PROCEEDINGS
JOINT CONVENTION YOGYAKARTA 2019, HAGI – IAGI – IAFMI- IATMI (JCY 2019)
Tentrem Hotel, Yogyakarta, November 25th – 28th, 2019

Source-Sink Matching for CO_2-EOR Application with Network Clustering Methods in Pertamina EP Fields

Nurus Firdaus[1], Reza Oktokilian Chon[2], Dadan DSM Saputra[3]
[1,3] "LEMIGAS" R&D Centre for Oil and Gas Technology Ministry of Energy and Mineral Resources, Republic of Indonesia
[2] PT. PERTAMINA EP

Abstract

Mostly oil and gas fields in Indonesia in mature conditions with a very large remaining reserve requiring EOR (Enhanced Oil Recovery) technology to increase national oil and gas production. The alternative injection method in EOR is to use CO_2, where Indonesia has abundant potential and its application can help the greenhouse effect management program by the government. This study aims to determine the priority single pair between CO_2 source and three PT Pertamina EP field candidates/sink with network clustering and systematic multiparameter comparison method. Clustering is conducted by making buffers as far as 100 Km and 200 km. Consideration of source-sink matching is determined by the daily CO_2 rates, CO_2 removal facilities, source-sink distance, alternative sources, and infrastructure. Result shows that the sink F6 has the highest priority among the other two with CO_2 source from gas plant S98 which have CO_2 removal and CO_2 rate between 5.000-10.000 t/d, other alternative sources from power plant S21 and gas plant S99 that has rate at the same range. The detail economic and sub-surface condition are not considered, thus becoming a limitation in this study.

Introduction

Oil and gas fields in Indonesia are mostly in mature conditions which causes a natural decline in production. Based on existing data, the average decline in oil lifting during 2012-2017 reached 1.35% [1]. The decrease caused by several problems in optimizing oil and gas lifting included operational factors and subsurface conditions. On the other side, more than 50% of initial oil / gas volume estimated (> 35 billion barrels of oil) remains below the surface [2]. This condition is also coupled with a significant increase in oil consumption in the future, so EOR (Enhanced Oil Recovery) technology is needed to increase national oil and gas production. Utilization of EOR technology is currently limited to steam-flooding and water flooding technology. This is due to differences in the characteristics of wells or fields, so it is necessary to know suitable technology to test the feasibility of technology. The alternative EOR injection method is using CO_2, where Indonesia has abundant potential sources.

CO_2 contribution from oil and gas sector is estimated to reach 137 Mt CO_2 per year by 2030 from 122 Mt CO_2 in 2005 [3]. CO_2 emissions sources in oil and gas sector are from upstream facilities, including gas flaring, associated product with natural gas, gas processing facilities, and various combustion equipment used in oil and gas exploration and production activities.

In order to assist the government's commitment in reducing greenhouse gas emissions, this study was conducted with the aim of helping increase national oil and gas reserves. The technology of carbon capture, absorption and storage is very important for energy sector reserves and atmospheric carbon stabilization technology [4]. The advantage for the industry is to assist in strategic development for greenhouse gas problems, while oil companies can identify CO_2 sources for economical EOR applications or identify natural CO_2 storage for CO_2 supply security [4].

PT Pertamina EP as a national oil and gas company has the potential in CO_2 EOR application with many managing mature fields. The problem in CO_2 EOR application because the source and target have not been properly mapped. Optimization in selection of the source and target pairs of CO_2 is needed to obtain effectiveness both technically and economically. Further development planning will be easier to do because of the availability of sufficient data to determine development priorities.

Data and Method

This study aims to map the priority of a single pair between CO_2 sources and field candidates or sinks managed by PT. Pertamina EP with consideration of sources-sink matching. Previous studies have carried out a screening process by PT Pertamina EP on suitable fields for CO_2-EOR applications with some potential sources of CO_2 that can be utilized. This study only selected 3 sink or field candidates from the previous study [2] which will determine priority of the single source pair from several potential sources in the cluster. CO_2-producing sources that are considered to have great potential are oil and gas wells, refineries, gas plants, flares, power plants and industry [5] [6]. Types of industries collected are the fertilizer, cement, steel / metal, ceramic, pulp and paper industries.

Method in the study uses cluster network mapping. This method maps potential CO_2 sources at a radius of 100 km to 200 km from the sink. then an analysis of the availability of CO_2 was conducted for each single source with the nearest distance. The analysis will determine a single pair that can be implemented as the CO_2 source of the selected sink.

The database of source-sink in network clusters is based on geographic information systems (GIS) to provide space for the addition and development of dynamic information. Its organized collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information [7]. GIS is a logical choice for a system to house the CO_2 source and sink data, it could visually display spatial relationships and perform queries and screening analysis with ease [4].

The initial process in GIS is inputing data plots of source and target location coordinates, digitization and management of table data information on the map. Analysis process for the network clustering method starts with a buffer process that is divided into 2 clusters to limit the network between source and sink, within radius of 100 km and 200 km. Distance analysis is a geographical analysis based on the relationship between objects in distance units. This stage helps in analyzing the nearest distance to optimize the distribution of CO_2 from the source to the sink to be injected. The result of quantity analysis is the grouping of objects based on parameters that have a certain value.

Furthermore, prioritizing the source-sink pair is determined by multi-parameter comparison, in the form of Original Oil in Place (OOIP) data, daily CO_2 total rate from multiple sources, availability of CO_2 removal at source, distance of candidate sources, alternative sources of CO_2, and the infrastructure included is the availability of the Pipeline network. The flow chart for the study is shown in the following figure 1.

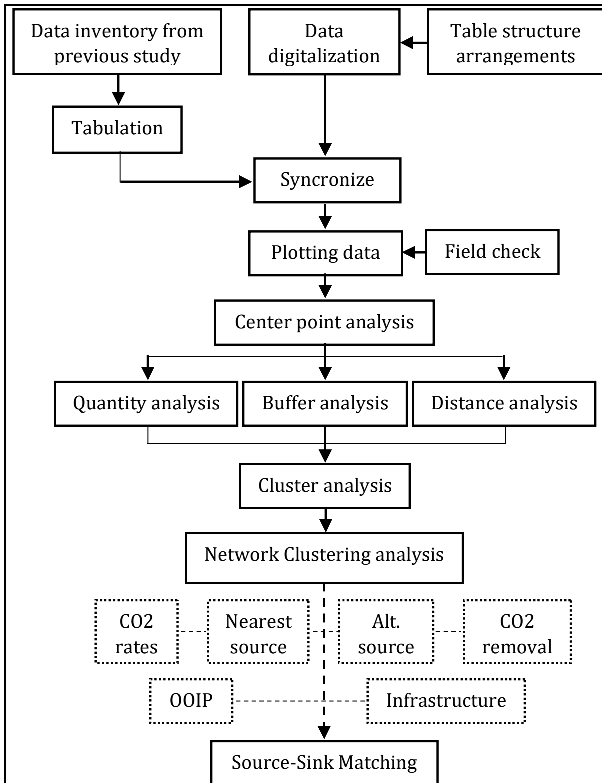


Figure 1: Source-sink mathcing flow diagram

Result and Discussion

Screening results of previous studies by PT. Pertamina EP and LEMIGAS is determined by 24 candidate structures / targets that are characteristically suitable to be applied by CO_2-EOR technology in Java and Sumatra [2]. However, from 24 structures only known total CO_2 sources potential within a radius up to 200 km. Not yet known the single potential of a CO_2 source that suitable for EOR application.

Input results in this study obtained a distribution of CO_2 sources of more than 150 locations for 24 sinks / target shown in figure 2. However, this study was only discussed for 3 sinks which were considered to have high compatibility in previous studies, namely sinks F2, F6 and F23.

Network clustering shows that for F2 sinks in clusters 100 km radius has 17 potential CO_2 sources network, while for 200 km has 28 potential CO_2 sources. F6 sinks in the 100 km and 200 km cluster sequentially are 27 and 58 potential, while F23 sinks are 18 and 30 potential respectively. But in terms of quantity for field scale applications not all meet, so it is necessary to do a selection. Each sink has a potential CO_2 source according to the minimum requirement of 2500 t / d in the 100 km cluster of 3, 3 and 2 potential sources. The number of potential sources for each sink is shown in Figure 4 while the potential distribution is shown in Figure 5.

Figure 2: CO_2 Source Distribution Map

Results of distance analysis show that the nearest distance of source in a straight line from F2, F6 and F23 is approximately 35, 45 and 30 km, respectively. Quantity analysis distinguishes groups based on OOIP value, CO_2 rate and nearest distance. Based on cluster analysis, all three sinks have a potential CO_2 rate more than 15,000 t / d, which means that it is sufficient to meet CO_2 requirements on a field scale. For larger demonstration project scale, it requires CO_2 source of 500–2,500 t / d CO_2 [5], so that on field scale requires greater CO_2 support. Comparisons of each sink for OOIP and rate single source shown in the following figures 3.

Source-sink matching is used to see the potential of a single source with nearest distance in meeting EOR injection needs. It's mainly due to the economic reasons for the high cost of developing CO_2-EOR technology facilities. Parameter comparison table of each sink shown in table 1, while the results of sink-source matching to get a single pair are shown in figure 6.

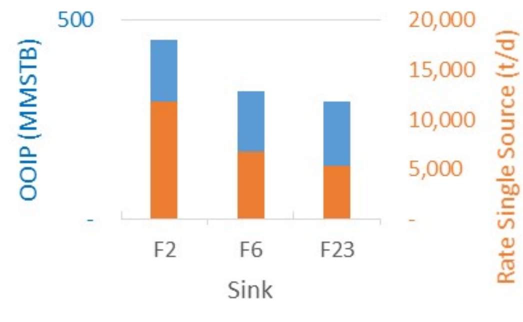


Figure 3: OOIP and Rate Single Source

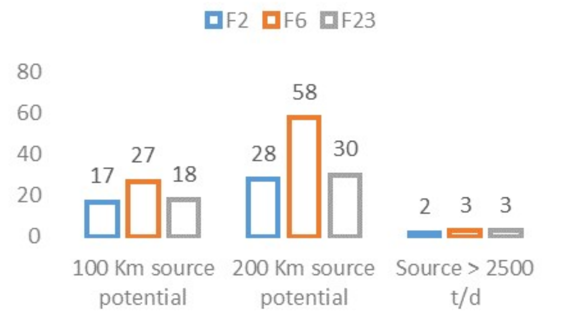


Figure 4: CO_2 Potential Source for each sink

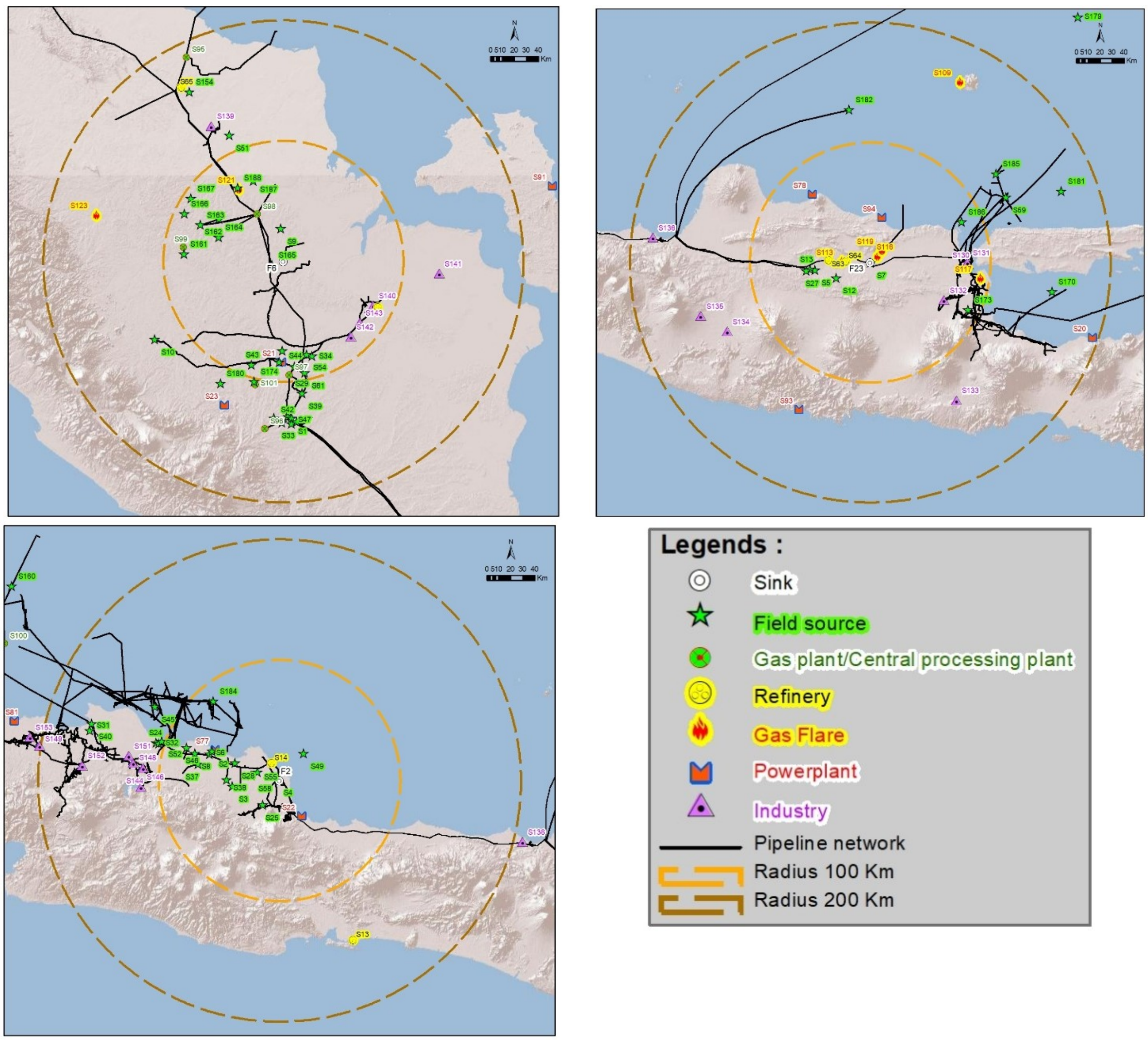


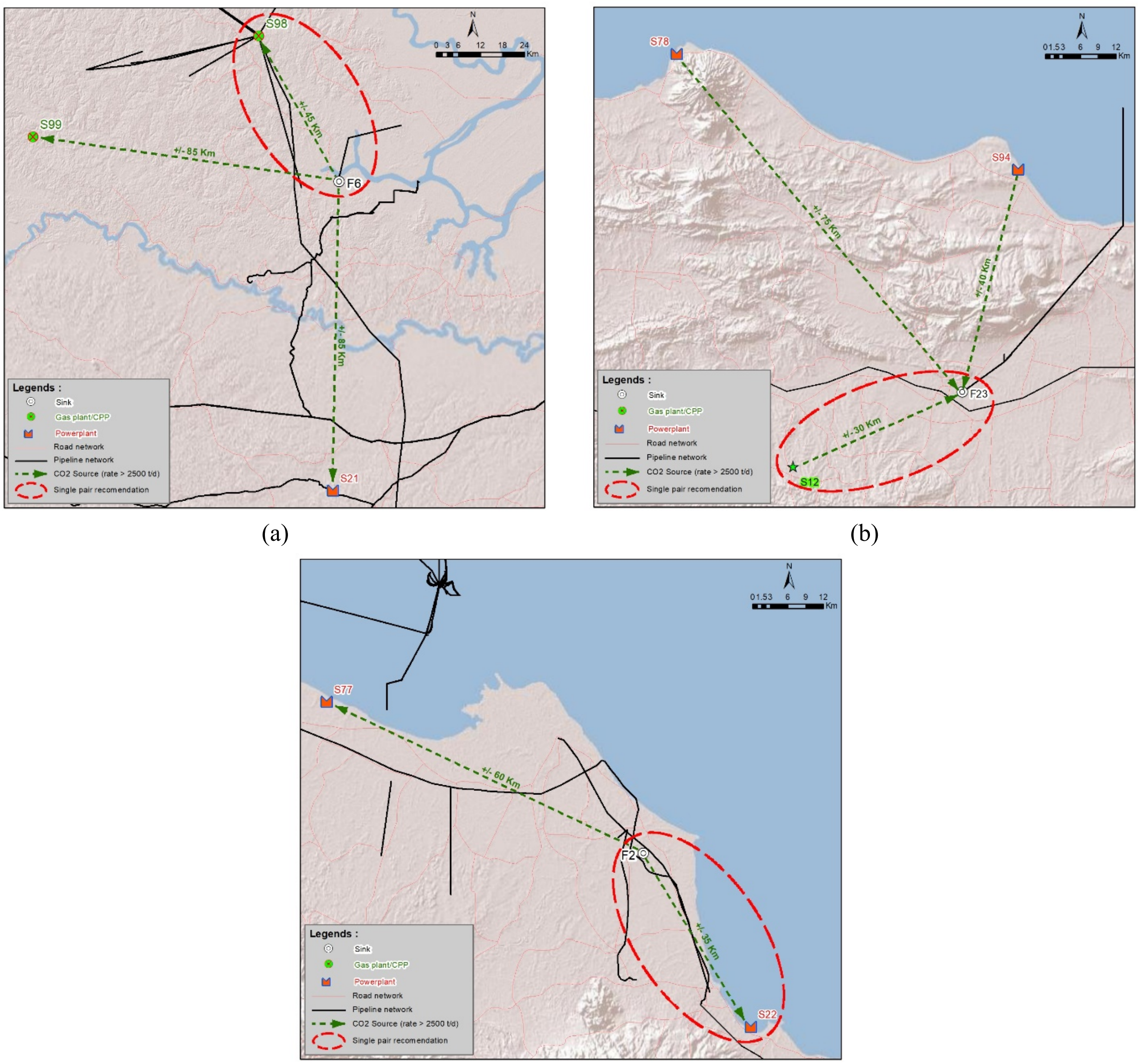
Figure 5. Potential CO_2 source distribution for each sink

Based on analysis, the F6 sink has the highest potential to be developed especially because the single source selected is a gas plant with CO_2 removal facilities, so it will be more economically developed than the other.

Although it has a single source rate in the range of 5,000 - 10,000 t/d and the total CO_2 rate is less than 20,000 t/d but it is enough to be injected. The distance of ± 45 km is considered still feasible as a distribution path either through pipes or using truck. This

Table 1. Parameter comparison for network clustering

No.	Sink	OOIP (MMSTB)	Total Rate CO2 Potential (TPD)	CO2 Removal	Nearest CO2 Source	Rate Single Source (TPD)	Nearest Distance (Km)	Alternative Source	Infrastructure
1	F6	> 300	10.000 - 20.000	Available	Gas Plant S98	5.000 - 10.000	± 45	Gas plant S99	Available
2	F23	100 -300	> 20.000	N/A	Structure S12	5.000 - 10.000	± 30	Power plant S94	Available
3	F23	> 300	> 20.000	N/A	Power plant S22	10.000 - 20.000	± 35	Power plant S77	Available



(a) (b) (c)

Figure 6. Single pair recommendation for each sink (a) Sink F6; (b) Sink F23; (c) Sink F2

structure also has the advantage of two alternative sources with distances below 100 km, powerplant S21 that has a rate at the same range or an S99 gas plant, so it will be easier if there is an increase in CO_2 requirements.

Sink F23 has a similar character with sink F6, but does not have CO_2 removal and has the advantage of nearest single source among the other. Sink F23 is also located on dense island where infrastructure and development will be better. In addition, the disadvantages of this sink are having the smallest OOIP value between the two other sinks.

Another sink, F2 has OOIP and good CO_2 rate which is> 300 MMSTB and> 20,000 t/d. Match single pair is the power plant S22 which is ± 35 km distance with a single rate greater than the other 2 sinks, but lack of this sink is same type of alternative source and does not have CO_2 removal.

Conclusions

These three sinks have sufficient requirements for the application of CO_2-EOR. Requirements in terms of sub-surface were conducted in previous studies. This study shows more considerations from surface, especially the distance between single partners, the existence of alternative CO_2 sources, facilities and infrastructure.

This study still considers straight distances with flat terrain, so further analysis is needed to determine more economical transportation modes. Costs analysis must be considered slope of terrain, the bypassed protected areas such as urban areas and national parks and crossing of rivers, railways or highways [6] and it will deepen development priority analysis.

Economic parameters and sub-surface conditions in detail are not considered, thus becoming a limitation in this study. However, this study can help in planning the development of CO_2-EOR technology from the surface. Packaged data based on geographic information systems will be very helpful in making decisions both for CO_2-EOR applications or the development of other EOR technologies that relate to sources-sinks that have collected data. The strength of GIS in displaying data visually, analytical skills, and development flexibility is a goal in meeting industry and government needs to support effective carbon management strategies [4].

References

[1] Direktorat Jenderal Minyak dan Gas Bumi. 2018. *Laporan Kinerja Direktorat Jenderal Minyak dan Gas Bumi Tahun 2017*. Direktorat Jenderal Minyak dan Gas Bumi – KESDM. Jakarta.

[2]PPPTMGB "LEMIGAS". 2018. *Laporan Final Studi Pemetaan Potensi Implementasi Injeksi CO_2 di Indonesia*. PT. PERTAMINA EP. Jakarta. Tidak dipublish.

[3]Program Dukungan Rendah Karbon. 2015. *Opsi Kebijakan Fiskal dalam Mempromosikan Penyerapan dan Penyimpanan Karbon pada Industri Minyak dan Gas di Indonesia*. Program Dukungan Rendah Karbon - Kementerian Keuangan. Indonesia.

[4] Dahowski, R., Dooley, J., Brown, D., Mizoguchi,A, Shiozaki, M. 2001. *Understanding Carbon Sequestration Options in the United States: Capabilities of a Carbon Management Geographic Information System*. Proceedings of the First National Conference on Carbon Sequestration, Washington, DC, May 2001.

[5] Usman, Utomo P. Iskandar, Sugihardjo, Heru Lastiadi S.2014. *A Systematic Approach to Source-Sink Matching for CO_2-EOR and Sequestration in South Sumatera*. Energy Procedia 63 (2014) 7750 – 7760. Science Direct.

[6] Chen, Wenying., Huang, Lingyan., Xiang, Xing., Chen, Jiyong., Sun, Liang. 2011. *GIS based CCS Source-Sink Matching Models and Decision Support System*. Energy Procedia 4 (2011) 5999–6006. Science Direct.

[7] ESRI. 1990. "*Understanding GIS : The Arc/ Info Method Environmental System*, Research Institute, Redlands, California.

Acknowledgements

This study was supported by the National Oil & Gas Company, PT. Pertamina EP and Indonesia Research & Development Centre for Oil & Gas Technology "LEMIGAS".