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Follow-Up Study to Abate Carbon Emissions in Jack Up Rig Operation in East Java Area, Indonesia

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Abstract

Nowadays, offshore drilling operations are still rare to record the number of carbon emissions, primarily from fuel combustion. This paper provides the guideline to measure the quantity compared with production routine activities and how to abate the emission to focus on drilling activities. On the other hand, the legislative requirement might be emphasized to support the recent Glasgow Climate Pact at COP26 in November 2021 to keep the hope of limiting global temperature to 1.5˚C.

Carbon emissions are analyzed based on the API Compendium of Greenhouse Gas Emission Methodologies for The Oil and Natural Gas Industry (2009). The authors provide practical equations to implement in offshore drilling activities to estimate carbon emission of CO2, N2O, and CH4 from stationary combustion of rig engines and marine vessels. SANGEA™ Software as a GreenHouse Gas (GHG) emissions calculation tool owned by the American Petroleum Institute (API), will be used to support this study.

Based on actual fuel consumption data at Field X from September 2021 until June 2022, total carbon emissions from Jackup rigs and marine vessels in drilling operations were calculated at 2,404 tons CO2e/ month or 27 % compared with total emissions from routine production activities at Field X at 6,522 tons CO2e/ month. This data will continually drive well engineering and operations optimization from drilling activities to abating carbon emissions.

This follow-up study will be continued and expanded in other drilling activities to obtain more data sets for further analysis to boost efforts in supporting Net Zero Carbon Emission aspirations in the oil and gas industry.

Keyword(s): Drilling Emission, Jack Up Rig, GHG Mitigation

1 Introduction

The Intergovernmental Panel on Climate Change Article 5 (2014) defined *climate change* as a change of the climate that can be identified by changes in the mean or the variability of its properties and that persists for an extended period of decades or longer. These changes can be caused by human activities that alter the atmospheric composition and climate variability attributable to natural causes.

GHGs are gasses that absorb and emit radiant energy within the infrared range. Gasses are quantified based on their Global Warming Potential (GWP) against a reference of carbon dioxide according to the API GHG Compendium (2009), with units of tonnes of carbon dioxide equivalent (CO2e). The Compendium also provides emissions estimation methods for 6 (six) classes of GHGs (CO2, CH4, N2O, SF6, HFCs, and PFCs). Of these six, only 3 GHGs are significant to the oil and gas industry: carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O).

For the Fourth Assessment Report of the Intergovernmental Panel on Climate Change in 2017, Working Group 1 on the physical sciences listed common GHGs, as per the GHG Protocol, along with their respective GWP100 (100-year global warming potential), as summarized in Table 1. The impact of GHGs is typically reported as tonnes of carbon dioxide equivalent (tCO2e) to compare the emissions from various greenhouse gasses based on their Global Warming Potential (GWP). For example, 1 (one) tonne of CH4 equals 25 tonnes CO2e.

Table 1. List of GHGs and Global Warming Potential (Source: Table TS2 Page 33-34, Climate Change 20017: The Physical Sciences, Working Group 1 Contribution To The Fourth Assessment Report Of The Intergovernmental Panel On Climate Change)

GHG	Chemical Formula	GWP_{100} (tonnes)
Carbon Dioxide	CO_2	1
Methane	CH_4	25
Nitrous Oxide	N_2O	298
Hydrofluorocarbons	HFCs	12 – 14,800
Perfluorocarbons	PFCs	7,390 – 12,200
Sulphur Hexafluoride	SF_6	22,800
Nitrogen Trifluoride	NF_3	17,200

As for emission scopes as explained in The Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions, 2nd Edition (2011), there are 3 (three) categories that have been established as follows:

A. Scope 1 (Direct Emissions)
   This scope is from sources where the reporting company has operational control. The company typically accounts for and reports all direct GHG emissions at operations with operational control.
B. Scope 2 – Indirect Emissions
   Scope 2 emissions are indirect emissions resulting from the consumption of purchased energy from a third party i.e. electricity, steam, cooling or hot water.
C. Scope 3 – Other Indirect Emissions
   Scope 3 emissions are other types of indirect emissions that are not related to purchased energy (Scope 2). The sources shall only be accounted as Scope 3 emissions after demonstrating that the company has no operational control over the said activities. If it is proven that the company has operational control over any of the above activities, the emissions shall be accounted as Scope 1 emissions.

2 Field X Operational Background

In Indonesia, PETRONAS through its subsidiary of PC Ketapang II Ltd ("PCK2L") has been operating for more than 20 years, starting with its venture into non-operator equity in 2000, opening the Jakarta office in 2003 and achieved its first oil from operating an Offshore East Java block in 2015. Along the journey as one of the PSC's in Indonesia with a high commitment to sustainability and compliance with government regulations, emissions intensity from the functional block has been recorded thoroughly since 2018. However, the emissions intensity covers routine activities from production and supporting facilities. Emissions from non-routine activities, specifically drilling operations, are not yet recorded. After all, they were thought to have an insignificant carbon intensity because they are non-continuous.

In Field X, Phase 1 development drilling in 2015 consisted of 5 (five) development wells to produce oil and gas from a carbonate reservoir. Phase 2a and 3 of the field development comprised drilling 2 (two) wells in 2017-2018 and 4 (four) wells in 2019-2021. Phase 2b development drilling started in Q4 2021 to drill 5 (five) wells. Because this drilling activity has been relatively constant, it is good to understand the associated carbon intensity with regards to the operation performance of Non Productive Time (NPT) parameter.

3 Carbon Emission Estimation

3.1 API Compendium

The American Petroleum Institute (API) and many member companies are implementing action plans to address greenhouse gas (GHG) concerns and policy issues. Concurrently, local, regional, national and international bodies are developing or revising their guidance on estimating, reporting, and verifying GHG emissions. The API Compendium was first released in April 2001 (API, 2001). Collaborating with other industry-related protocol development organizations, this version of the API Compendium represents industry best practices for estimating GHG emissions. The latest version of the third edition was published in August 2009, representing the latest information available at that time.

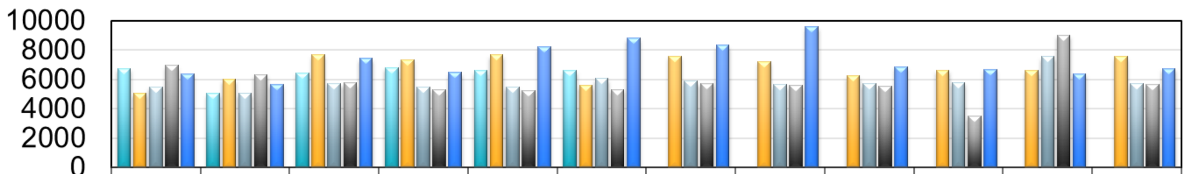
3.2 SANGEA™ Software.

Sung and Adefemi (2012) informed the history of this software in the paper SANGEA™ 4.0 Facilitating Standardization of Greenhouse Gas Emissions Quantification for the Petroleum Industry. The Chevron Corporation developed the original software as a GHG emissions reporting tool and implemented it across the entire corporation in the early 2000s based on API Compendium 2001. Later in June 2004, Chevron donated the ownership of SANGEA to API to make it available free of charge to the entire oil and gas industry as a standardized method of GHG emissions estimation.

In 2009, API published the updated compendium with current industry best practices for estimating GHG emissions. The U.S. Environmental Protection Agency (USEPA) promulgated the Mandatory Reporting Rule (MRR) for all industrial sources of GHG emissions. With the development of new GHG emission accounting and reporting protocols and regulatory requirements, the free-of-charge SANGEA™ must continue to develop further. In 2012, SANGEA™ 4.0 was released with a user-friendly interface, emission factors, and calculation equations coded in visual basic using an access database for storing emissions inventory records that are also used for this paper's analysis.

3.3 Existing Carbon Emission Record of Routine Production Activities at Field X

Production and supporting facilities to operate Field X are in East Java Offshore, East Java Onshore, and the Jakarta Office. Quantities of GHG emissions from direct and Indirect Emissions Sources from routine operation activities with units of metric tons of CO_2e are estimated using SANGEA™ 4.0 GHG emission calculation software. Figure 1 shows the emission quantity from January 2018 until June 2022, with an average of 6,413 tCO_2e per month or 76,955 tCO_2e/year, exclusive of drilling activity.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2022	6734	5033	6445	6796	6599	6580						
2021	5069	6009	7681	7348	7666	5565	7577	7208	6236	6627	6608	7564
2020	5479	5041	5735	5453	5483	6070	5876	5652	5710	5784	7559	5686
2019	6953	6334	5751	5266	5230	5303	5721	5579	5514	3490	9017	5652
2018	6394	5671	7432	6479	8235	8792	8337	9587	6859	6675	6397	6759

Figure 1. Estimated carbon emission in Field X for routine activities from January 2018 until June 2022 with average emission 6,413 tCO_2e/month or 76,955 tCO_2e/year

3.4 Carbon Emission in Jack Up Rig Operation at Field X

The drilling risks and complexity in this field are considered high based on the historical data of the 11 (eleven) development wells which were drilled in previous campaigns. The challenges of this drilling comprise of the loss of circulation in depleted reservoirs, and high vibration on the drill string in carbonate sections. Another challenge is the geological targets which are relatively far from the location of the wellhead platform, and so require high-angle Extended Reach (ERD) trajectories as summarized by Musa et al (2021). Normally, drilling projects are non-routine activities involving many service partners or contractors. Emissions from these sources are classed under Scope 3 because these activities are not controlled by company. As present, there is no mandatory requirement to report carbon emissions from drilling activities to the host authority. Despite this, PCK2L Indonesia has taken the initiative to analyze fuel consumption data from rig engines and supporting marine vessels in drilling activities to estimate total carbon emissions over a certain period using the detailed equation and examples as described in the API Compendium 2009.

3.5 Stationary Combustion from Rig Engines

The Jack Up rig type that was used for this study is BMC Class 375 with 3000 HP that was built in 2006. The fuel consumption record in the recent drilling campaign from September 2021 until June 2022 is plotted in Figure 2. The average consumption is around 17,923 liter/ day. Low fuel consumption happens during preparation and rig moves at the beginning of a campaign, whilst high fuel consumption happens during drilling operations, especially if there are hole problems because that will require extra power consumption. The simulation result from SANGEA^{TM} 4.0 for stationary combustion of rig engines based on actual fuel consumption data input is summarized in Table 2. Total carbon emissions from rig engines of a jack up rig from September 2021 until June 2022 is around 13,754-ton CO_2e.

Table 2. The simulation result from SANGEATM 4.0 for stationary combustion of rig engines

Reporting Year	Reporting Month	Location	Module Name	GHG - CO2	GHG - CH4	GHG - N2O	Total GHG - CO2e
2021	9	Drilling	Stationary Combustion	305,98	0,02	0,00	307
2021	10	Drilling	Stationary Combustion	1.452,05	0,07	0,01	1.457
2021	11	Drilling	Stationary Combustion	1.398,37	0,07	0,01	1.403
2021	12	Drilling	Stationary Combustion	1.484,26	0,08	0,01	1.490
2022	1	Drilling	Stationary Combustion	1.792,92	0,09	0,01	1.799
2022	2	Drilling	Stationary Combustion	1.218,54	0,06	0,01	1.223
2022	3	Drilling	Stationary Combustion	1.454,73	0,07	0,01	1.460
2022	4	Drilling	Stationary Combustion	1.382,26	0,07	0,01	1.387
2022	5	Drilling	Stationary Combustion	1.680,19	0,08	0,01	1.686
2022	6	Drilling	Stationary Combustion	1.535,25	0,08	0,01	1.541

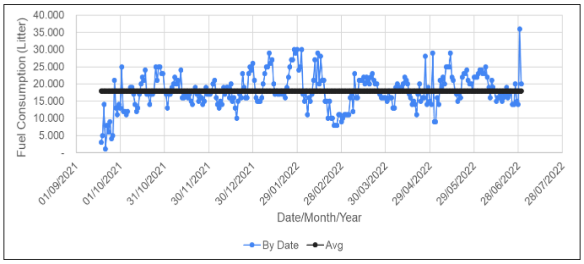


Figure 2. Jack Up drilling rig fuel consumption record at 17,923 liter/day averagely

3.6 Mobile and Transportation Emission from Marine Vessels

Drilling activities in Field X require 2 (two) AHTS vessels for equipment mobilization/ demobilization and 1 (one) FCB for personnel movement. Sometimes, the vessels must be replaced with other vessels due to contract expiry, maintenance, or other requirements. The fuel consumption was recorded and allocated based on the actual activities on which the vessels were utilized. Marine vessels' fuel consumption will be highly variable, depending on factors such as distance, weather conditions, speed, and engine specifications.

Table 3. The simulation result from SANGEATM 4.0 for mobile and transportation emissions of marine vessels

Reporting Year	Reporting Month	Location	Module Name	GHG - CO2 (tonnes)	GHG - CH4 (tonnes)	GHG - N2O (tonnes)	Total GHG - CO2e (tonnes)
2021	9	Drilling	Mobile and Transportation	399,06	0,02	0,17	451
2021	10	Drilling	Mobile and Transportation	1.104,63	0,06	0,46	1.248
2021	11	Drilling	Mobile and Transportation	992,68	0,06	0,41	1.121
2021	12	Drilling	Mobile and Transportation	940,94	0,05	0,39	1.063
2022	1	Drilling	Mobile and Transportation	1.129,60	0,06	0,47	1.276
2022	2	Drilling	Mobile and Transportation	883,11	0,05	0,37	997
2022	3	Drilling	Mobile and Transportation	883,86	0,05	0,37	998
2022	4	Drilling	Mobile and Transportation	1.047,07	0,06	0,43	1.178
2022	5	Drilling	Mobile and Transportation	849,86	0,05	0,35	956
2022	6	Drilling	Mobile and Transportation	876,21	0,05	0,36	985

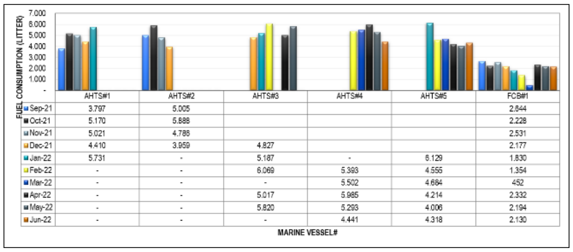


Figure 3. Drilling vessel fuel consumption record at 3,210 liter/day averagely for AHTS and 1,987 liter/day for FCB

The actual fuel consumption data for this study has been gathered and plotted in Figure 3. The simulation result from SANGEA 4.0 for mobile and transportation emissions of marine vessels based on actual fuel consumption data input can be shown in Table 3. Total carbon emission from mobile and transportation of marine vessels to support a Jack up rig operation from September 2021 until June 2022 is around 10,273-ton CO2e.

3.7 RESULTS

From September 2021 until June 2022, the total carbon emissions from drilling operations at Field X were 24,027 tons of CO2e or 2,404 tons of CO2e per month. Over the same period, routine production activities generated around 6,522 tons of CO2e/ per month. So the emission contribution from drilling activity at Field X is significant at around 27% of total emissions, as shown in Figure 4. By understanding the emission quantity from drilling activities from this paper, all related parties and stakeholders can start to monitor and reduce carbon emissions from drilling projects to support the net zero carbon emission target.

4 GHG Mitigation Efforts in Jack Up Rig Operation

In PETRONAS, GHG mitigation efforts, especially for routine production activities, are classified under 4 (four) building blocks, i.e., Operational Excellence, Low Carbon Energy and Solutions, Technology and Innovation, and Carbon Offsets. Drilling activity can support GHG mitigation blocks through the following opportunities. The current study focuses on the operational excellence block, especially well engineering and operation optimization, where drilling performance is commonly measured in terms of HSE, duration, and cost. Especially for HSE as first priority in oil and gas industry, any incidents will lead to non-productive activities and prolonged operation.

Additionally, dealing with subsurface uncertainties and third parties involvment in drilling operation is almost impposible to achieve zero operational problems or normally called as non-productive time (NPT). The drilling performance can be improved through a lessons-learned process for well engineering and operation optimization. As the number of carbon emissions in drilling activities is proportional to the operational duration, it is essential to understand NPT history at Field X from all drilling campaigns, especially in development field. Figure 5 shows that NPT ranged from 1% to 38% for 11 (eleven) development wells drilled from 2015 until 2021.

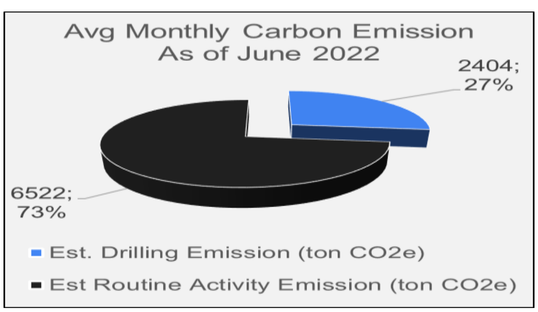
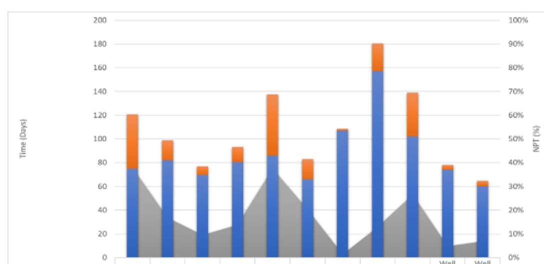


Figure 4. Average monthly CO2e emission from September 2021 until June 2022 at Field X at 6,464 tCO2e/month from routine activities and



	Well #1	Well #2	Well #3	Well #4	Well #5	Well #6	Well #7	Well #8	Well #9	Well #10	Well #11
% NPT [without WOW]	38%	17%	10%	14%	37%	20%	1%	13%	27%	5%	7%
NPT Days	45,6	16,8	7,3	12,8	51,6	16,8	1,5	23,3	37,0	3,7	4,5
PT Days	75,0	82,2	69,6	80,4	86,1	66,1	107,0	157,1	102,1	74,2	60,2

Figure 5. Field "X" drilling performance history with NPT range from 1% to 38%

So there is an opportunity to reduce NPT and abate carbon emissions from improved well engineering and operations. By analyzing this recorded data statistically, NPT targets are set as a base target of 10%. For example, by achieving 1% NPT on Well#7, the carbon emission has been abated by 9% NPT compared to the base target of 10% NPT. The reduction in carbon emissions is around 731 tCO2e, which is calculated from 9% x 108.5 (total drilling days) x 2,404 (tCO2e/ month from historical information) / 30 (days/month).

In the case of limited historical data that normally faced in exploration stages can use closest offset wells information and previous rig performance history in other locations to set NPT target. The target should be updated once the new drilling performance has been obtained from recent drilling activities.

5 Conclusion

The follow-up study of drilling carbon emission based on actual fuel consumption data record from September 2021 until June 2022 on Jack Up Rig Operation at Field X, Offshore East Java conclude following points:

- Drilling carbon emission is under GHG Scope 3 refer to The Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions, 2nd Edition, 2011 , where the monitoring is also still rare.
- The estimated carbon emissions from routine production activities is averagely ± 6,500 ton CO2e per month.
- The estimated carbon emissions from drilling activities using a Jack Up Rig as the new baseline target is averagely ± 2,400 ton CO2e per month or around 27% of total emission
- GHG Mitigation efforts from drilling operation will focus on the operational excellence, especially well engineering and operation optimization by using Non Productive Time (NPT) expectation as key targets.
- The involvement of service providers or contractors that highly related in drilling activity will be crucial to abate carbon emission from the overall activities

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