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DOI
10.2139/ssrn.3366212

Publication date
2018

Document Version
Final published version

Citation (APA)
Yañez, E., Ramirez, A., Núñez-López, V., Castillo, E., & Faaij, A. (2018). *Exploring the potential of CO_2-EOR as a mitigation strategy in the Colombian oil value chain*. Paper presented at 14th International Conference on Greenhouse Gas Control Technologies, GHGT 2018, Melbourne, Australia. https://doi.org/10.2139/ssrn.3366212

14th International Conference on Greenhouse Gas Control Technologies, GHGT-14

21st -25th October 2018, Melbourne, Australia

Exploring the potential of CO_2-EOR as a mitigation strategy in the Colombian oil value chain.

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Abstract

CCS is considered a primary strategy to curb CO_2 emissions. In many models, CCS is an essential technology to meet the 2°C target [1]. Drastically reducing GHG emissions in the oil and gas industry will be needed to reach the 2°C target as this industry is one of the five most energy and GHG intensive sectors [2]. The implementation of CCS technologies has been widely studied for the refining stage of the oil value chain. According to Berghout et al. [3], between 80 to 90% of GHG emissions in the refining industry could be reduced using CCS. However, the cost involved for its implementation, make it an unattractive pathway. CO_2-EOR is currently a promising alternative to reduce CCS costs [4], and would be able to produce an oil with low-associated emissions during its recovery. This paper aims to estimate the techno-economic potential of CO_2-EOR for reducing GHG emissions in the Colombian oil industry. For this purpose, the supply and demand of CO_2 is studied by including the CO_2 capture potential of the oil industry, cement, power generation and bioethanol, as well as the storage potential of CO_2 through the oil recovery miscible process. The state-owned oil company Ecopetrol S.A. was taken as a case study, which represent the oil value chain in Colombia, with about 70% of crude oil produced and 100% of oil transported and refined in the country. A total of 193 Mt CO_2 between 2025 and 2040 could be stored through CO_2-EOR. As the projected emissions of the oil and gas industry in Colombia from 2010 to 2040 are estimated at 570 Mt CO_2 [11], this is equivalent to a potential 34% reduction in CO_2 emissions. This mitigation represents approximately 20% of the total reduction under the INDC target for the period 2025 to 2030.

Keywords: Oil industry; Enhanced oil recovery; Carbon capture utilization and storage (CCUS); CO_2 mitigation; Sink-source matching

1. Introduction

Colombia is committed to reducing its GHG emissions by 20% with respect the BAU scenario of 2010 by 2030 [5]. The country accounts for around 0.4% of the global emissions, but it ranks in the 33rd position (out of 180) regarding risk to climate change and 66 (out of 182) regarding vulnerability. Colombia is a net exporter of fossil fuels.

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According to [6] in 2015, Colombia energy production was 5.3 EJ with a final consumption of just 1.1 EJ as a result of a net export of 1.6 EJ of oil and 2.1 EJ of coal. In Colombia, specific targets and technological strategies in the petrochemical sector have not been set. As the country is still committed to keep oil production, CO_2 enhanced oil recovery (CO_2-EOR) has started to be considered as an option that could also contribute to the total reduction of emissions in the industry.

Although still new in Colombia, CO_2 injection for incremental oil recovery has commercially been done for decades worldwide. Since 1972, the United States has injected around 900 Mt CO_2 in more than 7,000 injection wells, using a pipeline network of 6,500 km to transport 57 Mt CO_2 [7]. Godec et al.[8], estimate a global storage potential of 140 Gt CO_2 with a total CO_2-EOR oil recovery of around 470 Gbbl. The IEA [9] estimates that by 2050, a cumulative of 60, 240 and 360 Gt CO_2 could be stored through conventional, advanced EOR+ and maximum storage EOR+ processes, respectively. In both studies, the storage potential through CO_2-EOR exceeds the IEA 2DS cumulative storage requirements which are around 120 Gt CO_2. Despite the potential the significance of CO_2-EOR as mitigation option for the Colombian oil industry, there is knowledge lacking on the option. This paper aims to make a first estimate of the techno-economic potential of CO_2-EOR for reducing GHG emissions in the Colombian oil value chain. For this purpose, the supply and demand of CO_2 is studied by including the CO_2 capture potential of the oil industry value chain and others relevant sectors, as well as the storage potential of CO_2-EOR.

2. Methodology

This study follows four main steps: 1) inventory of CO_2 industrial sources suitable for CO_2-EOR projects in Colombia, 2) identification of potentially suitable oil fields for CO_2 injection and estimation of the CO_2 storage potential in EOR projects, 3) matching of sources and sinks taking into account technical and economic constraints, and finally, 4) analysis of the potential impact of CO_2-EOR on the oil industry and national emissions in Colombia.

The CO_2 inventory for the oil industry included the two largest refineries in the country taking as potential sources the hydrogen production, catalytic cracking, and cogeneration process as well as the three largest oil production facilities. From the cement sector, eight clinker production plants were included, due to their proximity to the oil fields. In addition the inventory included 28 power generation units as well as 7 bioethanol plants. CO_2 emissions data for the oil industry were obtained from the Ecopetrol emissions inventory, which uses a bottom-up approach with measurements at the process unit level. For the other industrial sectors, public reports were used and emission factors were applied to estimate the CO_2 emissions for each processing plant and industrial group. A stochastic estimate of the CO_2 storage potential was conducted using results from a quick-look screening methodology to identify amenable oil fields for CO_2-EOR in Colombia. This study modifies and use the quick-assessment methodology proposed by [10]. From a total of 410 oil production fields in Colombia in 2017, 77 were selected for further screening. Note that only oil fields with OOIP greater than 50 million barrels were included, which is a minimum requirement by the Ecopetrol reservoir department for analysis of prospective projects. The CO_2 capture potential was calculated using capture efficiency values reported in the literature for each industrial CO_2 source. The matching of sources and sinks was carried out by identifying four geographical regions defined by the presence of CO_2 sources and potential sinks at distances below 150 km and where there was infrastructure available such as transport routes and gas pipelines. A group of potential matching scenarios was developed based on a feasibility rank created by following criteria such as: distance, type of industrial source, capture feasibility, CO_2 volume, infrastructure, CO_2 cost (capture, transport and injection), and CO_2 storage potential.

The impact of the reduction of CO_2 emissions in the oil industry through the CO_2-EOR scenarios was estimated as the share of CO_2-EOR in the projection of emissions from the sector to 2040, as well as the emissions reduction target established by Colombia in 2030 through the Intended Nationally Determined Contributions (INDC)[5].

3. Results

In Colombia, CO_2 emissions from industry, transport and energy generation account for 40% of total emissions It was estimated that there are about 18 Mt CO_2 per year that could be considered for capture processes and subsequent use in EOR projects. From the initial screening of oil fields, it was estimated that about 18% would be eligible to implement recovery projects. Only 16 oil fields were selected as potentials reservoir to deploy CO_2-EOR projects. A total recovery potential of 736 Mbbl of crude oil and a storage potential of 302 Mt CO_2 was calculated for the selected oil fields using the stochastic method. Figure 1 shows the cost per bbl as compared with the reference oil price for the different source-field pairs examined in this study. CO_2 mitigation potential for the oil industry was estimated considering CO_2-EOR projects with production costs equal to or lower than the price of crude oil would be implemented from 2025 on, and that, after 2030 projects with higher cost would deployed (assuming leverage fund). A total of 193 Mt CO_2 between 2025 and 2040 could be stored through CO_2-EOR . As the projected emissions of the oil and gas industry in Colombia from 2010 to 2040 are estimated at 570 Mt CO_2 [11], this is equivalent to a potential 34% reduction in CO_2 emissions. See Figure 2.

In the scenario discussed above, any potential revenue from storing the CO_2 during EOR operation was neglected. In current work, scenarios are being explored that take into account potential revenues for oil operators from co-storing CO_2 in the fields. This can potentially change the life of operation as well as the selection and operation of fields.

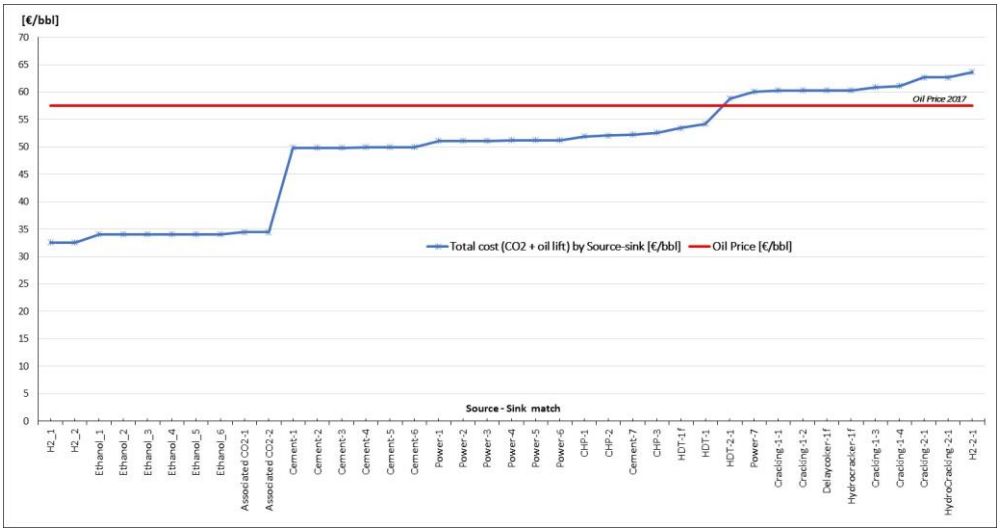

Figure 1. CO_2 Cost per barrel of oil compared with the oil price. (including capture, transport and injection of CO_2 and oil lifting cost).

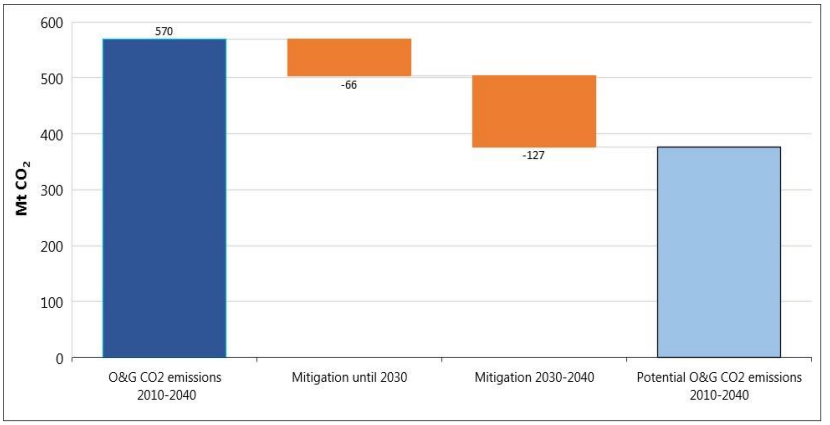

Figure 2. Potential CO_2 emissions reduction in the oil industry through CO_2-EOR.

References

[1] IPCC. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. 2014.

[2] IEA. Energy Technology Perspectives 2014. Paris: 2014. doi:10.1787/energy_tech-2014-en.

[3] Berghout N. Deployment pathways for decarbonizing industry and electricity generation. University of Groningen, 2015.

[4] Koelbl BS, van den Broek MA, van Ruijven BJ, Faaij APC, van Vuuren DP. Uncertainty in the deployment of Carbon Capture and Storage (CCS): A sensitivity analysis to techno-economic parameter uncertainty. Int J Greenh Gas Control 2014;27:81–102. doi:10.1016/j.ijggc.2014.04.024.

[5] UNFCC. Colombia's INDC - UNFCC. 2015.

[6] IEA. Key world energy statistics. 2017. doi:10.1017/CBO9781107415324.004.

[7] Hill B, Hovorka S, Melzer S. Geologic Carbon Storage Through Enhanced Oil Recovery. Energy Procedia 2013;37:6808–30. doi:10.1016/j.egypro.2013.06.614.

[8] Godec M, Kuuskraa V, Van Leeuwen T, Stephen Melzer L, Wildgust N. CO2 storage in depleted oil fields: The worldwide potential for carbon dioxide enhanced oil recovery. Energy Procedia 2011;4:2162–9. doi:10.1016/j.egypro.2011.02.102.

[9] International Energy Agency (IEA). Storing CO2 through enhanced oil recovery. 2015.

[10] Nuñez-López V, Holtz MH, Wood DJ, Ambrose WA, Hovorka SD. Quick-look assessments to identify optimal CO2 EOR storage sites. Environ Geol 2008;54:1695–706. doi:10.1007/s00254-007-0944-y.

[11] Universidad de los Andes, PNUD, Colombia EM of. Productos Analíticos para Apoyar la toma de decisiones sobre acciones de mitigación a nivel sectorial oferta de Energía: Generación Eléctrica, Petróleo, Gas y Carbón. Bogotá: 2014. doi:10.1017/CBO9781107415324.004.