate those old oil fields to increase the oil recovery by CO_2 injection. CO_2 miscible flooding, one of the EOR method, is being conducted on commercial scale in many oil reservoirs. This method is basically very efficient as an EOR method to improve the oil recovery, even in immiscible injection it may still produce oil recovery improvement when the injection pressure close to the MMP (minimum miscibility pressure)

Unfortunately at this area huge CO_2 emissions have not been managed properly. Emissions of CO_2 in South Sumatera arise from a number of sources, stationary and non-stationary, which are mainly fossil fuel combustion in the power generation, industrial, oil and gas extraction activity, coal mining, residential and transport sectors. The list consists of identified large stationary CO_2 sources in South Sumatera of the following types: Power plant, Oil and gas extraction activities, Petroleum Refinery, Coal mining, Cement plant, and Fertilizer plant. Oil and gas extration activities such as gas gathering system normally is avilable CO_2 removal which proximity is close to the oil fields, and very good candidate as CO_2 sources for CO_2 injection.

The concept application of Clean Development Mechanism (CDM) includes an alternative solution of storing CO_2 into geological formation down deep in the earth. However, this project will be costly and no additional profit. The other choice is to utilize the CO_2 production in EOR projects to recover additional trapped oil in the old reservoirs in the surrounding areas.

II. GEOLOGY AND STRATEGRAPHY OF SOUTH SUMATRA BASIN

The South Sumatra Basin is located to the east of the Barisan Mountains and extends into the offshore areas to the northeast and is regarded as a foreland (back-arc) basin bounded by the Barisan Mountains to the southwest, and the Pre-Tertiary of the Sunda Shelf to the northeast (de Coster, 1974)[3]. Most of the published data stated that South Sumatra basin is divided into sub-basins: Jambi, North Palembang, Central Palembang, and South Palembang (Bishop, 2000)[2]. The province covers an area of approximately 117,000 km^2 primarily onshore Sumatra, Indonesia.

There are several formations in the South Sumatra Basin which play as reservoir rocks, event basement rocks. They are basement rocks, Lahat Formation, Talang Akar Formation, Batu Raja Formation, Gumai Formation, Air Benakat Formation, and Muara Enim Formation (Bishop, 2000). Figure 1 of Regional Stratigraphy also shows oil and gas zones in South Sumatra Basin. The most prolific reservoirs are the Talang Akar and the Baturaja Formations.

III. CO_2 EOR SCREENING AND STORAGE RULES

CO_2 flooding mechanisms include miscible and immiscible processes. The process is called miscible if the CO_2 dissolve in the oil, in one hand, which can decrease its viscosity, density, and residual oil saturation, but in the other hand, increase its mobility. Meanwhile, the process will be called immiscible when the CO_2 function is only to push the oil bank from a specific well to the existing producing wells. The basic behavior of CO_2 gas is capable to develop multi-contact miscibility with reservoir fluids, then, improving the fluid properties.

This Preliminary Study is conducted to screen a number of oil reservoirs for the CO_2 flooding in the oil fields in the South Sumatra Basin. The screening of CO_2 injection for EOR has included most of oil fields in South Sumatra Basin near Pendopo region. Therefore Pendopo has been used as the basic for the distance measurement of the oil field locations. Figure 2 shows the oil fields surrounding Pendopo area.

The objectives of the CO_2 EOR screening is to perform screening works of existing old oil reservoirs in the regions of South Sumatra Basin to determined reservoirs existing in those fields which are suitable for CO_2 injection. The screening was carried out by comparing the reservoir characteristics and residual oil volume trapped in each reservoir with the CO_2 flooding criteria. Besides that, the incremental oil recovery due to CO_2 injection is also calculated and the CO_2 storage as well based on the assumptions that normally used in petroleum industries.

The screening criteria are useful for a cursory examination of many candidate reservoirs before the expensive reservoir descriptions and economic

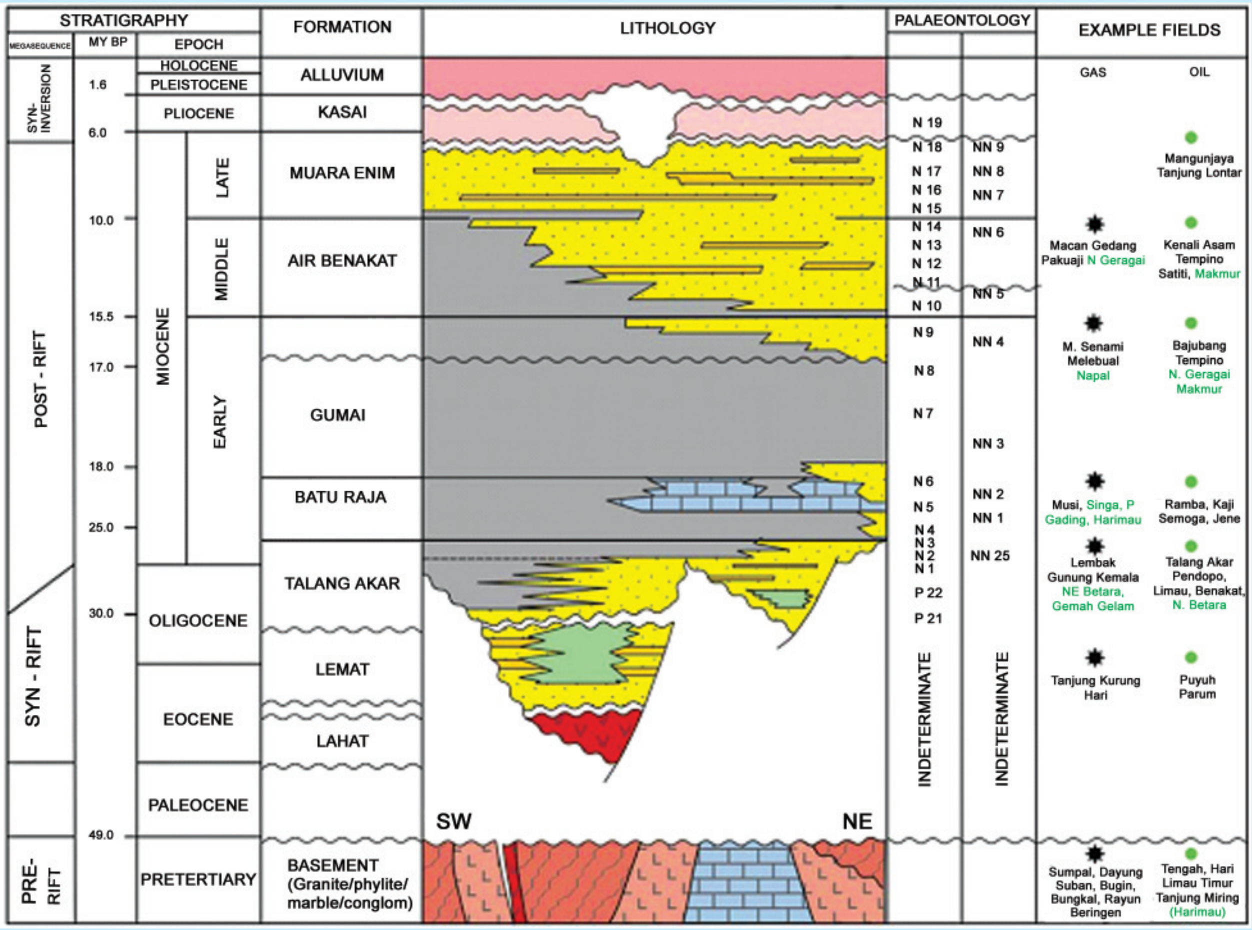

Figure 1
Regional Stratigraphy of South Sumatera Basin

evaluations will be conducted. There are two parameters of reservoir that are considered for this screening, i.e. depth and API gravity (if the data is limited). The other parameters, however, can also be used such as original oil inplace (OOIP), remaining oil, pressure, and temperature. The CO_2 screening criteria is used to estimate the total amount of CO_2 that might be needed for flooding the oil in the reservoirs in order to get the optimum incremental oil recovery. EOR reservoir screenings performed for the oil fields in South Sumatra Basin is carried out using EOR Screening Criteria Revisited papers introducing by J.J Taber *at all.* 1977,[4,5] the criteria including: API gravity, oil viscosity, current pressure, temperature, oil saturation, remaining oil, formation depth, thickness, porosity, permeability, and rock type. All of these reservoirs parameters should be screened whether they can fulfill the criteria and suitable for CO_2 injection. Table 1 is the screening criteria for CO_2 injection.

All reservoirs with oil gravity greater than 22°API can qualify for some immiscible displacement at pressures less than the MMP. In general, the reduced oil recovery will be proportional to the difference between the MMP and flooding pressure achieved. These arbitrary criteria have been selected to provide a safety margin of approximately 500 feet above typical reservoir fracture depth for the required miscibility (MMP) pressure and about 300 psi above the CO_2 critical pressure for the immiscible floods at the shallow depths. For successful and achieving the optimum incremental oil production from CO_2 flooding, the oil gravity should be in the range between 30^o and 45^{o}API with the average depth of reservoirs greater than 2,000 ft. These conditions make the CO_2 miscible process possible.

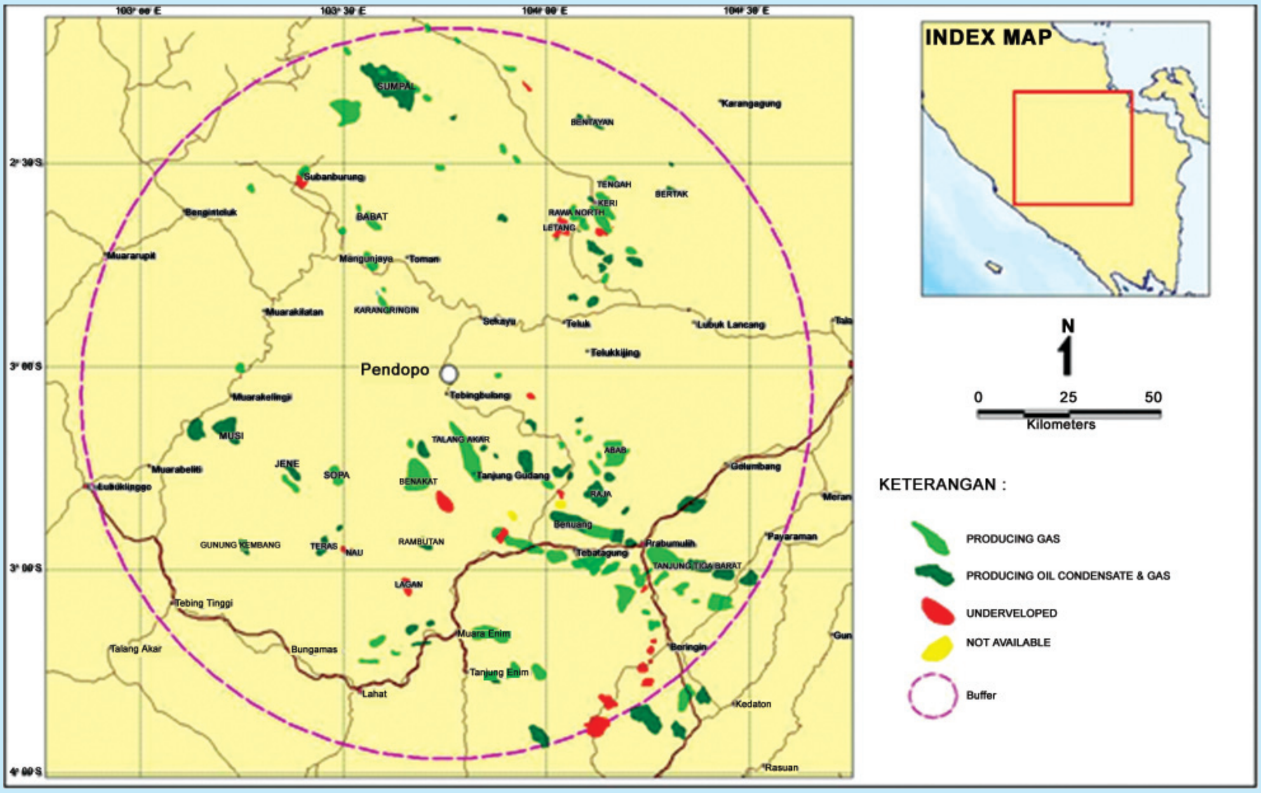

Figure 2
Oil Fields Surrounding Pendopo Area

Table 2 shows an example of screening work. The Table shows for example the oil gravity should be greater than 22°API the greater is the better but the average oil gravity of the CO_2 projects in the world is 36°API and greater than 36°API has the better results. On the other hand, the oil viscosity should be smaller than 10cp the lower the better but the average oil viscosity of the CO_2 projects in the world is 1.5cp and lower than 1.5 has the better results.

Common rule of incremental oil recovery based on the world CO_2 injection projects could be summarized as follows:

1. Incremental oil recovery of miscible injection is around 10 to 15% of STOOIP
2. Incremental oil recovery of Immiscible injection is 5 to 7% to STOOIP

Therefore, additional oil recovery due to CO_2-EOR in this study has been assumed as high as 12% of OOIP incremental oil recovery at miscible process and only 5% for immiscible displacement. The calculation of CO_2 storage is based on voidage replacement of the produced oil at the ultimate primary recovery for each field in addition of the additional recovery due to CO_2-EOR. Both primary and tertiary recovery has been used as the basic for calculating the CO_2 storage.

For oil and gas fields, the total storage capacity in tonnes of CO_2 may be calculated from reservoir volumes, Recovery Factors, and OOIP or OGIP in place (= Method 1), or by oil and gas production and reserve estimates (= Method 2).

Methodology for Storage Capacity Estimates based on Recovery Factors,[1]

The formulate for the Method 1 calculations are

$$M_{CO2t} = d_{CO2r}((R_f \cdot OOIP/B_f) - V_{iw} + V_{pw}) \quad \ldots\ldots\ldots\ 1$$

And for a gas field, the total storage in tonnes of CO_2 is:

$$M_{CO2t} = d_{CO2r} R_f (1-F_{IG}) \cdot OGIP(P_s Z_r T_r / P_r Z_s T_s) \quad \ldots\ldots\ 2$$

where R_f is the recovery factor, F_{IG} is the fraction of injected gas if any, P, T and Z denote pressure,

Table 1
CO_2-EOR Screening (J.J Taber *at al.*)[4,5]

Description:

The CO_2 flooding is carried-out by injecting a large quantity of CO_2 (30% or more of the hydrocarbon pore volume, PV) into the selected reservoir. Although the CO_2 is not firstly contact in miscible form with the crude oil, it is able to extract the light to intermediate components from the oil, and if the pressure is high enough, it will also develop miscibility to displace the crude oil from the reservoir (MMP). The immiscible displacements are less effective, but they recover of oil much better than the waterflooding displacement.

Mechanisms:

The CO_2 recovers crude oil by (1) swelling the crude oil (CO_2 is a very soluble in the high gravity oils); (2) lowering the viscosity of the oil (much more effective than N_2 or even CH_4); (3) lowering the interfacial tension between the oil and the CO_2/oil phase in the near miscible regions; and (4) generation of miscibility when the pressure is high enough

Technical Screening Guides

	Recommended	Range of Current Projects
Crude Oil:		
Gravity, °API	>22	27 to 44
Viscosity, cp	<10	0.3 to 6
Composition	High percentage of intermediate components Hydrocarbons (especially C5 to C12)	
Reservoir:		
Oil saturation, % PV	>20	15 to 70
Type of formation	Sandstone or carbonate and relatively thin, unless dipping Not critical, if sufficient injection rates can be maintained.	
Average permeability	For miscible displacement, depth must be great enough to allow injection pressures greater then MMP, which increases with temperature, and for heavier oil	
For CO_2 miscible flooding	Oil Gravity, °API	Depth must be greater than (ft)
	> 40	2500
	32 to 39.9	2800
	28 to 31.9	3300
	22 to 27.9	4000
	<22	Miscible fails, then screen for immiscible
	13 to 21.9	1800
For immiscible CO_2 flooding (lower oil recovery)	<13	All oil reservoirs fail at any depth

Notes:

- At < 1800 ft, all reservoirs fail in screening for either miscible or immiscible flooding with supercritical CO_2
- Limitations: A good source of low cost of CO_2 is required
- Problems: Corrosion can cause problems, especially if there is early breakthrough of CO_2 in producing wells

temperature and gas compressibility factor respectively, B_f is the formation volume factor that brings the oil volume from standard conditions (s) to in situ conditions (r), V_{iw} and V_{pw} are the volumes of injected and produced water, respectively (applicable in the case of oil reservoirs), OOIP is the original oil in place and OGIP is the original gas in place as proposed by Bachu et al., 2007. An estimate of the injectivity can be obtained from the production rates divided by the number of production wells and average pressure drop (i,e. obtained from the difference between reservoir pressure and wellhead pressure). In this calculation Method 1 has been used, and Method-2 normally is apllied for gas reservoir.

IV. CO_2 EOR SCREENING AND CO_2 STORAGE RESULTS

Data has been collected only from the 3 big companies and consists of 103 fields and 581 reservoirs including failed category. All of these reservoirs parameters should be screened whether they fulfill the criteria and suitable for CO_2 injection. All reservoirs have been screened using the above table of CO_2 injection screening criteria. The results of the screening whether a reservoir categories in immiscible, miscible injection and failed fulfill EOR-CO_2 injection criteria are tabulated as follows. The detail results are shown in Table 3. Additional recovery factor from EOR (RF-EOR) is presented

Table 2
CO_2 Screening and Storage Determination

Company : Indonesian Oil Company
Contract Area : SSE
Field : H#3
Reservoir : Baturaja Limestone

No	Fluid Characteristic and Reservoir Rock			CO_2 Flooding Screening Criteria	Remark
1	Reservoir Pore Volume	MM cuft	5,185		Miscible Injection Flooding
2	Formation Thickness	ft	171		
3	Formation Type		Lime Stone	Sand Stone / Lime Stone	
4	Reservoir Depth	ft, SS	5,720	> 2500	
5	Initial Reservoir Temperature	°F	265		
6	Initial Reservoir Pressure	psig	2,767		
7	Current Reservoir Temperature	°F		Not Critical	
8	Current Reservoir Pressure	psig	2,402		
9	Porosity	%	19		
10	Permeability	mD	407	Not Critical	
11	Water Saturation	%	89		
12	Oil Saturation	%	11	> 20 ↗ 55 ↗	
13	Gas Saturation	%	-		
14	Oil Formation Volume Factor	RB/STB	1.27		
15	Gas Formation Volume Factor	cuft/scf	-		
16	OOIP	MSTB	124,301		
17	Ultimate Recovery	MSTB	57,180		
18	Remaining Oil	MSTB	68,811		
19	Oil Gravity	°API	35	> 22 ↗ 36 ↗	
20	Oil Viscosity	cp	0.50	< 10 ↘ 1.5 ↘	
21	CO_2 Storage UR	Ton	3,940,756		
22	CO_2 Storage EOR	Ton	1,027,996		
23	Additional Oil Recovery	MSTB	14,916		

↗ = Suggested for higher reservoir fluid characteristic
↘ = Suggested for lower reservoir fluid characteristic
55 = Average application of reservoir fluid characteristic

Table 3
The Result of CO_2-EOR Screening and Storage Determination

Fields	Reservoir Number	Distance From Pendopo (Km)	Additional RF-EOR (MSTB)	CO_2 Storage UR (Ton)	CO_2 Storage EOR (Ton)	CO_2 Storage Total (Ton)	STATUS
3	**57**	**0-20**	**117,415**	**15,425,471**	**4,501,323**	**19,926,795**	
A1	1	9.4	108,288	14,185,909	4,255,773	18,441,682	Immiscible
A2	45	9.4	8,151	1,126,747	222,987	1,349,735	Immiscible
A3	11	15	976	112,815	22,563	135,378	Immiscible
6	**64**	**20-30**	**21,574**	**3,304,222**	**1,149,774**	**4,453,996**	
B1	21	21.86	3,107	260,986	119,876	380,861	Miscible
B2	12	21.86	1,089	71,854	31,638	103,492	Miscible
B3	1	21.86	109	10,259	4,924	15,183	Miscible
B4	23	21.86	9,445	1,053,113	384,385	1,437,497	Miscible
B5	2	21.86	530	8,986	15,661	24,647	Miscible
B6	5	28.6	7,294	1,899,024	593,291	2,492,316	Miscible
20	**52**	**30-40**	**9,641**	**1,469,117**	**616,565**	**2,085,682**	
C1	2	37.2	262	28,888	16,853	45,741	Miscible
C2	6	37.2	5,384	851,318	363,105	1,214,423	Miscible
C3	1	37.2	158	29,430	11,654	41,084	Miscible
C4	3	37.2	115	18,190	7,484	25,673	Miscible
C5	2	37.2	-	9,014	3,477	12,491	Miscible
C6	7	37.2	576	97,544	38,752	136,297	Miscible
C7	3	37.2	220	30,234	13,550	43,784	Miscible
C8	1	37.2	232	34,997	16,886	51,883	Miscible
C9	1	37.2	222	28,383	13,698	42,081	Miscible
C10	1	37.2	139	21,596	8,589	30,185	Miscible
C11	1	37.2	19	2,966	1,139	4,105	Miscible
C12	3	37.2	196	25,037	11,389	36,426	Miscible
C13	2	37.2	122	15,570	6,148	21,718	Miscible
C14	3	37.2	317	43,304	18,793	62,096	Miscible
C15	2	37.2	214	32,033	12,671	44,704	Miscible
C16	3	37.2	122	17,796	7,261	25,057	Miscible
C17	1	37.2	71	11,910	4,685	16,595	Miscible
C18	2	37.2	77	10,865	4,392	15,257	Miscible
C19	1	37.4				-	Gas Reservoir
C20	7	39.9	1,196	160,043	56,042	216,084	Miscible/Gas Reservoir
27	**157**	**40-50**	**92,810**	**17,538,751**	**4,821,539**	**22,360,289**	
D1	4	40.1		8,731		8,731	Failed
D2	1	41.5	3,863	379,387	50,157	429,544	Immiscible
D3	3	43.5	18,300	3,698,252	555,163	4,253,415	Immiscible
D4	7	44.5	1,986	534,584	146,099	680,683	Miscible
D5	3	47.1	11,897	2,783,257	347,717	3,130,974	Immiscible
D6	1	48.1	14,916	3,940,756	1,027,996	4,968,752	Miscible
D7	7	48.8	6,826	1,096,117	448,193	1,544,311	Miscible
D8	8	48.8	10,014	1,595,771	612,065	2,207,836	Miscible
D9	1	48.8	253	22,590	13,619	36,209	Miscible
D10	3	48.8	1,345	96,814	72,353	169,167	Miscible
D11	5	48.8	634	71,470	34,687	106,157	Miscible
D12	1	49.8	3,897	55,136	217,487	272,623	Miscible
D13	8	49.9	2,222	311,961	122,926	434,886	Miscible
D14	15	49.9	4,696	813,036	322,986	1,136,022	Miscible
D15	12	49.9	1,564	267,138	110,502	377,640	Miscible
D16	16	49.9	1,099	179,239	72,434	251,673	Miscible
D17	17	49.9	2,816	517,052	196,257	713,309	Miscible
D18	4	49.9	772	143,679	52,792	196,470	Miscible
D19	6	49.9	1,926	352,494	131,880	484,374	Miscible
D20	1	49.9	293	41,735	20,033	61,768	Miscible
D21	4	49.9	600	105,061	42,024	147,086	Miscible
D22	14	49.9	1,378	255,505	105,384	360,890	Miscible
D23	4	49.9	487	95,277	38,058	133,335	Miscible
D24	8	49.9	794	127,908	62,341	190,249	Miscible
D25	2	49.9	226	44,271	17,835	62,105	Miscible
D26	1	49.9	7	1,530	551	2,081	Miscible
D27	1	49.9				-	Failed

Table 3
The Result of CO_2-EOR Screening and Storage Determination (Continued)

Fields	Reservoir Number	Distance From Pendopo (Km)	Additional RF-EOR (MSTB)	CO_2 Storage UR (Ton)	CO_2 Storage EOR (Ton)	CO_2 Storage Total (Ton)	STATUS
15	**149**	**50-60**	**84,945**	**9,159,250**	**4,464,427**	**13,623,677**	
E1	1	51.2	11,106	950,598	288,936	1,239,534	Miscible
E2	11	51.7				-	Failed
E3	12	52	2,803	311,107	119,334	430,441	Miscible
E4	28	52.3	2	190	122	312	Miscible/Gas Reservoir
E5	5	53	392	37,168	8,287	45,455	Immiscible
E6	14	53.9	1,214	166,521	28,453	194,974	Immiscible/Gas
E7	1	55.6	338	114,559	10,415	124,974	Immiscible
E8	1	55.6	2,161	646,527	67,164	713,691	Immiscible
E9	1	55.7	1,608	170,219	68,428	238,647	Miscible
E10	4	55.7	11,520	1,157,207	443,334	1,600,541	Miscible
E11	5	55.7	14,640	1,982,704	576,654	2,559,358	Miscible
E12	12	56.2	8,605	617,269	658,957	1,276,226	Miscible
E13	26	56.2	23,274	2,718,784	1,795,629	4,514,413	Miscible
E14	22	56.2	6,649	208,282	382,221	590,502	Miscible
E15	6	56.6	633	78,115	16,493	94,608	Immiscible
9	**11**	**60-70**	**39,466**	**5,045,911**	**1,331,201**	**6,377,112**	
F1	3	62.8	906	80,684	30,887	111,571	Miscible
F2	1	64	1,370	10,290	58,024	68,314	Miscible
F3	1	65.7	3,109	391,098	168,842	559,940	Miscible
F4	1	66	5,350	652,229	213,118	865,347	Miscible
F5	1	66.8	16,931	2,114,509	508,499	2,623,008	Miscible
F6	1	66.8	2,904	751,300	83,608	834,908	Miscible
F7	1	66.8	3,528	379,243	100,307	479,550	Miscible
F8	1	66.8	702	83,762	20,776	104,538	Miscible
F9	1	66.8	4,666	582,796	147,140	729,936	Miscible
5	**11**	**70-80**	**36,239**	**7,305,064**	**1,317,322**	**8,622,386**	
G1	1	70.4	6,108	191,911	281,102	473,013	Miscible
G2	2	70.9	952	113,298	51,651	164,949	Miscible/Gas Reservoir
G3	1	73.6	529	47,445	18,978	66,423	Miscible
G4	3	73.8	28,650	6,952,410	965,590	7,918,001	Miscible/Immiscible
G5	4	76				-	Failed
8	**36**	**80-100**	**61,081**	**8,783,305**	**3,300,033**	**12,083,338**	
H1	9	82.5	19,243	1,573,711	738,725	2,312,435	Miscible
H2	1	83.6	6,453	1,377,820	288,609	1,666,429	Immiscible
H3	2	83.9	560	63,511	25,405	88,916	Miscible
H4	1	88	3,899	676,755	195,536	872,291	Miscible
H5	4	90.4	11,764	2,377,402	749,216	3,126,618	Miscible/Immiscible
H6	8	96.2	16,322	2,321,165	1,205,641	3,526,806	Miscible
H7	10	96.2	2,803	388,333	95,695	484,028	Miscible/Immiscible
H8	1	97.4	38	4,608	1,207	5,815	Immiscible
10	**44**	**>100**	**17,293**	**1,860,908**	**709,109**	**2,570,017**	
I1	2	111	2,546	418,717	156,033	574,750	Miscible
I2	15	139.7	11,842	808,055	391,080	1,199,134	Immiscible
I3	1	141.9	1,021	389,288	59,725	449,013	Immiscible
I4	8	145.3				-	Failed
I5	1	154.6	275	86,803	16,378	103,181	Immiscible
I6	1	190	1,571	154,538	85,459	239,996	Miscible
I7	4	390	38	3,507	436	3,943	Immiscible
I8	2					-	Failed
I9	2					-	Failed
I10	8					-	Failed
				TOTAL			
103	**581**		**480,465**	**69,891,999**	**22,211,293**	**92,103,292**	

in column 4, and CO_2 storage capacity at ultimate recovery is in column 5 and storage at EOR in column 6 while total storage in Column 7. The Status of EOR is (miscible, immiscible, and fail) mentioned in the last column.

From 103 fields they can be categorized as 18 fields immiscible, 77 miscible, 7 failed and 1 gas reservoir. Total incremental oil recovery from CO_2-EOR is approximately 480.5 MMSTB. While the total CO_2 storage is 92 MMton.

V. CONCLUSIONS AND RECOMMENDATIONS

The result of this study has actually given preliminary evaluations on the possibility of implementation of CO_2-EOR in South Sumatra Basin oil fields. Some conclusions and recommendation can be given as follows:

1. Based on CO_2-EOR screening in South Sumatra Basin oil fields, there are 77 reservoirs fulfilled the criteria of CO_2 EOR miscible, while 18 immiscible.
2. Total incremental oil recovery from CO_2-EOR is approximately 480.5 MMSTB.
3. CO_2 storage after ultimate recovery and EOR stages is around 92 MMton.
4. More detail data is needed to calculate the number of CO_2 consumption of each field for further analysis.
5. Further detail study should be carried out if CO_2-EOR project will be implemented soon.

REFERENCES

1. **Bachu, S., Bonijoly, D., Bradshaw, J., Burruss, R., Holloway, S., Christensen, H.P.** and **Mathiassen, O.M.** (2007) CO_2 storage capacity estimation: Methodology and gaps; Int. J. Greenhouse Gas Control, 1, 430-443.
2. **Bishop M. G.,** 2000, South Sumatra Basin Province, Indonesia: The Lahat/Talang Akar-Cenozoic Total Petroleum System, U.S. Department of The Interior U.S. Geological Survey, http://geology.cr.usgs.gov/energy/WorldEnergy/OF99-50S/province.html
3. **De Coster G. L.,** 1974, The Geology of the Central and South Sumatra Basins. In proceedings Indonesian Petroleum Association, Third Annual Convention, Jakarta, pp. 77 – 110.
4. **Taber J.J., Martin F.D., Seright, R.S.** 1977: "EOR Screening Criteria Revisited-Part 1: Introduction to Screening Criteria and Enhanced Recovery Field Projects", SPE Reservoir Engineering, Augustu, page 189-198.
5. **Taber J.J., Martin F.D., Seright, R.S.**1997: "EOR Screening Criteria Revisited-Part 2: Introduction to Screening Criteria and Enhanced Recovery Field Projects", SPE Reservoir Engineering, August.