PROCEEDINGS
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Preliminary CO_2 Project Implementation Priority with Multicriteria Analysis Approach using CO_2 Source-Sink Networking Models in Pertamina EP Fields

Reza Oktokilian Chon[1], Dadan DSM Saputra [2], Nurus Firdaus[2]
[1] PT Pertamina EP
[2] "LEMIGAS" R&D Centre for Oil and Gas Technology Ministry of Energy and Mineral Resources, Republic of Indonesia

Abstract

The needs of CO_2-Enhanced Oil Recovery (EOR) implementation in Indonesia become much more important as Indonesia have abundant sources of CO_2, while the state of national oil production declining from year to year. In this study, the ranking for various CO_2-EOR suitable field candidate which owned by Pertamina EP will be determined and can be used further to make priority for CO_2-EOR implementation.

The ranking is determined by using multicriteria analysis with scoring and weighting method based on modified EOR screening parameter such as API gravity, Remaining in Place, CO_2 single source's distance to the candidates, rate of CO_2 sources near the candidates, infrastructures, and CO_2 injection methods. Each parameter is shown with a number representing the assessed relative weight of that factor in comparison to other factors by using Pareto Chart. In the scoring and weighting analysis, each parameter was given the score of 5 (Class C), 3 (Class B), and 1 (Class A) with each parameter have different relative weight based on Pareto analysis that have been conducted. Then, the ranking can be determined from the total score from each parameter for every field candidate.

The results given by 24 selected field candidates give 5 Fields with high priority for CO_2-EOR. The high priority fields mainly influenced by remaining in place value and the availability of CO_2 source surrounding the fields. CO_2 source which have high CO_2 rate come from power plant with the average rate more than 3,000 tonnes per day, followed by Gas Plant and Fields which produce gas with high CO_2 content. From the results, it could be used as preliminary method to prioritize CO_2-EOR implementation project for Pertamina EP in Indonesia. However, this study has not yet considered the economic analysis which is very important to be conducted before CO_2-EOR project implementation.

Introduction

CO_2-EOR injection is one of the methods to enhance oil production through Enhance Oil Recovery (EOR) mechanism. As previous study stated, CO_2 injection in miscible state can increase oil recovery by 10 – 20 %, while in immiscible state, oil production can be improved by 5-15% (Kulkarni, 2003; Stalkup, 1978). As Indonesia have a lot of CO_2 source available from various industry, which includes oil and gas industry, and also national oil production keep declining (SKK Migas, 2018), CO_2-EOR injection is one of the priorities to be implemented in Indonesia to enhance oil production in mature oil fields.

With the abundance source of CO_2 spread throughout the country, the need to make a mapping for the potential CO_2 sources and the fields which suitable and prospective to be injected by CO_2 become much more substantial. For the pilot use, usually CO_2 needed is around 100 ton/day, commercial scale is around 100 – 300 ton/day and for full scale commercial scale is around 500 – 1000 ton/day (Bilhartz et al., 1978; Holm, 1982)

Pertamina EP as major national oil company in Indonesia have a lot of mature fields which already have been screened for EOR implementation suitability by their internal study (Pertamina, 2015). Several of them is suitable for CO_2-EOR injection implementation based on EOR screening from Taber et al (1997) and Al-Adasani (2010). However, the method to prioritize which field for CO_2-EOR project implementation have not been determined. The field priority list is important to be made as it will make the further development strategy for the fields to be more comprehensive in terms of enhancing oil production.

The purpose of this study is to analyze and make priority list of Pertamina EP's Fields which suitable for CO_2 injection based on multicriteria analysis approach using CO_2 source-sink networking models.

Methodology

Methodology for this study includes the parameter screening for CO_2-EOR, weighting parameter and scale determination, and the field priority list for preliminary CO_2-EOR project implementation in Pertamina EP's oil fields.

The screening parameter was using parameter used by Taber et al (1997) and Al-Adasani (2010) and modified with the needs for CO_2 project implementation in Indonesia as previously studied by Usman, et al. (2014). The screening criteria that was used as reference can be seen at Table 1.

Table 1: The technical screening guides for CO_2 – EOR (Taber, 1997)

	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 (especialy C_5 to C_{12})	
Reservoir :		
OOIP	>5 MMbbl, > 10 wells	
Oil Saturation, % PV	>20	15 to 70
Type of formation	Sandstone of Carbonate and relatively thin,unless dipping	
Average permeability	Not critical, if sufficient injection rates can be maintained	
For CO_2 miscible flooding	For miscible displacement, depth must be great enough to allow injection pressure greater then MMP, which increases with temperature, and for heavier oil.	
	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
For immiscible CO_2 flooding	13 to 21.9	1800
(lower oil recovery)	< 13	All oil reservoirs fail at any depth

The parameter used for this study is described as follows:

1. Remaining in-place
2. CO_2 flow rate
3. API Gravity
4. Injection Methods (Miscible, immiscible or near-miscible – based from MMP value)
5. CO_2 source distance
6. Infrastructure / facility

The list of fields which was used in this study was based from the internal study from Pertamina EP (2015) and can be seen at Table 2.

Table 2: Fields Candidate for CO_2-EOR (Pertamina)

No.	Candidate Structure	No.	Candidate Structure
1	XA	13	XM
2	XB	14	XN
3	XC	15	XO
4	XD	16	XP
5	XE	17	XQ
6	XF	18	XR
7	XG	19	XS
8	XH	20	XT
9	XI	21	XU
10	XJ	22	XV
11	XK	23	XW
12	XL	24	XY

Each parameter used for the screening then was divided into three different class (Class A, Class B, and Class C) which gives different score for each class. Class A gives score of 1, Class B gives score of 3, while Class C gives score of 5. The full detail of the screening parameter for each class can be seen at Table 3.

Table 3: Classification Parameter

Parameter	Class A	Class B	Class C
API Gravity	< 30	30 - 35	> 35
Injection Method	Immiscible	Near Miscible	Miscible
Remaining In-Place	< 100 MMSTB	100 - 200 MMSTB	> 200 MMSTB
Nearest CO2 Source Distance	> 100 km	50 - 100 km	< 50 km
Infrastructure	Offshore, Far from CO2 Source	Onshore, Far From CO2 Source	Onshore, Close to CO2 Source
CO2 Flow Rate	< 10,000 TPD	10,000-20,000 TPD	>20,000 TPD

Each parameter also had the scoring weight which vary from 0.1 to 0.25 which illustrated the significance between one parameter to the others. The weighting scale used in this study was based on the survey conducted by LEMIGAS regarding these parameters to the professionals which have expertise in EOR sector. Total of 40 persons become respondent of the survey to determine the significance of each parameter toward the others.

Based on those parameters, the priority field for CO_2 implementation could be determined by ranking the fields based on the total score which could be done by summing each parameter's score for each field. From these results, the fields then were sorted from highest score to lowest score to make the preliminary CO_2 project implementation priority in Pertamina EP.

Result and Discussion

The weighting score which was gained from the expertise correspondence survey then was analyzed by making Pareto Chart of the weighting parameter. The pareto chart of the survey can be seen at Figure 1.

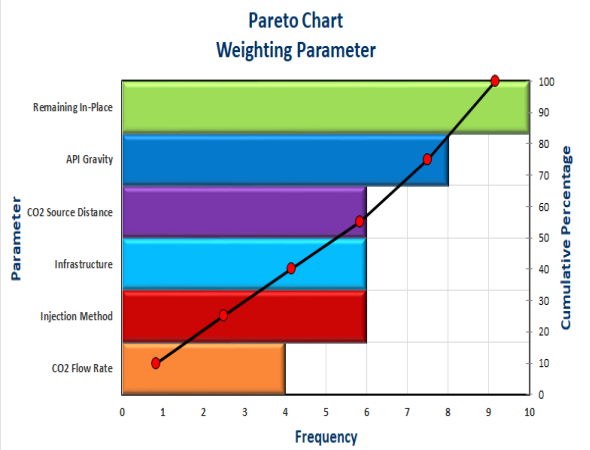

Figure 1: Pareto Chart Weighting Parameter

From the Chart above, it can be seen that the most impacting parameter in the screening parameter is the Remaining in Place (25%), followed by API Gravity (20%), injection methods, source distance, infrastructure (15%), and the least parameter of CO_2 flow rate (10%). The weighting scale result can be seen at Figure 2. The remaining in place gives the highest weighting scale because the it will give the best outcome from the CO_2 injection and more oil to be produced from CO_2 injection.

The result of the scoring and ranking of the Pertamina EP's fields based on the parameters in Table 3 can be seen at Table 4.

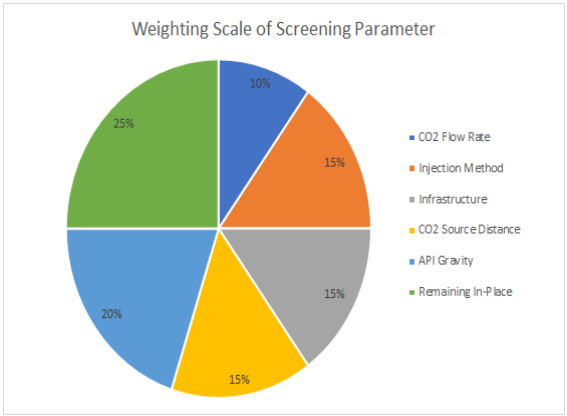

Figure 2: Weighting Scale of Screening Parameter

Table 4: Priority List of CO_2 Project Implementation

No.	Candidate Structure	Total Score	Priority Class
1	XF	4.5	High
2	XY	4.5	High
3	XB	4	High
4	XA	4	High
5	XL	4	High
6	XG	3.8	Moderate
7	XR	3.7	Moderate
8	XH	3.7	Moderate
9	XK	3.6	Moderate
10	XD	3.6	Moderate
11	XC	3.6	Moderate
12	XV	3.4	Moderate
13	XE	3.4	Moderate
14	XN	3.3	Moderate
15	XI	3.1	Moderate
16	XQ	3.1	Moderate
17	XO	2.9	Moderate
18	XJ	2.9	Moderate
19	XM	2.7	Moderate
20	XP	2.7	Moderate
21	XW	2.6	Moderate
22	XT	2.2	Low
23	XU	2.1	Low
24	XS	2	Low

From Table 4, it can be seen that most of the fields which become the highest priority still have higher remaining in-place and also higher in-place. It was because from the weighting parameter of the criteria used in this study, field with higher in place and remaining reserves is preferable to be injected with CO_2-EOR method. It also inferred that it will give better outcome of oil production and profit to the

contractor than the fields which have in place in middle to low range of volume. The chart in Figure 3 also showed that 5 of the highest priority fields still have high remaining oil in place which will give better oil incremental result.

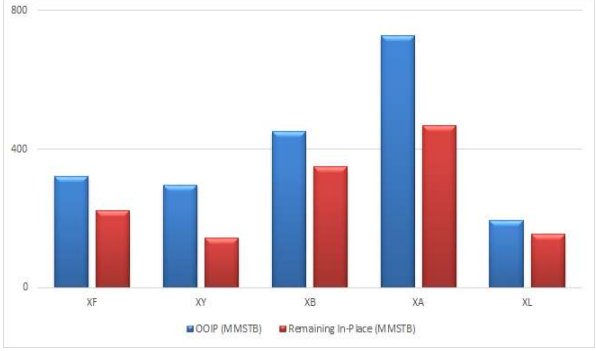

Figure 3: Priority Fields' OOIP and Remaining in Place

The results given by 24 selected field candidates give 5 Fields with high priority for CO_2-EOR. The high priority fields mainly influenced by remaining in place value and the availability of CO_2 source surrounding the fields. CO_2 source which have high CO_2 rate come from power plant with the average rate more than 3,000 tonnes per day, followed by Gas Plant and Fields which produce gas with high CO_2 content. From the results, it could be used as preliminary method to prioritize CO_2-EOR implementation project for Pertamina EP in Indonesia. However, this study has not yet considered the economic analysis which is very important to be conducted before CO_2-EOR project implementation.

Conclusions

- From 24 candidate fields, there are 5 fields that give the highest score which is become preliminary CO2 project implementation priority fields in Pertamina EP. The candidate fields are XF, XY, XB, XA, and XL which all located in Pertamina EP Asset Area.
- The screening, scoring and weighting parameter are useful for determining the preliminary EOR project implementation priority not only in Pertamina EP's fields but also for another fields in Indonesia
- Further economic analysis must be done to improve the results from the preliminary implementation priority study to further analyze the feasibility of the EOR project.

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Acknowledgements

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