



TESTING CENTER FOR OIL AND GAS LEMIGAS

SCIENTIFIC CONTRIBUTIONS OIL AND GAS (SCOG)

Vol. 49. No. 3, September: 299 – 314 - <https://journal.lemigas.esdm.go.id>

ISSN: 2089-3361, e-ISSN: 2541-0520

Published by:

LEMIGAS

Feasibility of Upper Baturaja Interval as a Carbon Storage Reservoir in Kandanghaur-Gantar High, Jatibarang Sub-basin, West Java: A Literature-Based Preliminary Study

Oki T Musakti^{1*}, Muhamad Syaifudin¹, Aris Buntoro¹, and Bambang Widarsono²

¹*Universitas Pembangunan Nasional Veteran*

Ring Road Utara Street, No. 104, Sleman Regency, Special Region of Yogyakarta 55283, Indonesia.

²*Badan Riset dan Inovasi Nasional (BRIN) – Jakarta*

Kw Puspipstek Street, Muncul, Setu Subdistrict, South Tangerang City, Banten, 15314, Indonesia.

*Corresponding author: Oki Musakti (omusakti@gmail.com)

Received: 27 March 2026; Revised: in revised form 11 May 2026; Accepted: 02 June 2026

Available: online 30 September 2026.

ABSTRACT - Carbon Capture and Storage (CCS) is a major approach for reducing carbon emissions, particularly in areas with intensive industrial and hydrocarbon production activities. Therefore, this study aims to evaluate feasibility of Upper Baturaja Interval in Kandanghaur-Gantar High (KGH), Jatibarang Sub-Basin, West Java, as a potential field-scale carbon dioxide (CO₂) storage area. The designed preliminary assessment is based on available literature and field data to provide an initial technical evaluation of the area at a maturity level suitable for pre-feasibility stage development. A qualitative method is adopted using standard CO₂ storage screening criteria, including reservoir depth, petrophysical properties, thickness and lateral continuity, caprock integrity, storage capacity, and proximity to emission sources. The results show that Upper Baturaja interval occurred at depths of approximately 1600–1900 m, with porosity ranging from 20% to 25%. This interval is dominated by secondary porosity, characterized by ideal field-scale continuity. The presence of hydrocarbon accumulations, including the absence of significant structural disturbances above the target interval, suggested an effective sealing system. Based on an implementation perspective, the study area benefitted from neighboring CO₂ sources derived from associated gas production alongside existing oil and gas infrastructure. The estimated storage capacity is also relatively modest compared to large-scale CCS projects. The combination of favorable geological and operational factors suggested KGH is a viable candidate for pilot-scale or early-stage CCS/CCUS development. Future studies should include static and dynamic modelling, injection simulation, and risk assessment to quantitatively validate storage performance.

Keywords: CCS, upper baturaja interval, CO₂ storage, kandanghaur-gantar high, Jatibarang sub-basin

How to cite this article:

Oki T Musakti, Muhamad Syaifudin, Aris Buntoro, and Bambang Widarsono, 2026, Feasibility of Upper Baturaja Interval as a Carbon Storage Reservoir in Kandanghaur-Gantar High, Jatibarang Sub-basin, West Java: A Literature-Based Preliminary Study, Scientific Contributions Oil and Gas, 49 (3) pp. 299-314.



© 2026 The Author(s). Published by LEMIGAS under the Creative Commons Attribution-ShareAlike 4.0 International License (CC BY-SA 4.0)

<https://doi.org/10.29017/scog.v49i3.2126> | 299

1. Introduction

Carbon dioxide (CO₂) is widely recognized as the main greenhouse gas responsible for driving global warming. As a result, Carbon Capture and Storage (CCS) has materialized as a critical reduction strategy, enabling emissions reduction without compromising economic development. Kaya & Yokobori (1997) outlined the relevance of the strategy by formulating an equation, which showed global anthropogenic CO₂ emissions were directly proportional to the population, gross domestic product, and energy consumption. These variables have historically shown persistent upward trends, as in Figure 1.

Indonesia possesses significant potential for CO₂ storage in both surface (such as reforestation efforts) and subsurface formations. This study focused on storage in subsurface formations, which have estimates ranging between 400–600 gigatons (Boston Consulting Group 2023; Best et al., 2011; International Energy Agency 2022; Sugihardjo 2021; Usman et al., 2014; Iskandar & Syahril 2009; ERIA 2023). However, the estimates remain largely speculative, based on basin-scale calculations rather than detailed field-scale assessments.

The International Energy Agency report showed that Northern West Java has the highest CO₂ emission intensity in Southeast Asia (International Energy Agency 2021). This trend was driven by the concentrated manufacturing sector of the area, as shown in Figure 2.

The main objective of this study is to determine the inconsistency between regional, multi-basin assessments and additional local, area-specific potential. This was achieved by investigating feasibility of Baturaja Formation within several hydrocarbon fields in Jatibarang Sub-Basin. Area-specific studies on CO₂ storage potential in multiple hydrocarbon-bearing fields in the area have not been conducted. Baturaja Carbonate interval was selected because it is among the main reservoir producers in the area. Moreover, the existing production facilities imply the potential switch to a CO₂ storage interval.

1.1 Upper baturaja carbonate of kandanghaur-gantar high (KGH)

KGH is a structural high bounded to the east and north by Cemara Low, as well as the west and south by Cipunegara Low. This structure is located approximately 60 km northwest of Cirebon. Furthermore, hydrocarbon bearing fields such as GTR, ABG, TGB, and PCT operated by PT Pertamina EP, as shown in Figure 3, were also found. Majority of this mature fields have been producing hydrocarbons since the 1980s, a typical example is the ABG, representing the most recent discovery in 2009. The main productive reservoir in this High is the Middle Miocene carbonate interval, known as Baturaja Formation. Therefore, the interval is the focus of this present study.

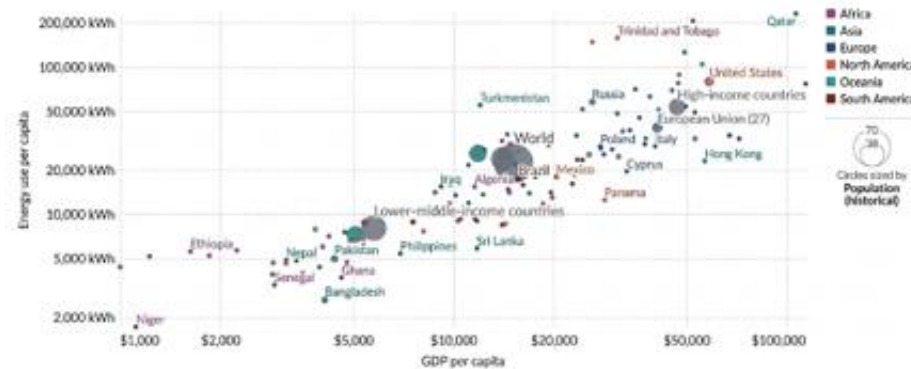
The naming of the carbonate stratigraphic units in KGH area varies significantly among structures, fields, and previous studies. In ABG and GTR structures, the carbonate stratigraphic units are known as Layer L and Z-16, respectively (Ambarwati 2018). The units in TGB and PCT structures to the south correlate with the Upper Baturaja or the Equivalent. Additionally, the unit is termed Layer P in the Kandanghaur Timur (KHT) structure located at the northern part of the study area. The nomenclature of the interval in Cemara Barat (CMB) and Cemara Selatan (CMS) to the north is designated as Layer L and Upper Cibulakan, respectively. Widodo (2018) identified a similar interval in Melandong Field and described it as part of Baturaja Formation, which further complicated regional nomenclature.

The term Upper Baturaja or Upper Baturaja Interval was adopted to denote the carbonate interval exceeding 100 meters in thickness that served as the main reservoir in KGH. Furthermore, Upper Baturaja Interval was deposited above the tight, occasionally dolomitized, limestone of its Formation.

The limestone of Upper Baturaja Interval is generally characterized by superior reservoir quality compared to Baturaja Formation. Moreover, a distinct amplitude contrast was found on seismic sections in the ABG and GTR structures. The amplitude contrast was derived from impedance differences caused by variations in density and porosity of the limestone. This impedance difference between Upper Baturaja Interval and Baturaja Formation is relatively continuous in the area as well as used for stratigraphic correlation.

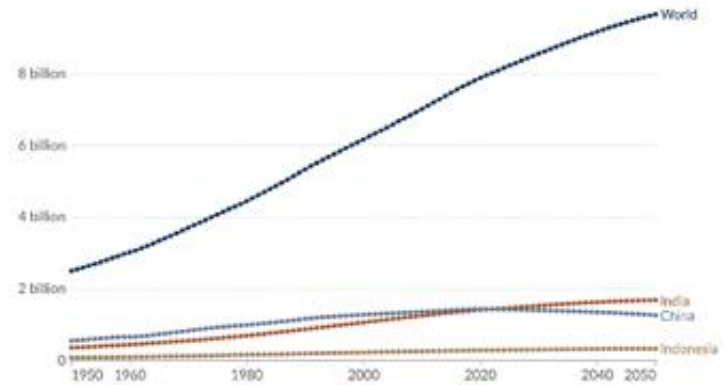
GDP per capita vs. energy use, 2015

Annual energy use per capita, measured in kilowatt-hours per person vs. gross domestic product (GDP) per capita, which is adjusted for inflation and differences in the cost of living between countries.



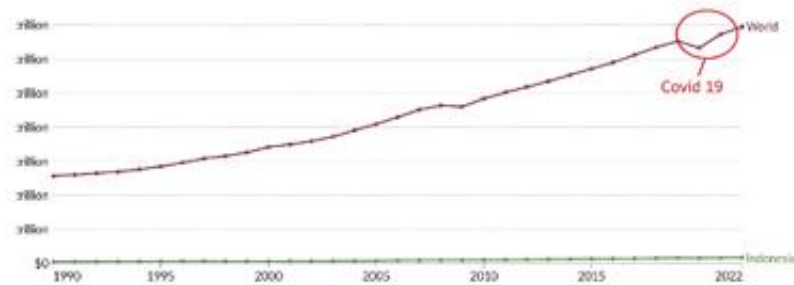
Population, 1950 to 2050

Projections from 2024 onwards are based on the UN's medium scenario.



Gross domestic product (GDP), 1990 to 2022

data is adjusted for inflation and differences in the cost of living between countries.



Annual CO₂ emissions

Carbon dioxide (CO₂) emissions from fossil fuels and industry. Land-use change is not included.

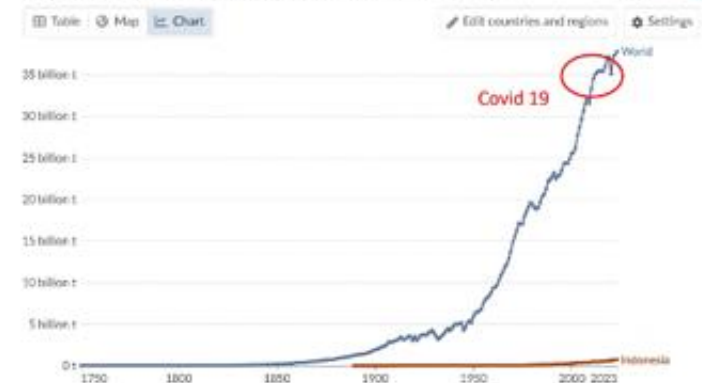


Figure 1.

Figure D is showing Global CO₂ emission trends showing continuous increase (blue line) and Indonesia's CO₂ emissions (red line) for comparison largely due to increase in world's GDP (Figure C) and global population (Figure B), even in the middle of Covid pandemic. Figure A is crossplot showing a very strong correlation between per capita GDP and Energy Use for individual countries. Source: Our World in Data.

CO₂ sources and storage potential in Southeast Asia

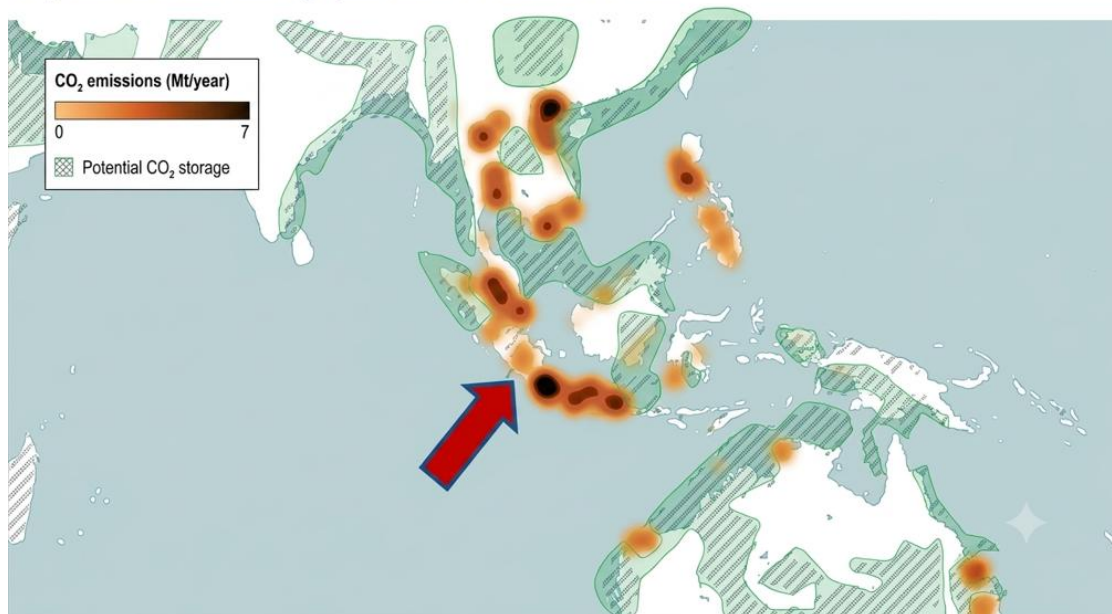


Figure 2.

CO₂ emission intensity across Southeast Asia. Northern West Java represents the region's largest emission source (International Energy Agency 2021). Green outline denotes potential storage sites potential storage sites.

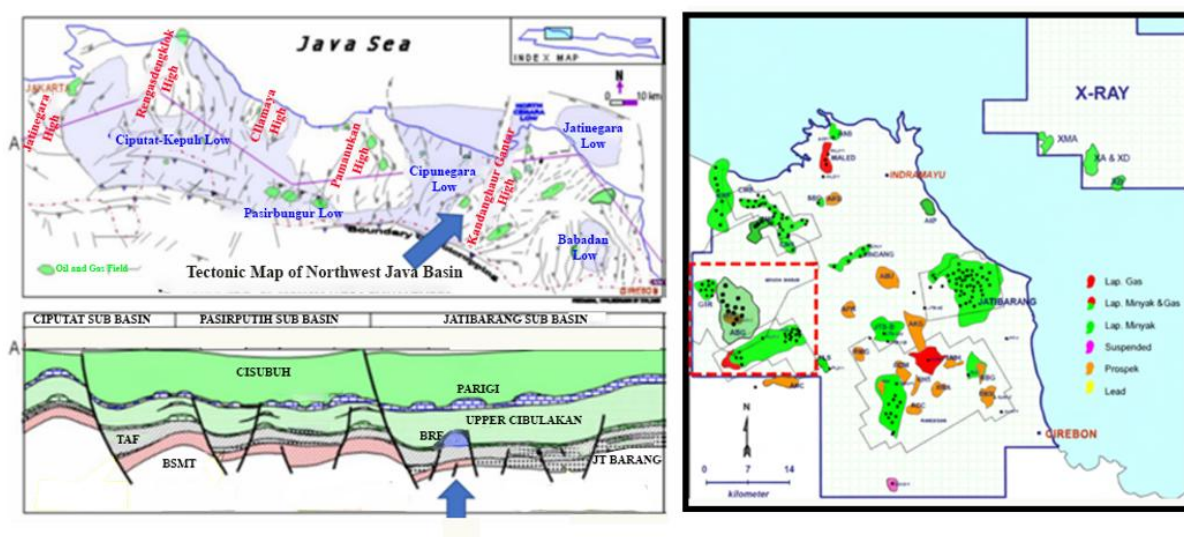


Figure 3.

Location map and regional geological cross-section along northern West Java, including Kandanghaur–Gantar High. The red box indicates the study area.

Seismic interpretation of KGH area showed that Baturaja interval maintained a relatively uniform thickness, with no significant depositional thickening typically associated with reef development. Sedimentological and petrographic analyses of core samples further showed the interval was dominated by large foraminiferal fragments and red algae. These facies were predominantly classified as packstone and grainstone. However, the non-reservoir intervals were characterized by mudstone.

Baturaja interval showed only minor lateral changes in thickness, compared with the more pronounced thickness variations observed in Parigi Formation shown in Figure 4. In addition, the relatively low abundance of coral fragments compared with other skeletal grains showed that Upper Baturaja Limestone was not mainly formed as a coral reef. The succession was interpreted as a carbonate platform dominated by large foraminifera and red algae, with deposition occurring in a lagoonal setting landward of the shelf margin (LAPI-ITB 2025; Widodo 2018).

1.2 Reservoir quality

Upper Baturaja interval in KGH area showed reservoir characteristics defined by alternating sequences of tight limestone and more porous zones. Furthermore, Figure 5 shows a pronounced upward trend of improving reservoir quality toward younger strata.

The petrographic analysis carried out showed that the pore system was dominated by moldic and connected vuggy porosity types shown in Figure 6. The main porosity within the carbonate matrix was subjected to significant degradation. This was due to destructive diagenetic processes, which substantially reduced the pore storage capacity of the carbonate rocks.

The porosity enhancement observed in the upper portion of Upper Baturaja interval was attributed to subaerial exposure of the interval above sea level, which arose from eustatic sea-level fall. The interaction with meteoric water (rainwater) during this stage triggered diagenetic processes responsible for generating selective dissolution, including secondary porosity development. Previous studies by LAPI-ITB (2025 internal report) have identified evidence of karstification, as shown by collapsed breccia structures observed in core samples from well ABG-3.

The reservoir quality in Upper Baturaja Interval is generally controlled by the distribution of secondary porosity formed through diagenetic processes, with non-structural porosity predominating. These characteristics represent a critical factor in assessing the potential for CO₂ injection and storage in the study area. Image log evaluations across the three wells in ABG structure showed the presence of conductive, presumably open, fractures. These showed a highly localized distribution, with a 1D fracture density remaining below 3 fractures per meter and restricted to specific intervals. Subsequently, the natural fractures do not constitute the main pore system governing the reservoir.

Widodo (2018) reported that porosity in Baturaja Formation of Melandong area was significantly enhanced by meteoric diagenesis. Additionally, geochemical and petrographic evidence suggested that meteoric water dissolution was reflected in the presence of related voids and intervals that showed carbon-13 isotope depletion ($\delta^{13}\text{C}$). The negative shifts in $\delta^{13}\text{C}$ values signified subaerial exposure episodes that facilitated interaction between carbonate rocks and acidic meteoric water.

1.3 Fluid contents

Upper Baturaja interval in the main structural closure contains hydrocarbons in the form of crude oil, topped by a gas cap at the crest. Thickness of the gas column is approximately five times larger than oil and is characterized by relatively high CO₂ concentrations of approximately 60%.

The fluids within the carbonate sandstone of Upper Cibulakan Formation overlying Upper Baturaja interval are dominated by gas, with oil occurrence limited to select intervals. A significant observation is the systematic decrease in CO₂ content toward stratigraphically higher layers, approaching zero in some of the youngest formations, namely intervals D and F in the ABG Field, as shown in Figure 7. However, the proposed hypothesis used to explain this phenomenon led to the triggering of fluid buoyancy segregation. Following the description above, the hypothesis posited that larger CO₂ molecules encountered difficulty migrating through the inter-strata seal between reservoirs. The smaller methane molecules migrated to the uppermost reservoir before being trapped by the basic seal. The elevated CO₂ concentration in the gas cap of Upper Baturaja interval portrayed crude oil production as the main focus. Based on this perspective, the associated gas served as the byproduct. In several operational scenarios, oil production from wells has been reduced or suspended due to gas coning phenomena entering the perforation interval. The outcome led to increased gas production characterized by high CO₂ content.

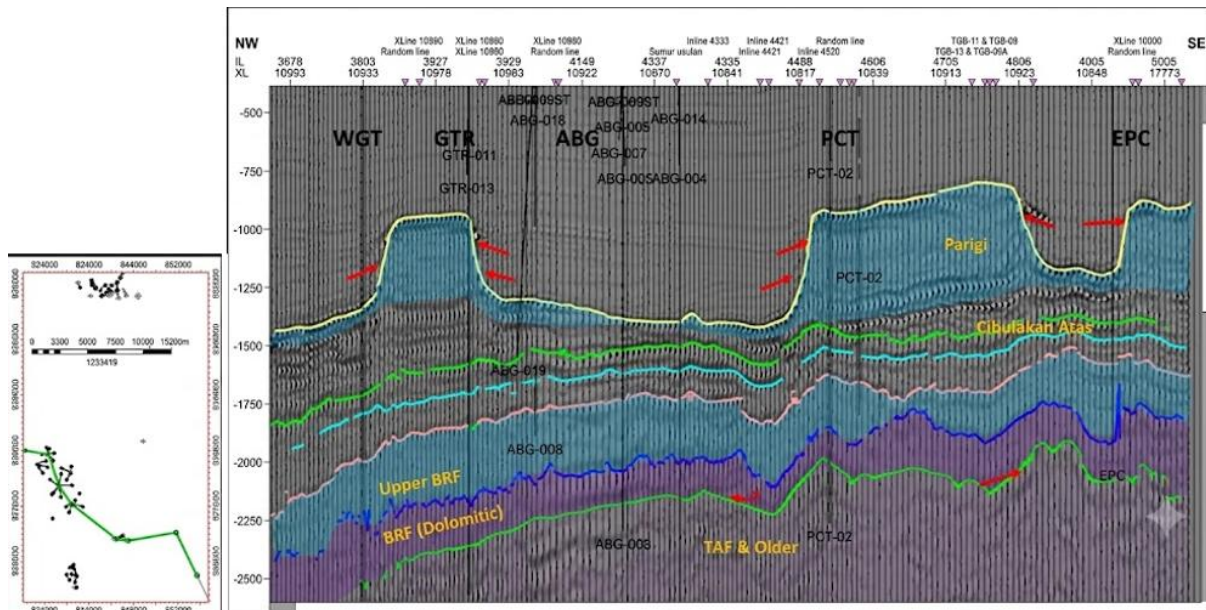


Figure 4.
Northwest-southeast seismic profile from WGT to EPC showing the absence of significant thickness variations, characteristic of a carbonate reef deposit.

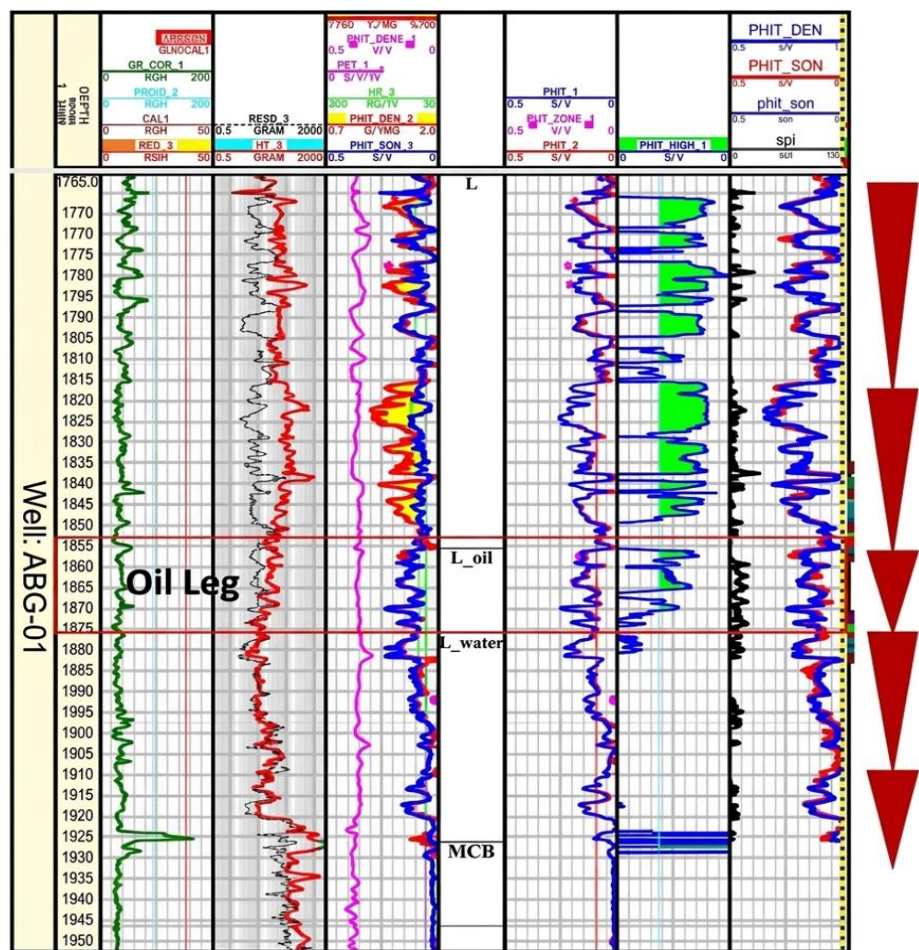


Figure 5.
Parasequence stacking patterns within Upper Baturaja interval, illustrating a trend where enhanced porosity predominantly occurs in the upper portions. Well example adapted from LAPI-ITB (2025) report.

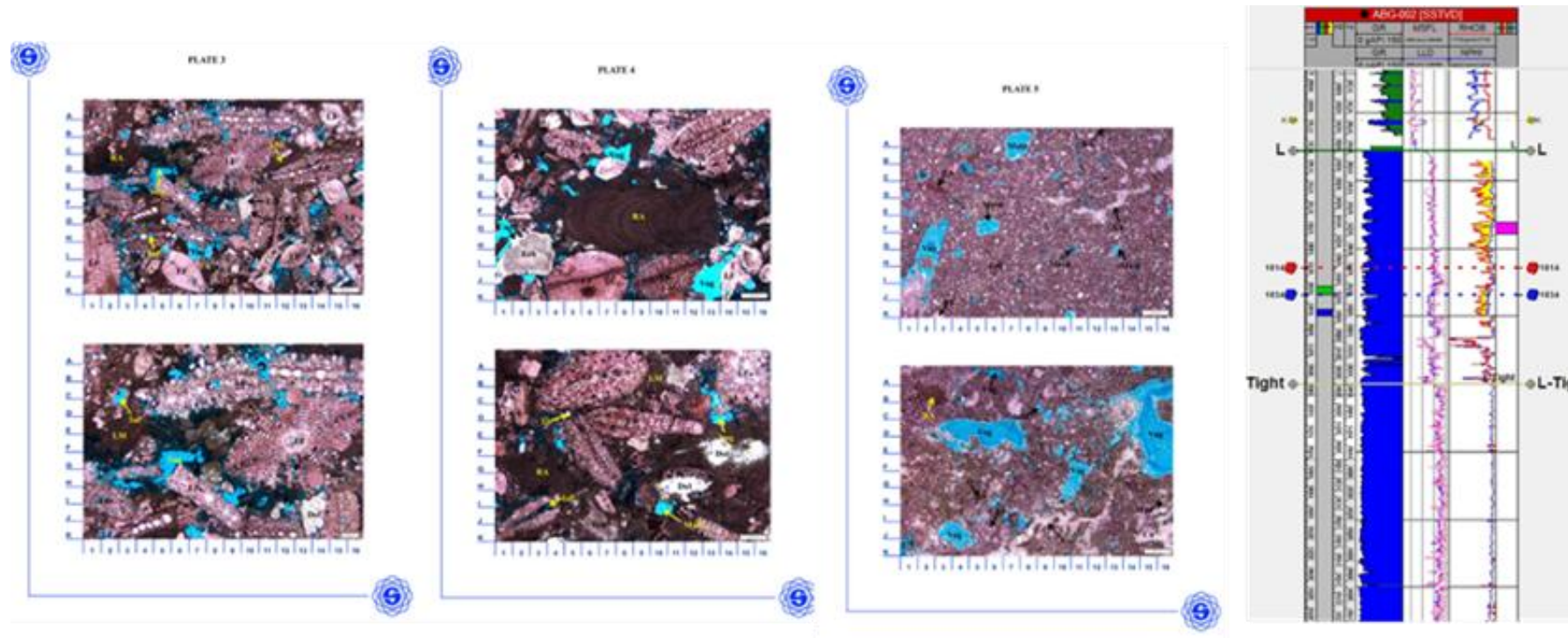


Figure 6.

Thin-section analysis of core samples from well ABG-2 at depths of 1,911 meters (Plate 3), 1,912 meters (Plate 4), and 1,915 meters (Plate 5), revealing large benthic foraminifera as the primary framework constituents and dominant porosity types of vuggy and subordinate moldic character.

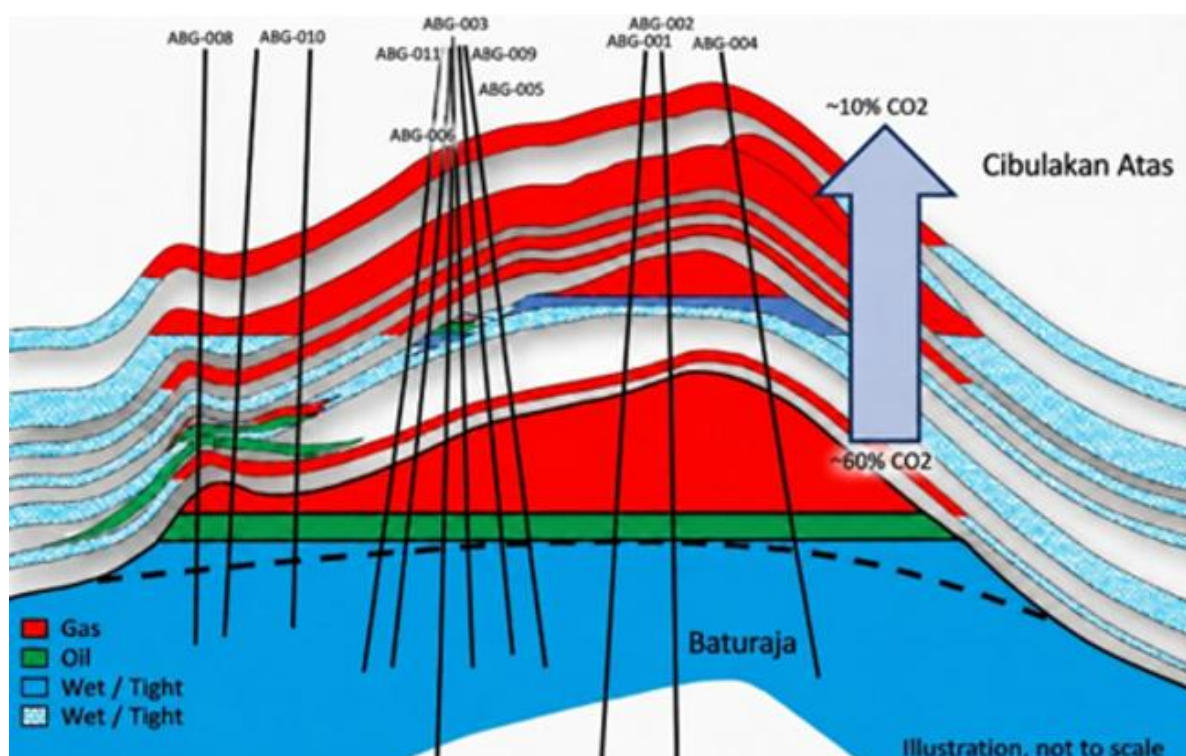


Figure 7.

Hydrocarbon types in the study area. CO₂ content in the gas cap of Upper Baturaja interval is approximately 60% and decreases in younger strata. Image adapted from [Pertamina EP 2017](#) report.

2. Methodology

This study evaluated the technical feasibility of the Baturaja Formation carbonate reservoir in the KGH area of West Java as a potential geological storage site for carbon dioxide. The assessment was conducted through a qualitative screening of key site-selection criteria identified in previous studies, including [Bachu 2003](#); [Raza et al., 2016](#); and [Callas et al., 2022](#). These criteria provide a general framework for assessing whether a geological formation possesses the appropriate characteristics for safe, effective, and long-term CO₂ storage.

The evaluation considered several geological, operational, and logistical parameters. These included reservoir depth, porosity, permeability, caprock integrity, structural intensity, proximity to potential CO₂ emission sources, and estimated storage capacity. Reservoir depth was assessed to determine whether the formation could maintain CO₂ in a dense or supercritical state, while porosity and permeability were used to evaluate the reservoir's capacity to store and transmit injected CO₂. Caprock integrity and structural intensity were examined to assess the potential for CO₂ leakage through fractures, faults, or other geological discontinuities. In addition, the distance between the reservoir and nearby emission sources was considered because proximity can reduce the infrastructure requirements and transportation costs associated with CO₂ capture and injection.

The objective of this study was to determine whether the KGH area satisfies the fundamental technical requirements for further consideration as a CO₂ storage site. Because the assessment was primarily qualitative, the results should be regarded as a preliminary screening rather than a final confirmation of storage feasibility. Nevertheless, the findings provide an initial basis for identifying the strengths, limitations, and uncertainties of the Baturaja Formation reservoir. The results can also support future investigations involving detailed geological modelling, dynamic reservoir simulation, geomechanical analysis, injectivity assessment, and monitoring design.

3. Result and discussion

Depleted hydrocarbon fields represent an established subsurface CO₂ storage location, with numerous case studies (Hannis et al., 2017; Lai et al., 2015; and Wei et al., 2023). The storage capacity of depleted hydrocarbon fields is lower than alternative geological media such as saline aquifers. However, in many cases this relatively limited storage capacity is offset by reduced uncertainty, as existing data are more comprehensive and production infrastructure can be converted to injection facilities.

Bachu (2003) introduced the screening method for assessing CO₂ storage area potential, which had been modified and further developed by numerous studies (Callas et al., 2022; and Raza et al., 2016). Although originally designed for basin-scale assessment, this method can be adapted for smaller spatial scales, including producing hydrocarbon fields.

The adaptations of the Bachu method in Indonesia have been applied in studies conducted by LEMIGAS (Iskandar & Usman 2011). The principal parameters evaluated include depth, distance from CO₂ sources, reservoir quality (porosity and permeability), and thickness, as well as lateral continuity, structural complexity, seal rock quality, and storage capacity. Additionally, these parameters were discussed qualitatively to provide a preliminary assessment of the suitability of KGH area as a CO₂ storage location. The summary of the qualitative evaluation of the diverse parameters is shown in Table 1 and discussed in the following sections.

3.1 Reservoir depth

Reservoir depth is among the most critical parameters for evaluating the suitability of an area for CO₂ sequestration. Previous studies by Metz et al. (2005), Bachu (2003), Callas et al. (2022), and Tomić et al. (2018), have reported that the optimal depth for CO₂ injection ranges from 800 to 3,000 meters below the surface. In this interval, CO₂ tends to reach a supercritical state, ensuring that the volume stored in the reservoir is significantly smaller than the equivalent under surface conditions (Raza et al., 2016). The depth of Upper Baturaja Interval in KGH, which is from 1,600 to 1,900 meters, falls within the ideal range. Based on this context, the aim is to achieve and maintain supercritical conditions.

3.2 Proximity to emission sources

The transportation of CO₂ from capture or source locations to storage areas through pipelines, tankers, or terrestrial transport constituted the most significant cost components in CO₂ storage projects. The higher distances between emission sources and storage areas naturally led to a commensurate increase in the expenditures. In KGH, CO₂ source evolved from both associated and non-associated gas produced alongside oil, with concentrations reaching approximately 60%. The high CO₂ was separated using stripping facilities installed within the existing fields, thereby enabling significant savings in transportation costs.

3.3 Reservoir quality

The main petrophysical parameters of a reservoir, namely porosity and permeability, are critical factors used to determine the volume of CO₂ that can be stored and the rate of injection. Raza et al. 2016 proposed that an ideal reservoir should possess a porosity and permeability greater than 20% and 100 mD, respectively. Meanwhile, Callas et al. 2022 established minimum criteria of 10% porosity and 10 mD permeability for the preliminary selection stage.

The petrophysical analysis conducted internally by Pertamina EP on more than 40 wells in KGH provided average Effective Porosity (Phie) and permeability of approximately 14% to 17% and 50-70 mD, respectively. These values adequately satisfied the basic requirements for further investigation.

3.4 Reservoir thickness and continuity

The study by Raza et al. 2016 reported an ideal reservoir thickness of over 50 meters, with a minimum threshold of 10 meters. In addition, reservoirs with continuous lateral and vertical distribution were preferred, as this facilitated more efficient CO₂ storage as well as reduced the required number of injection wells.

The carbonate lithology of the combined Baturaja and Upper interval showed a maximum gross thickness of 250 and 400 meters in GTR structure and PCT, respectively. The application of the petrophysical cutoff of Shale Volume (V_{shale}) > 30% and Effective Porosity ($Phie$) > 8% to all the wells in KGH produced relatively 114 meters TVD thickness of Net Reservoir and 200 meters in ABG structures and GTR, respectively, as shown in Table 1. The maximum thickness parameters were used because only some of the wells penetrated the whole carbonate interval of both Upper Baturaja and Baturaja.

Table 1.
Petrophysical lumpings showing thickness and average porosity-permeability within Net Reservoir for each structure.

Structures	Well number	Max vertical thickness (mtrs)		Average	
		Gross	Net	Phie	Perm (mD)
ABG	39	129	114	0.15	52.48
GTR	3	249	207	0.17	72.16
TGB	10	Not fully penetrated		0.16	74.00
PCT	5	465	353	0.14	59.73

3.5 Caprock integrity and structural disturbance

Seismic interpretation depicts the absence of significant structural intensity in the topmost section of Upper Baturaja interval within KGH. Meanwhile, no faults were observed penetrating the productive reservoir that could potentially serve as leakage pathways for hydrocarbons to the surface. The absence of vertical migration indicators from the reservoir to the surface, such as gas chimneys, was identified in the interpreted seismic data.

The presence of hydrocarbon accumulations across all structural highs in this area was additional evidence that supported caprock integrity. These accumulations showed that the seals and trap configurations have successfully contained lateral and vertical hydrocarbon migration (gas and oil) over geological timescales of millions of years. As a result, the accumulations are expected to effectively retain CO₂ column as well.

Upper Cibulakan Formation, which consisted of claystone and shale couplets including carbonaceous sandstones, was deposited above Upper Baturaja interval. These carbonaceous sandstone intervals frequently served as reservoirs for hydrocarbon accumulations, specifically gas. Furthermore, the presence of multiple sealing layers increased confidence in the containment integrity for CO₂ injected into the underlying reservoir.

3.6 Storage capacity

LAPI-ITB performed a simplified calculation of CO₂ storage capacity within the hydrocarbon intervals of ABG field. In addition, the simplified calculation was performed using Equation 1

$$\begin{aligned}
 M_{CO_2} &= A \times H \times \phi \times (1 - S_w) \times RF \times \rho_{CO_2} \\
 M_{CO_2} &= HCPV \times RF \times \rho_{CO_2}
 \end{aligned}
 \quad (1)$$

Where M_{CO_2} , A , H , ϕ , S_w , RF and ρ_{CO_2} are the volumetric CO₂ storage capacity in tonnes, the reservoir area in square metres, is the reservoir thickness in metres, the reservoir porosity, the water saturation, Recovery Factor and the CO₂ density under reservoir conditions in kilograms per cubic metre, respectively. The product of $A \times H \times \phi \times (1 - S_w)$ represents the hydrocarbon pore volume, or HCPV, in cubic metres. Accordingly, the equation can be simplified by expressing the storage capacity as a function of HCPV, recovery factor, and CO₂ density.

The equation calculates the volume of hydrocarbons estimated to be producible and measured at reservoir conditions. Furthermore, it assumed that the volume could be replaced with injected CO₂ (See glossary of terms and symbols). HCPV in oil and gas columns of ABG field was 39.13 and 112.9 million m³, respectively. The

equation produced a CO₂ storage capacity of 25.96 million tons and 1.5 million tons in the gas and oil columns, assuming RF of gas, oil, and CO₂ density was 60%, 10%, and 383.16 kg/m³, respectively. This suggested that every million m³ of hydrocarbon pore volume in ABG field gas and oil columns provided a storage capacity of 0.23 and 0.038 million tons of CO₂, respectively. The application of MCO₂/HCPV ratios to other fields in TKG area enabled the calculation of the total storage capacity using this method. In addition, the value obtained was approximately 34 million tons, as shown in Table 2.

Table 2.
Calculation of CO₂ storage capacity (million tons CO₂, MCO₂) across fields in KGH, using CO₂ storage capacity-to-hydrocarbon pore volume ratios (MCO₂/HCPV) derived from the Pertamina-LAPI ITB (2025) study.

Structure		HCPV (m3)	MCO2 (Tonne)
ABG (LAPI ITB)	Gas	112910926.8	25957770.43
	Oil	39134361.89	1499472.21
GTR	Gas	196200	45105.59521
	Oil	4763200	182506,771
PCT	Gas	20296100	4665992
	Oil	11414700	437366
TGB	Gas	6472900	1488094
	Oil	5210800	199657
Total (m ³ - Tonne)		200399189	34475964
Total (10 ⁶ m ³ - Tonne)		200	34
Assumption		Gas	Oil
MCO ₂ /HCPV (Tonne/m ³)		0.229896	0.038316
RF		0.6	0.1
CO ₂ density kg/m ³		383.16	

3.7 Surface facilities

An active hydrocarbon production area is equipped with adequate surface infrastructure, including production wells, pipeline networks (flowlines and trunklines), compressors, and other supporting facilities. This infrastructure has the potential to be efficiently repurposed into CO₂ injection system, thereby reducing the initial capital investment required for the development of new facilities. Regional accessibility is not a significant constraint, because the area is currently established for the movement of heavy vehicles and large-scale equipment which support drilling and production operations.

3.8 Discussions

The summarized qualitative feasibility analysis for Upper Baturaja interval is shown in Table 3. This suggested that the target interval possessed adequate geological conditions considered as a viable CO₂ storage medium. Moreover, the assessment was supported by the suitability of the depth, petrophysical quality, and well-developed geometry of the reservoir body. The presence of multiple seals above the target area, including the absence of prominent structural disturbances, and the existing hydrocarbon accumulations further increased confidence in the sealing effectiveness of the injected CO₂.

The calculated storage capacity of approximately 34 million tons is relatively small compared to the Indonesian potential storage capacity (Boston Consulting Group 2023) or other global CO₂ storage projects based on saline aquifer (Aminu et al., 2017). However, this area remains relevant for further investigation, particularly given the proximity to CO₂ sources and the availability of operational production facilities. The outcome minimized the need for new facility development as well as reduced transportation overheads.

The storage capacity in KGH area was classified as theoretical in the techno-economic resource pyramid and level of detail assessment. Previous studies reported that the storage capacity was also classified as low to medium level in line with regional to basin scale assessments (Bachu et al., 2007), as shown in Figure 9.

Table 3.
Qualitative assessments of feasibility of Upper Baturaja Interval as CO₂ storage site.

Parameters	Measured value (KGH)	Reference range / criteria	References	Notes
Depth	1600–1900 meters subsea	800–3000 meters subsea	Metz et al. (2005); Bachu (2003); Callas et al. (2022)	Meets criteria
Distance from emission source	Co-located, in the same location	As close as possible	—	Meets criteria
Porosity	20–25% within Net Reservoir	10–20%	Raza et al. (2016); Callas et al. (2022)	Meets criteria
Permeability	20–60 mD within Net Reservoir	10–100 mD	Raza et al. (2016); Callas et al. (2022)	Meets criteria
Reservoir thickness	—	—	—	—
Reservoir extent	Laterally continuous (present in all wells)	Laterally continuous	Raza et al. (2016)	Meets criteria
Caprock	Multiple layers	More than one layer	Raza et al. (2016)	Meets criteria
Structural disturbances	Minimal	Minimal	Raza et al. (2016)	Meets criteria
Hydrocarbon leakage indication	Not observed	None	—	Meets criteria
CO ₂ storage capacity	200–300 million tonnes	As much as possible	—	Small
Surface facilities	Available	—	—	Meets criteria

4. Conclusion

In conclusion, the initial assessment proved the Upper Baturaja Formation in KGH was favorable for field-scale CO₂ storage. This evaluation was supported by the suitability of subsurface conditions, quality of target rocks, and presence of an adequate sealing system.

The main advantage of this area centered on the proximity to CO₂ sources, including the availability of existing production facilities, besides the geological factors. These conditions provided significant added value for implementation by reducing the requirement for new infrastructure development.

The study area remained relevant for early-stage development, considering that the identified capacity was limited compared to large-scale projects. Subsequently, KGH was ideally positioned as a candidate for field testing or pilot projects. This required further detailed quantitative studies, injection simulations, and comprehensive risk evaluations. Based on the results of the preliminary analyses of various technical and geological parameters, Upper Baturaja Formation in KGH possessed viable potential. However, further investigation should be carried out as a CO₂ storage area.

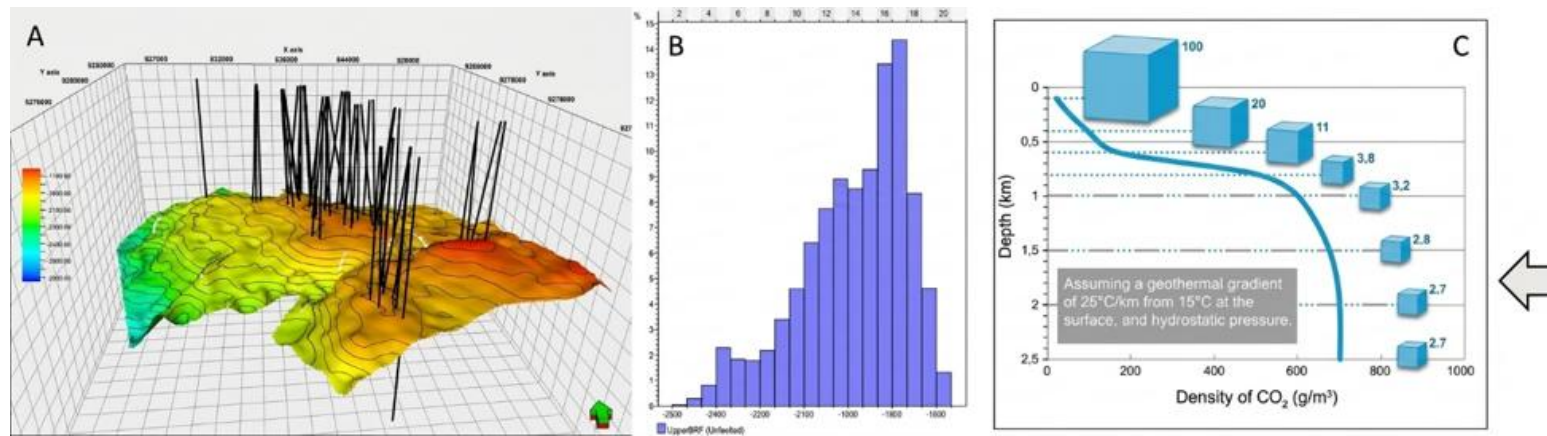


Figure 2.

The top of Upper Baturaja reservoir interval mostly occurs at depths between 1,600–1,900 meters below sea level (Figures A and B), representing optimal depth conditions for CO₂ storage under typical subsurface conditions (Figure C, modified after Metz et al., 2005).

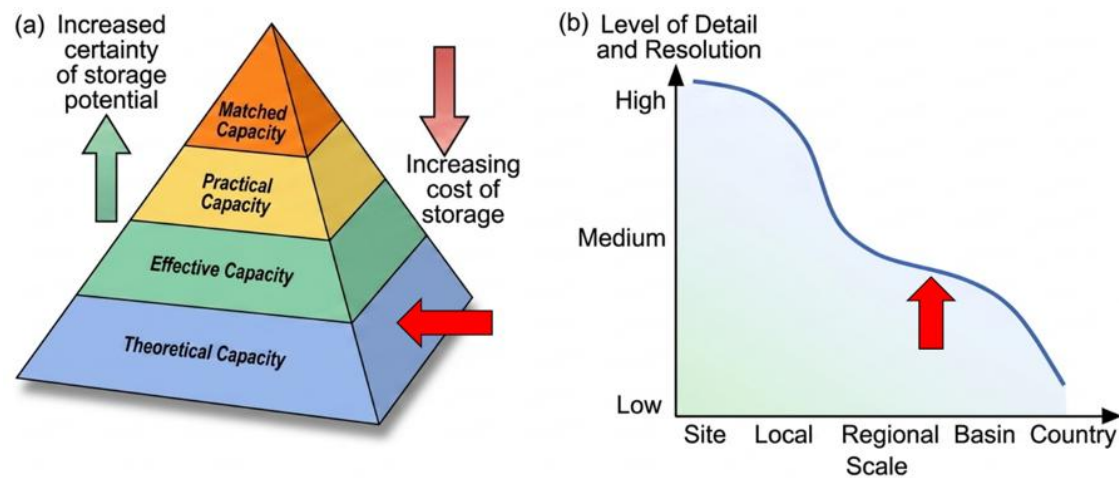


Figure 9.

Classification of the storage capacity and level of detail (Red arrow) of the study according to Bachu et al. (2007).

5. Acknowledgement

This study is predominantly founded on publicly available literature and open-access scientific data. The authors are grateful to PT. Pertamina EP Area 2 and PT. Pertamina EP Area 7 for authorizing the use of proprietary data and confidential technical reports. The authors are also grateful to the constructive engagement and intellectual contributions of colleagues at both organizations, whose insights and collaborative discussions proved instrumental to this study. Furthermore, the authors are grateful to Ms. Dhea Rizky Nurhadi from PT Pertamina EP Area 7, who provided petrophysical analysis used in this writing.

6. Declarations

6.1 Author contributions

O. T. Musakti served as the primary contributor to this paper. All other authors provided valuable input on the ideas and direction as well as reviewed and approved the final manuscript.

6.2 Funding statement

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

6.3 Competing interests

The author(s) declare no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

6.4 The use of AI or AI-assisted technologies

Artificial Intelligence (AI) technologies, specifically Jenni.AI and Perplexity, were utilized to perform grammatical checks on the final draft of this paper. Perplexity was also adopted to enhance, refine, and sharpen some of the figures included. All original ideas and data presented exclusively belonged to the authors.

7. Glossary of terms and symbols

Terms & Symbols	Definition	Unit
A	Field/reservoir area	m^2
H	Reservoir thickness	m
$\varnothing$	Porosity	vol/vol
S_w	Water saturation	vol/vol
RF	Recovery factor	%
ρ_{CO_2}	CO_2 Density	kg/m^3
$HCPV$	Hydrocarbon Pore Volume	m^3
CO_2	Carbon dioxide	
M_{CO_2}	CO_2 Storage Capacity	Tonne
SPI	Secondary Porosity Index	% or Decimal

8. References

- Ambarwati, W. L., Sulisty, D. M., & Fajar, M. (2018). Early Miocene carbonate diagenetic of Northwest Java Basin, implication to reservoir properties; case study Akasia Bagus structure. In *Proceedings of the Indonesian Petroleum Association Core Workshop*. Indonesian Petroleum Association.
- Aminu, M. D., Nabavi, S. A., Rochelle, C. A., & Manović, V. (2017). A review of developments in carbon dioxide storage. *Applied Energy*, 208, 1389–1419. <https://doi.org/10.1016/j.apenergy.2017.09.015>
- Bachu, S. (2003). Screening and ranking of sedimentary basins for sequestration of CO₂ in geological media in response to climate change. *Environmental Geology*, 44, 277–289. <https://doi.org/10.1007/s00254-003-0762-9>
- Bachu, S., & Grobe, M. (2006). Characterization of sites for geological storage of carbon dioxide. *Environmental Geosciences*, 13(2), 67–70. <https://doi.org/10.1306/eg.intro0606020906>
- Bachu, S., Bonijoly, D., Bradshaw, J., Burruss, R., Holloway, S., Christensen, N. P., & Mathiassen, O. M. (2007). CO₂ storage capacity estimation: Methodology and gaps. *International Journal of Greenhouse Gas Control*, 1(4), 430–443. [https://doi.org/10.1016/S1750-5836\(07\)00086-2](https://doi.org/10.1016/S1750-5836(07)00086-2)
- Best, D., Mulyana, R., Jacobs, B., Iskandar, U. P., & Beck, B. (2011). Status of CCS development in Indonesia. *Energy Procedia*, 4, 6152–6156. <https://doi.org/10.1016/j.egypro.2011.02.624>
- Boston Consulting Group. (2023). *Indonesia's CCS 2023 achievements and 2024 outlook* [Conference presentation]. International & Indonesia Carbon Capture and Storage Forum 2023.
- Callas, C., Saltzer, S. D., Davis, J. S., Hashemi, S. S., Kovscek, A. R., Okoroafor, E. R., Wen, G., Zoback, M. D., & Benson, S. M. (2022). Criteria and workflow for selecting depleted hydrocarbon reservoirs for carbon storage. *Applied Energy*, 324, Article 119668. <https://doi.org/10.1016/j.apenergy.2022.119668>
- Economic Research Institute for ASEAN and East Asia. (2023). Estimation of basin-scale CO₂ storage in Indonesia (Report prepared by Center for Technology Services National Research and Innovation Agency (BRIN) in collaboration with Testing Center for Oil and Gas LEMIGAS, and Center for Geological Survey – Geological Agency, Ministry of Energy and Mineral Resources).
- Hannis, S., Lu, J., Chadwick, A., Hovorka, S., Kirk, K., Romanak, K., & Pearce, J. (2017). CO₂ storage in depleted or depleting oil and gas fields: What can we learn from existing projects? *Energy Procedia*, 114, 5680–5690. <https://doi.org/10.1016/j.egypro.2017.03.1707>
- International Energy Agency. (2021). *Carbon capture, utilisation and storage: The opportunity in Southeast Asia*.
- International Energy Agency. (2022). *An energy sector roadmap to net zero emissions in Indonesia*.
- Iskandar, U. P., & Syahrial, E. (2009). Carbon capture and storage (CCS)–enhanced oil recovery (EOR): Global potential in Indonesia. *Scientific Contributions Oil and Gas*, 32(3), 228–238. <https://doi.org/10.29017/SCOG.32.3.855>
- Iskandar, U. P., & Usman. (2011). CO₂ storage capacity estimation of depleted oil and gas reservoirs in Indonesia. *Scientific Contributions Oil and Gas*, 34(1), 53–59. <https://doi.org/10.29017/SCOG.34.1.791>
- Kaya, Y., & Yokobori, K. (Eds.). (1997). *Environment, energy, and economy: Strategies for sustainability*. United Nations University Press.
- Lai, Y. T., Shen, C. H., Tseng, C. C., Fan, C. H., & Hsieh, B. Z. (2015). Estimation of carbon dioxide storage capacity for depleted gas reservoirs. *Energy Procedia*, 76, 470–476. <https://doi.org/10.1016/j.egypro.2015.07.887>
- LAPI-ITB. (2025). *Final report Akasia Bagus CCS feasibility study 2023–2024: Prepared for Pertamina Hulu Energi–Upstream Innovation* [Unpublished internal report].
- Metz, B., Davidson, O., de Coninck, H., Loos, M., & Meyer, L. (Eds.). (2005). *IPCC special report on carbon dioxide capture and storage*. Cambridge University Press.

- Pertamina EP. (2016). *Plan of further development Lapangan Tugu Barat (TGB)* [Unpublished internal report].
- Pertamina EP. (2017). *Plan of development Lapangan Akasia Bagus (ABG)* [Unpublished internal report].
- Raza, A., Rezaee, R., Gholami, R., Bing, C. H., Nagarajan, R., & Hamid, M. A. (2016). A screening criterion for selection of suitable CO₂ storage sites. *Journal of Natural Gas Science and Engineering*, 28, 317–327. <https://doi.org/10.1016/j.jngse.2015.11.053>
- Sugihardjo, Usman, & Tobing, E. M. L. (2012). Preliminary carbon utilization and storage screening of oil fields in South Sumatra Basin. *Scientific Contributions Oil and Gas*, 35(2), 57–65. <https://doi.org/10.29017/SCOG.35.2.778>
- Sugihardjo. (2021). Penyaringan dan peringkat Cekungan Kalimantan Timur serta potensinya untuk implementasi CCUS. *Lembaran Publikasi Minyak dan Gas Bumi*, 55(3), 167–185. <https://doi.org/10.29017/LPMGB.55.3.706>
- Tomić, L., Karović Maričić, V., Danilović, D., & Crnogorac, M. (2018). Criteria for CO₂ storage in geological formations. *Underground Mining Engineering*, 32, 61–74. <https://doi.org/10.5937/PodRad1832061T>
- Usman, Iskandar, U. P., Sugihardjo, & Lastiadi, H. (2014). A systematic approach to source–sink matching for CO₂ EOR and sequestration in South Sumatera. *Energy Procedia*, 63, 7750–7760. <https://doi.org/10.1016/j.egypro.2014.11.809>
- Wei, B., Wang, B., Li, X., Aishan, M., & Ju, Y. (2023). CO₂ storage in depleted oil and gas reservoirs: A review. *Advances in Geo-Energy Research*, 9(2), 76–93. <https://doi.org/10.46690/ager.2023.08.02>
- Widodo, R. W. (2018). *Evolution of the Early Miocene carbonate: Baturaja Formation in Northwest Java Basin, Indonesia* [Doctoral dissertation, Texas A&M University]. OAKTrust. <https://oaktrust.library.tamu.edu/items/6fd5b503-7e67-44a0-aa3f-92d09f235d0c>