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Evaluation of Sour Gas Field Development Strategy: A Feasibility Study in Indonesia using PSC Gross Split Mechanism

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Abstract:

PetroComp, a private oil and gas operator in Eastern Indonesia, has a limited room for gas production growth. A potential new long-term gas sales agreement (GSA) with PT. SMC, could double PetroComp's gas production and address its long-term growth needs. Jala field is the potential undeveloped resource to fulfill the gas demand requirement, however it contains high CO2 concentration which presents substantial investments for its development. Three development scenarios of Jala field are evaluated in the study, including a potential integration of CCUS. This study aims to evaluate the economic feasibility of the three development scenarios of Jala sour gas field using a Discounted Cash Flow (DCF) method to determine the best development strategy for PetroComp and Government of Indonesia. Conventional onshore development approach provides the highest NPV at US$ 113.8 million, meanwhile CCUS and full offshore development scenarios are not economic due to its high investment cost. Gas production volume and gas price are the most sensitive parameters affecting the project's profitability based on the sensitivity analysis. Uncertainty analysis suggests a promising thick positive NPV is expected from the project with the P90-P50-P10 cases are ranging from US$ 50.8 – 173.9 million. Time-dependent evaluation concludes the impact on profitability start to de-escalate exponentially if the project is delayed for more than four years (>10% NPV impact) at the given PSC period until 2045. This study is intended to support evidence-based decision-making by PetroComp in developing the high-CO2 Jala gas field and advancing the company's long-term growth strategy.

Keywords: *Gas Field Development; PSC Gross Split; Carbon Capture, Utilization and Storage (CCUS); Economic Evaluation, Discounted Cash Flow*

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1. Introduction

Oil and gas remain fundamental energy sources globally, having fueled industrial growth, transportation, and electricity generation for decades, thereby driving economic development and societal progress (Stern, 2007). Recognizing the critical role of hydrocarbons in meeting energy demands, the Indonesian government has set ambitious targets to increase oil production to 1 million barrels of oil per day (MMBOPD) and to double natural gas output from 6 billion standard cubic feet per

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day (BSCFD) in 2024 to 12 BSCFD by 2030. This national push reflects Indonesia's strategic priority to secure energy supply and stimulate economic growth. In response, PetroComp, a private oil and gas company operating in Eastern Indonesia, is actively pursuing opportunities to expand its gas portfolio through new Gas Sales Agreements (GSA). One significant opportunity arises from PT. SMC, a downstream mining company planning to develop a nickel smelter in East Indonesia with a projected gas demand of 40 billion British thermal units per day (BBTUD). Given its geographical proximity and infrastructure feasibility, pipeline-supplied gas from PetroComp's Jala field is considered the most viable solution to meet this demand, positioning PetroComp to potentially double its gas production.

However, the development of the Jala field presents considerable technical and economic challenges, primarily due to the high carbon dioxide (CO_2) content in the undeveloped reserves. The presence of acid gas necessitates complex operations and significant capital investment in an Acid Gas Removal Unit (AGRU), which increases project costs and operational risks (Roussanaly et al., 2021). Given the substantial financial commitment involved, a comprehensive engineering and economic evaluation is crucial to ascertain the project's viability. This study focuses on assessing the economic feasibility of three development scenarios for the Jala field, including the integration of a Carbon Capture, Utilization, and Storage (CCUS) business model, which is increasingly recognized as a vital technology to mitigate CO_2 emissions and align with global decarbonization trends (Parry, Black, & Zhunussova, 2022; Sheikhtajian, Bagherinejad, & Mohammadi, 2024). Furthermore, the study provides a novel case analysis of CCUS incorporation within the framework of Indonesia's Production Sharing Contract (PSC) Gross Split mechanism, which influences revenue sharing and risk allocation between contractors and the government (Rulandari et al., 2018).

The economic evaluation employs the Discounted Cash Flow (DCF) method to analyze key financial metrics such as Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period to identify the optimal development strategy that maximizes value for both PetroComp and the Indonesian government. Sensitivity and uncertainty analyses are conducted using Monte Carlo simulation techniques to identify critical parameters that impact project profitability and to quantify investment risk under varying operational and market conditions (Pannell, 1997; Or et al., 2023). Additionally, time-dependent evaluations examine how potential project delays may affect economic outcomes, providing strategic insight into risk management and decision-making (Sakakibara & Kanamura, 2025; Tao, 2024). By integrating technical, economic, and risk perspectives, this study aims to contribute to sustainable oil and gas development strategies in Indonesia amid the global energy transition (Saraswani & Hakam, 2024; Shokouhi, Khademvatani, & Beiky, 2024; Wheelen & Hunger, 2012).

2. Theoretical Background

Researchers have conducted investment evaluation using DCF method in various industry as shown in Table 1. The studies cover the DCF method implementation in oil and gas projects (Agusyasa & Nainggolan, 2023; Hutauruk & Prawiraatmadja, 2021; Indrasatwika & Prawiraatmadja, 2018; Kamil & Prawiraatmadja, 2019; Kemala & Hakam, 2024; Mahfoedz & Prawiraatmadja, 2023; Saraswani & Hakam, 2024; Sheikhtajian et al, 2024), geothermal (Husein & Hakam, 2024), electricity (Abdelhady, 2020; Dimanchev et al, 2023; Or, 2023; Paradongan & Hakam, 2023; Sakakihara & Kanamura, 2025; Tao, 2024), refinery (Mellichamp, 2019; Shokouhi, 2024), mining (Giovanni et al, 2017) and logistic (Jeong & Yun, 2023). These researches utilize DCF method in analyzing project’s valuation and comparison with other valuation technique.

In some researches, Real Options Valuation (ROV) method is utilized along with DCF as benchmarked methodology in performing project’s valuation (Dimanchev et al, 2023; Kemala & Hakam, 2024; Or et al, 2023; Sakakihara & Kanamura, 2024; Saraswati & Hakam, 2025; Sheikhtajian et al, 2024). However, in this study, the common DCF method is considered sufficient in determining project’s valuation combined with sensitivity analysis, uncertainty analysis and time-dependent evaluation approaches.

Sensitivity analysis applied by previous researches in determining the key sensitive parameters to research objectives (Abdelhady, 2020; Agusyasa & Nainggolan, 2023; Giovanni et al, 2017; Husein & Hakam, 2017; Hutauruk & Prawiraatmadja, 2021; Indrasatwika & Prawiraatmadja, 2018; Kamil & Prawiraatmadja, 2019; Kemala & Hakam, 2024; Mahfoedz & Prawiraatmadja, 2023; Or et al, 2023; Saraswati & Hakam, 2024; Sheikhtaijian et al, 2024; Shoukuhi et al, 2024; Tao, S., 2024). This analysis helps authors and stakeholders to navigate on variables that have major impact on project’s valuation.

In making investment decisions, volatility holds major impact on project’s valuation. Uncertainty analysis helps researchers to quantify the range of uncertain values in the future in navigating the investment insight. Monte Carlo simulation is the most common approach used for uncertainty analysis in previous researches (Agusyasa & Nainggolan, 2023; Dimanchev et al, 2023; Jeong & Yun, 2023; Kamil & Prawiraatmadja, 2019; Or et al, 2023; Saraswani & Hakam, 2024, Shokouhi et al, 2024). Latin Hypercube approach is an alternative approach of uncertainty analysis by customized data selection to ensure all data range are covered to minimize data sample (Shokouhi et al, 2024). However, if there is no constraint on data sample, Monte Carlo simulation is sufficient to represent the uncertain range of the result.
Time-dependent evaluation is a simple approach conducted by Author to offer the sensitivity analysis of a project’s NPV as a function of time. This approach is conducted to accommodate the integration of project’s timeline uncertainty and other economic variables of the project. It provide the insights of potential upside and risk on project’s valuation due to the project’s timeline.

Mahfoedz & Prawiraatmadja (2023) and Saraswani & Hakam (2025) studied the impact of CCUS in PSC cost recovery scheme, where this study fill the knowledge gap of the case study on the potential CCUS integration from PSC gross split mechanism perspective. In PSC gross split mechanism, all investments incurred to the Contractors. Contrarily, all investments are cost recovered by the Government in PSC cost recovery mechanism through production split. Different fiscal term framework applied in this study might provide different outcomes on the applicability of CCUS in oil and gas PSC.

Table 1. Research methods literature review summary

No.	Authors & Year	Research Context	Industry	Country	Research Method and Feature
01.	Agusyasa & Nainggolan (2023)	EOR projects investment evaluation	Oil and Gas	Indonesia	DCF, SA, MCS
02.	Hutauruk & Prawiraatmadja (2021)	Valuation of gas field development and sensitivity analysis	Oil and Gas	Indonesia	DCF, SA
03.	Indrasatwika & Prawiraatmadja (2018)	Gas development project investment evaluation	Oil and Gas	Indonesia	DCF, SA
04.	Kamil & Prawiraatmadja (2019)	Oil block termination evaluation	Oil and Gas	Indonesia	DCF, SA, MCS
05.	Kemala & Hakam (2024)	Offshore gas development investment evaluation	Oil and Gas	Indonesia	ROV, DCF, SA
06.	Mahfoedz & Prawiraatmadja (2023)	Valuation of CCUS in gas field development investment	Oil and Gas	Indonesia	DCF, SA
07.	Saraswani & Hakam (2024)	Valuation of CCS investment in oil and gas block	Oil and Gas	Indonesia	DCF, ROV, SA, MCS
08.	Sheikhtajian et al (2024)	CCUS investment evaluation	Oil and Gas	Netherlands	DCF, ROV, SA
09.	Husein & Hakam (2024)	Geothermal power plant investment evaluation	Geothermal	Indonesia	DCF, SA, RETScreen
10.	Abdelhady, S. (2020)	Solar dish power plant investment evaluation	Electricity	Egypt	DCF, SA
11.	Dimanchev et al. (2023)	EV Charging Investment Evaluation	Electric Vehicle	N/S	DCF, ROV, MCS
12.	Or et al. (2023)	Residential PV investment evaluation	Electricity	Turkey	DCF, ROV, SA, MCS
13.	Paradongan & Hakam (2023)	Feasibility study of solar PV power plant investment	Electricity	Indonesia	DCF, RETScreen
14.	Sakakibara & Kanamura (2025)	Wave power generation plant investment evaluation	Electricity	Japan	DCF, ROV
15.	Tao, S. (2024)	Offshore power grid investment model and valuation	Electricity	Norway-UK	DCF, SA
16.	Mellichamp, D. A. (2019)	Refinery investment evaluation	Refinery	N/S	DCF
17.	Shokouhi et al. (2024)	Oil refinery investment evaluation	Refinery	Iran	DCF, SA, MCS, LH
18.	Giovanni et al. (2017)	Feasibility of open pit gold mine investment	Mining	N/S	DCF, SA
19.	Jeong & Yun (2023)	Valuation of container ship's fuel alternatives	Logistics	China-UAE-Europe	DCF, MCS
20.	This Study	Offshore sour gas development investment evaluation	Oil and Gas	Indonesia	DCF, SA, MCS

Note:
N/S – Not Specified, DCF – Discounted Cash Flow, ROV – Real Options Valuation, SA – Sensitivity Analysis, MCS – Monte Carlo Simulation, LH – Latin Hypercube

3. Methodology

This research is mainly a qualitative study that focuses on exploring alternative development scenario of Jala field development using DCF method within PSC Gross Split fiscal term, performing sensitivity and uncertainty analysis of the selected investment strategy.

Conceptual Framework

The conceptual framework of the study, illustrated in Figure 1, begins with identifying strategic opportunity for PetroComp's growth through Jala field development. The core objective is to determine the optimal scenario among three defined development concepts, identifying key economic drivers and assessing business risks.

Discounted Cash Flow method is used as key evaluation tools to select the optimum scenario based on its key economic metrics within PSC gross split fiscal framework. The selected scenario is further analyzed through sensitivity analysis, uncertainty analysis and time dependent evaluation to understand most influential driver to the project's economics, quantify the investment risks and impact of potential project delay.

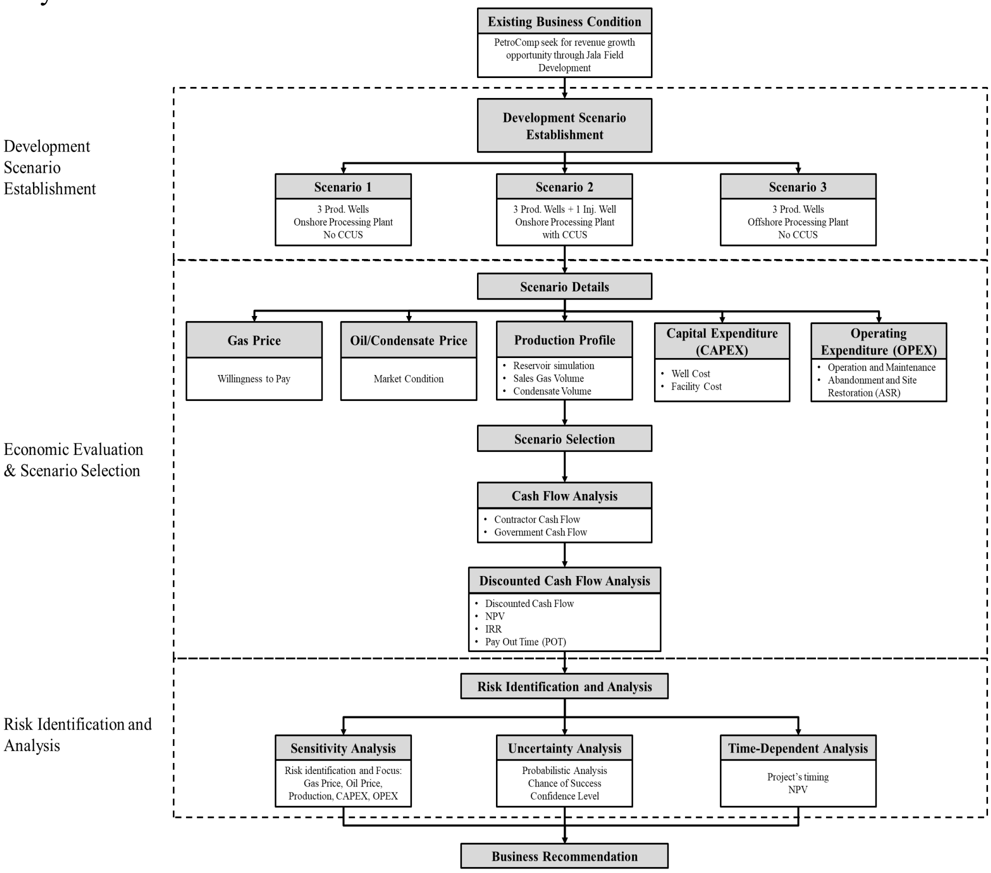

Figure 1. Conceptual Framework of the study

Data Analysis

PSC Gross Split Fiscal Term

Gross Split fiscal term which is applied in PetroComp refer to Ministry of Energy and Mineral Resources (MEMR) Regulation no. 52 year 2017, a revision of the previous MEMR Regulation no. 08 year 2017. The regulation explains detail revenue split between Government of Indonesia and Contractor, Domestic Market Obligation (DMO), Taxation system and Expense management of the Gross Split system as presented in Figure 2.

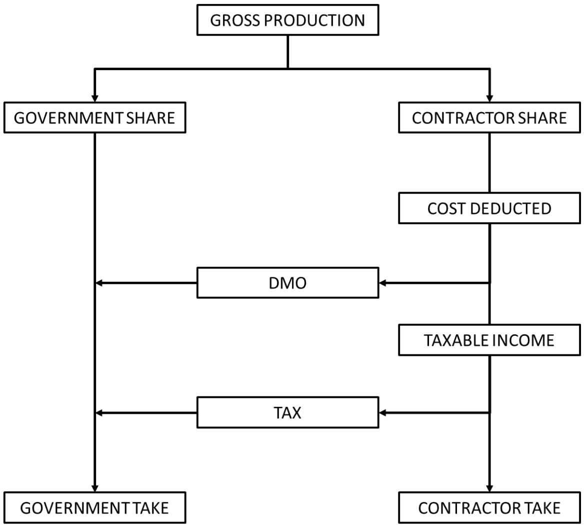

Figure 2. PSC gross split mechanism

Gross revenue of the project is represented as R_{total} which consists of oil/condensate and gas sales revenue:

$$R_{total} = (Q_{oil} \times P_{oil}) + (Q_{gas} \times P_{gas}) \quad (1)$$

whereas, Q_{oil} is oil rate, P_{oil} is the oil price, Q_{gas} is gas rate and P_{gas} is the gas price.
The total gross revenue of the project should be split into Contractor and Government's part based on the regulated splits factor. In general, there are three split factor involved in the calculation, such as variable split, progressive split and discretion:

$$S_{contractor} = S_{base} + S_{variable} + S_{progressive} + S_{discretion} \quad (2)$$

$$S_{government} = 1 - S_{contractor} \quad (3)$$

whereas, $S_{contractor}$ is total Contractor's split, S_{base} is total base split, $S_{variable}$ is variable split based on the asset operational condition, $S_{progressive}$ is progressive split based on production cumulative and oil/gas price, $S_{discretion}$ is additional split given by MEMR to the Contractor based on commerciality factor of the project or asset.
Domestic Market Obligation (DMO) might be applied if oil and gas production are produced for non-domestic market. Government of Indonesia regulates all oil and gas companies in Indonesia to allocate minimum 25% of its production into local market. In the case of PetroComp, all of its market are Indonesia oil and gas buyers, therefore there is no DMO fee applied.

Taxable income is total earnings received by the Contractors substracted by all expenses related to the operation, DMO and Depreciation. The term commonly called as earnings before interest and tax (EBIT):

$$EBIT = (R_{total}\ x\ S_{contractor}) - (CAPEX + OPEX + DMO_{fee} + Depreciation) \quad (4)$$

whereas, *CAPEX* is capital expenditure or investment, *OPEX* is operating expenditure, DMO_{fee} is DMO fee and *Depreciation* refers to depreciation of asset investment.

Income tax, represented as TAX_{income}, in oil and gas business consists of direct tax and deviden tax:

$$TAX_{income} = EBIT\ x\ [PPh + (1 - PPh) x\ Tax_{deviden})] \quad (5)$$

whereas, *PPh* is direct tax regulated at 25% and $Tax_{deviden}$ is withholding tax based on Contractor's shareholder position (Domestic shareholder regulated at 15%, while foreign shareholder regulated at 20%)

Final contractor take is represented as net operating cash flow after tax, CF_t. The calculation is represented as:

$$CF_t = EBIT\ x\ (1 - TAX_{income}) + Depreciation \quad (6)$$

Economic Evaluation – Discounted Cash Flow

Economic evaluation in this chapter refers to DCF method used for project's valuation. According to Gitman & Zutter (2015), there are several key financial metrics which typically used for investment evaluation, such as: Net Present Value, IRR and payback period. These parameters are suitable to represent project's valuation, especially in capital intensive industry like oil and gas, by considering future value of money and return factor of an investment.

Net Present Value (NPV) is the most common key financial metrics that represent the total present values of multi-year cash flow of an investment or project:

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+i)^t} \quad (7)$$

whereas, *i* is discount rate and *t* is reference time or year of the investment. A project is acknowledged to economically feasible if positive NPV is achieved. However, positive NPV doesn't necessarily reflect an investment to be attractive, additional financials metrics criteria are also considered. Evaluation of project's NPV is limited to the PSC expiry in 2045.

Another key measure for project's valuation is the Internal Rate of Return (IRR), which is defined as the discount rate that equates the NPV value of an investment is zero (Gitman & Zutter, 2015). It represents the cost of capital breakeven barrier of an investment. In other words, it is the condition when the present value of cash inflows equals to the initial investment. IRR can be expressed in an equation below:

$$\sum_{t=1}^{n} \frac{CF_t}{(1+IRR)^t} = CF_0 \quad (8)$$

whereas, CF_0 refers to the initial investment.

Payback period represents the amount of time (*t*) required for an investment to generate enough cash flows to recover its initial investment.

$$\sum_{t=1}^{n} CF_t = 0 \tag{8}$$

Sensitivity Analysis, Uncertainty Analysis and Time-dependent Evaluation
Sensitivity and uncertainty analysis are methods used to assess the influence of key variables on financial outcomes and identifying investment risks.

Sensitivity analysis measures how changes in input variables affect financial metrics. The technique really powerful to identify the most sensitive variables to the project's financial performance. By pinpointing these sensitive parameters, Contractor is able to focus on optimizing certain variables in maximizing the return. Results are commonly presented in Spider or Tornado charts. In this study, sensitivity analysis is conducted by considering ±20% variation on several input variables: production, gas price, oil price, CAPEX and OPEX. This range of variation in key input variables is sufficient to represent the uncertainty of market fluctuation and detail engineering evaluation's margin of error. Regulatory parameters (e.g. production split, tax tariff, DMO, etc.) are not part of the sensitivity because of well-defined value in PSC document and regulatory framework.

The general formula of sensitivity analysis is expressed below:

$$Sensitivity = \frac{\%\ Change\ in\ Output}{\%\ Change\ in\ Input} \tag{9}$$

Uncertainty analysis is a method in financial performance evaluation on predicting investment risk by incorporating uncertain factors of input variables. The most common technique used for uncertainty analysis is Monte Carlo simulation. It captures all uncertain possibilities or scenarios of the input variables' combination resulting thousands to millions experiments of financial evaluation. The outcome of the evaluation typically expressed in a statistical distribution model that represents investment's chance of success and level of confidence. Similar to sensitivity analysis, uncertainty analysis using Monte Carlo simulation utilizing the five key variables (production, gas price, oil price, CAPEX and OPEX) with ±20% variation resulting of 1,000 scenarios. The simulation process is generated by VBA and Phyton programs.

Time-dependent evaluation is an approach of evaluating project's financial metrics performance as a function of time. As the PetroComp's PSC agreement is limited to 2045, project's onstream timing could impact the financial metrics result by the end of the PSC. This evaluation provide insight to the PetroComp's team on the impact of potential project's delay to the valuation. In this study, the range of project's onstream assumptions are within 2029 – 2037 as benchmarked to basecase in 2030.

Case Study Description
Three development scenario are assessed in evaluation to obtain the best development strategy for Jala Field. Development scenarios are based on internal engineering evaluation and benchmarked to historical external consultant studies on offshore

development in other companies. Located in offshore with 11% CO_2 content and high H_2S concentration are considered challenging for the scale of PetroComp. Thorough evaluation of development scenario is mandatory to select the best scenario that provide the best return for the company.

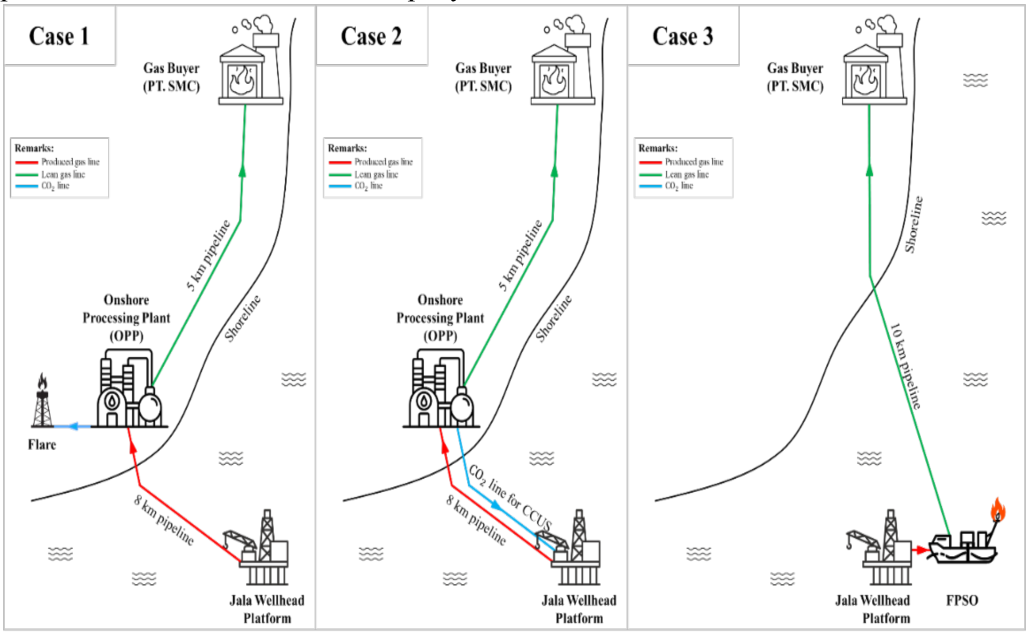

Figure 3. Three development scenario of Jala field development

Table 2. Jala field development scenario description

Parameters	Case 1	Case 2	Case 3
Facilities	1 Wellhead Platform	1 Wellhead Platform	1 Wellhead, Platform, 1 FPSO
Processing Plant	Onshore	Onshore	Offshore (FPSO)
Flare	Yes – Onshore	No	Yes – Offshore
CO_2 injection	No	Yes	No
No. of Wells	3 – producers	3 – producers 1 – injection	3 – producers
CR Pipeline	8 km – onshore to OPP	8 km – onshore to OPP 8 km – CCUS line	1 km – gross gas to FPSO
Sales Pipeline	5 km – OPP to buyer	5 km – OPP to buyer	10 km – FPSO to buyer

Note:
FPSO – Floating Production Storage and Offloading, OPP – Onshore Processing Plant, CR – Corrosion Resistance

Case 1 presents the simplest development concept, involving a dedicated Onshore Processing Plant (OPP) near the shoreline and PetroComp's existing facilities. Acid gas is flared to atmosphere as per conventional practice. Similarly, Case 3 adopts separate and flare mechanism for its acid gas, but from an offshore development standpoint. This practice is commonly applied by contractors in Indonesia and supported by MEMR Regulation No. 17 Year 2021, stating that flaring gas with high impurities is allowable if utilization is not feasible technically or economically. Ministry of Environment (ME) Regulation No. 13 Year 2009 that regulates flaring criteria also does not include CO_2 as a limiting factor for unavoidable flaring.

Case 2 explores a CCUS approach by reinjecting the separated CO_2 gas into the reservoir utilizing one injector well. The scenario will retain the pressure depletion of the field which consequently sustain its hydrocarbon gas production, this technique is called as Enhance Gas Recovery (EGR). This scenario is incorporated to accommodate the global trend of low-emission operation trend in the future.

The amount of Capital Expenditure (CAPEX) associated to all three cases of Jala field development scenario are generated from internal engineering analysis based on historical Preliminary Front End Engineering Study (Pre-FEED) of analogue fields nearby represented in the Table 3, while the Operating Expenditure (OPEX) is represented in Table 4.

Table 3. CAPEX for Jala field development scenario

CAPEX	CASE 1 MUS$	CASE 2 MUS$	CASE 3 MUS$
Drilling	98,040	140,524	98,040
Facility	119,532	223,613	264,628
Total Capex Drilling + Facility	217,572	364,137	362,668

Table 4. OPEX related to wells and facilities

OPEX (MUS$/year)	CASE 1 MUS$	CASE 2 MUS$	CASE 3 MUS$
Wells	700	700	700
Facility	3,071	6,788	4,351
Total OPEX Drilling + Facility	3,771	7,488	5,051

Three development wells are considered optimum for Jala Field with one additional injector well associated with Case 2 development scenario. Facility CAPEX consists of wellhead platform, FPSO hull, Acid Gas Removal Unit (AGRU), Gas Dehydration package, water and condensate separation and treatment package, compression package, instrumentation and metering System. OPEX components mainly are required for asset maintenance in supporting the production until 2045 with 2.5% escalation assumption per year. Variable OPEX of MUS$ 0.3/MBOE is incorporated for consumable.

The Jala field production is generated using commercial numerical reservoir simulation by the Author as part of the Subsurface Team. Total sales gas demand is 40 BBTUD within 5-year plateau period and 100% absorption guarantee afterward. Economic evaluation of the study is limited to the PSC period which will end in 2045. Sales gas and condensate rate forecast for Case 1 and Case 3 are identical following the similar development operating condition applied for both cases. Case 2 able to deliver higher total gas sales volume than Case 1 and Case 3 because of the CCUS impact that sustain Jala field production longer through Enhanced Gas Recovery (EGR). Sales parameters are presented in Table 5.

Table 5. Sales parameters

Parameters	Value	Remarks
Sales rate demand	40 BBTUD	Min. 5-year plateau rate
Case 1 Sales (Gas/Cond)	182.6 TBTU / 2.58 MMSTB	Without CCUS
Case 2 Sales (Gas/Cond)	190.8 TBTU / 2.77 MMSTB	With CCUS
Case 3 Sales (Gas/Cond)	182.6 TBTU / 2.58 MMSTB	Without CCUS
Case 2 CO_2 storage	1.38 $MtCO_2eq$	CO_2 storage until 2045

The monetization assumed in this study is derived solely from gas and condensate sales. Carbon credit and carbon tax had not yet been implemented at the time this study was conducted. Therefore, no revenue from carbon trading is assumed.

Table 6. Variable assumptions input for Economic Evaluation

Parameters	Value	Remarks
Prod Split (Gas/Oil)	Contr. (75%/78.25%) Gov. (25%/21.75%)	PSC document. Progressive split changes as function of production
Oil Price	US$69/BBL	5-year ICP and WTI crude price (ESDM, 2024; Investing.com, 2024)
Gas Price	US$6.1/MMBTU	Benchmarked gas price for Indonesia power plants US$4-8.3/MMBTU (Petromindo, 2024)
ASR	20% CAPEX	Typical to current asset's ASR
Depreciation method	Double decline (5 years)	Advised in PSC document
LBT	Tax tariff : 0.5% Taxable portion: 40% Capitalization: 10.04 Gas price slope: 17.92%	Advised in PSC document
DMO	100%	No value reduction – 100% local
Income Tax Tariff	40%	Advised in PSC document

Note:
ICP – Indonesia Crude Price, WTI – West Texas Intermediate, ASR – Abandonment and Site Restoration, LBT – Land and Building Tax, DMO – Domestic Market Obligation

4. Empirical Findings/Result and Discussion

DCF analysis

DCF models of three development scenarios concludes different results. Distribution of cumulative DCF model of Case 2 and Case 3 remains in negative value by 2045, while the DCF model of Case 1 starts to reach positive value in 2034 as represented in Figure 4.1. The Contractor's NPV in Case 1 shows a promising result of MMUS$ 113.8 by 2045, IRR 20.83% and 5.6 years payback period. In contrary, Case 2 and Case 3 project negative Contractor's NPV at MMUS$ -18.5 and MMUS$ -10.7, low IRR of below 10% and longer payback period for more than 7 years.

Contractor's perspective considers Case 2 and Case 3 are not attractive economically due to negative NPV, IRRs are lower than <10% and long payback period. These low financial metrics are mainly driven by the bigger investment required in the early phase development for CCUS or offshore-focus CAPEX following the given scenario. This finding supports the previous studies from Mahfoedz & Prawiraatmadja (2023) and Saraswani & Hakam (2024) that CCUS heavily burden the oil and gas block's economic due to its investment significance.

In contrast, Case 1 offers a thick positive NPV, high IRR and short payback period which mainly driven by lowest investment requirement to deliver the hydrocarbon and comply with the sales and environmental requirement. Similarly, from Government stand point, Case 1 offers the highest Government's take and NPV compared to Case 2 and Case 3. This scenario will enable multi-industry development in Eastern Indonesia.

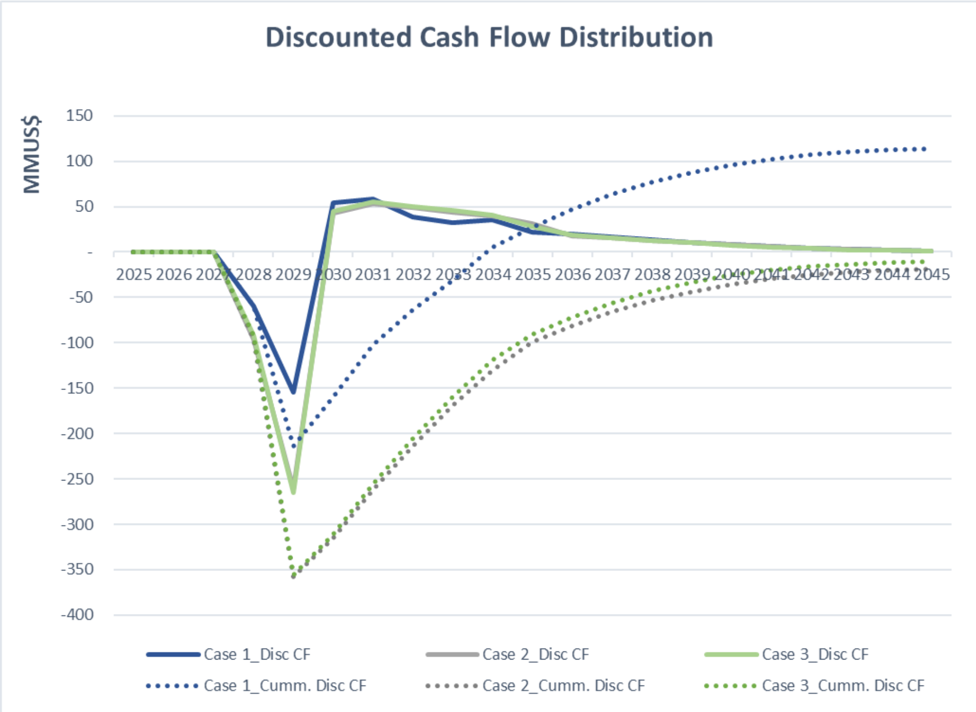

Figure 4. DCF comparison of Case 1, Case 2 and Case 3

Table 7. Economic evaluation summary - Jala field development

Summary	Unit	Case 1	Case 2	Case 3
IRR, %	%	20.83%	8.86%	9.32%
Payback Period, years	Years	5.6	7.8	7.6
Contr Cash Flow	MUS$	371,834	238,069	241,651
Contr. NPV 10%	MUS$	113,790	-18,530	-10,761
GOI Take	MUS$	575,631	523,609	506,886
Gov. NPV 10%	MUS$	284,428	254,840	251,630

Evaluation of DCF analysis suggests that Case 1 deliver the optimum scenario for Jala field development both for Contractor and Government. Therefore, Case 1 is selected as the development scenario and used for further analysis.

Sensitivity and Uncertainty analysis

Sensitivity analysis is conducted to evaluate key parameters of the investment which affecting the project's NPV. In this study, the selected Case 1 becomes the object of the sensitivity evaluation, a swing of 20% variation on several parameters (e.g. production, gas price, oil price, CAPEX and OPEX) as key inputs of DCF evaluation are performed and changes on NPV are evaluated as shown in Table 8 below:

Table 8. Sensitivity analysis result on NPV of various key parameters

NPV (MUS$)	Base NPV	+20% NPV	-20% NPV	ΔNPV% (+20%)	ΔNPV% (-20%)
Production	113,790	173,729	52,696	53%	-54%
Gas Price	113,790	153,764	69,198	35%	-39%
Oil Price	113,790	120,352	106,347	6%	-7%
CAPEX	113,790	81,679	145,145	-28%	28%
OPEX	113,790	109,591	117,989	-4%	4%

The tornado chart and spider plot present the significance of parameters affecting the project's NPV. As illustrated in Figure 5 and Figure 6 production and gas price are the top two of the most significant parameters to the project economic outcomes. By creating a variation of ±20%, the project's NPV impacted by 35%-54% from both parameters. This represent that production capacity or reserve and gas price are the top key parameters that PetroComp should focus to minimize the risk of the investment. Ensuring high production capability and settling a good negotiation on gas price will maximize the return for PetroComp and Government.

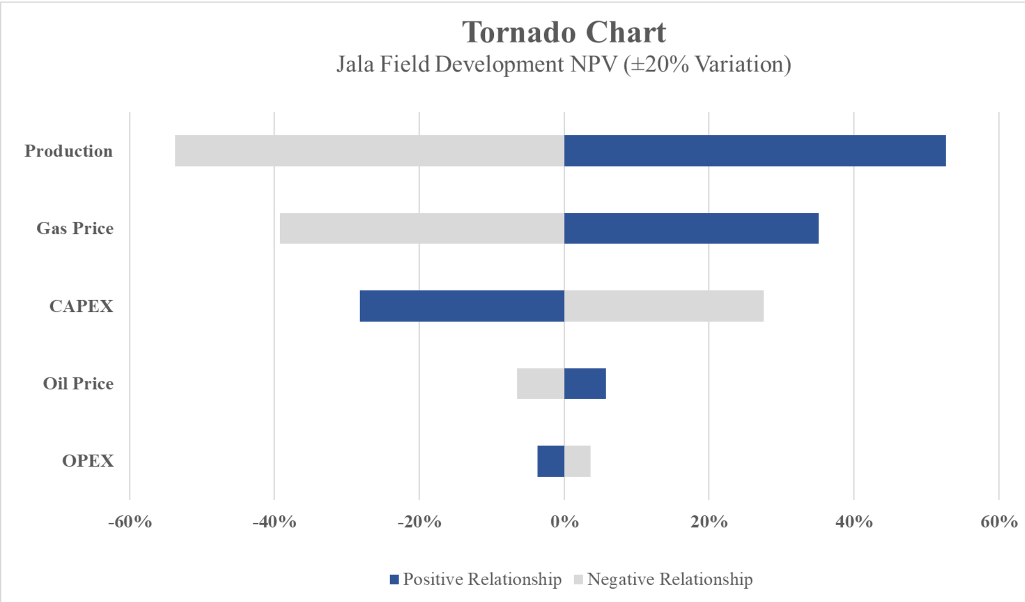

Figure 5. Tornado chart of parameters impact on NPV

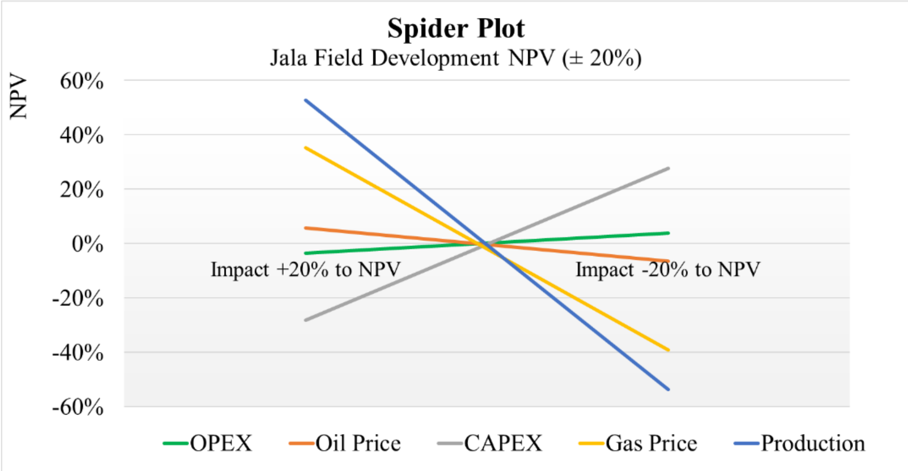

Figure 6. Spider plot of parameters impact on NPV

Uncertainty analysis is performed to illustrate the actual situation where uncertainty exists in several parameters involved in the evaluation. Using Case 1 as a basis and the same five key parameters above, combinations of variability from the key parameters are captured in the Monte Carlo simulation. In this evaluation, one thousand (1,000) samples of combination parameters' variation are evaluated through random numbers within 20% variability. A cumulative distribution function (CDF) is part of the outcome to determine the uncertainty of the project's NPV using probabilistic approach considering the chance of success and chance of success. The final outcome of the uncertainty analysis is presented in Figure 7 and Figure 8.

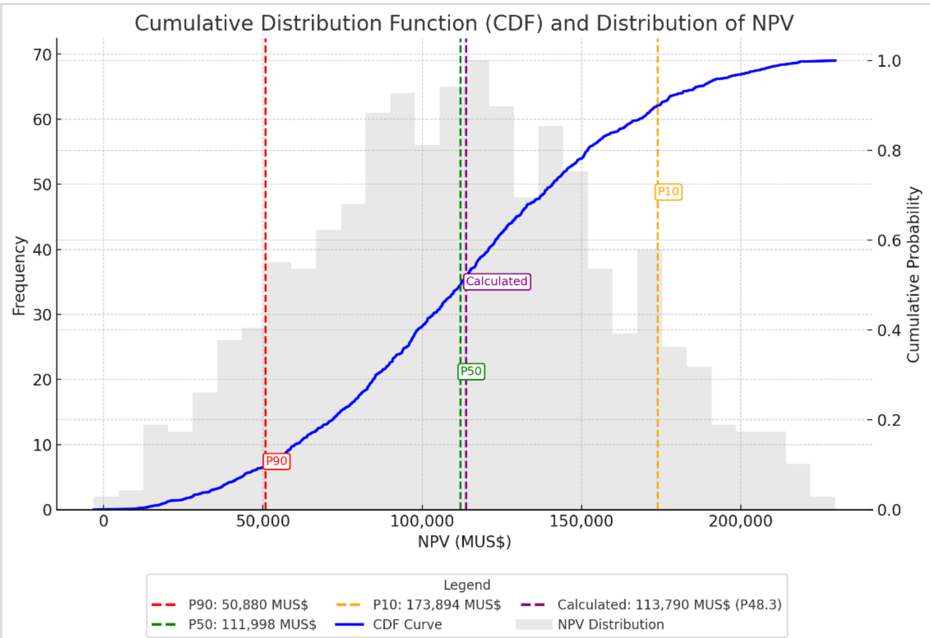

Figure 7. NPV CDF of uncertainty analysis (monte carlo simulation)

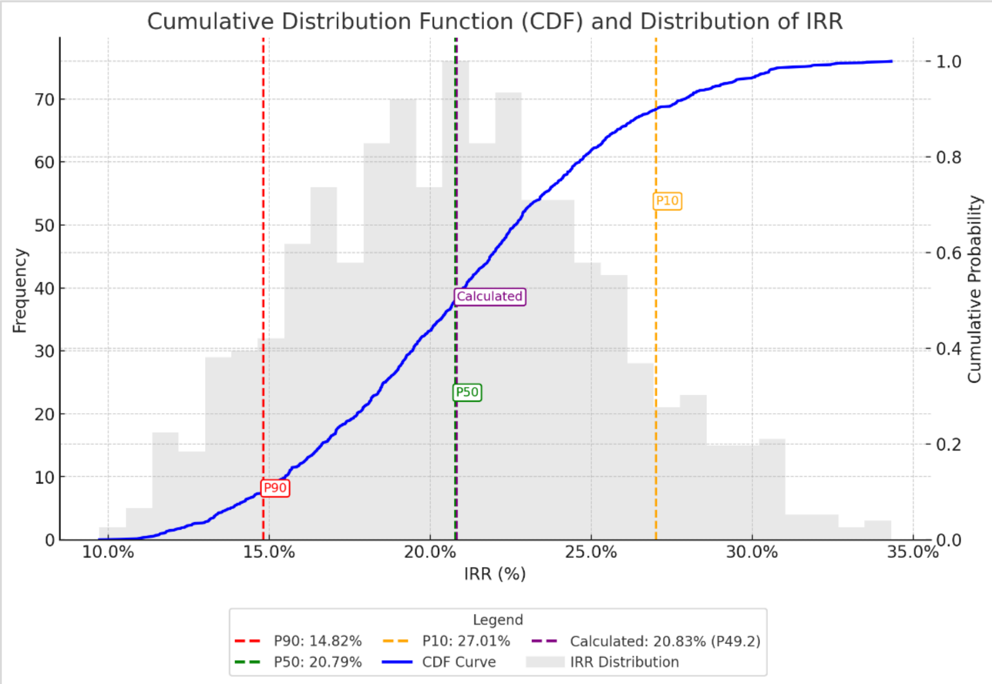

Figure 8. IRR CDF of uncertainty analysis (monte carlo simulation)

Based on the evaluation, three probabilistic outcomes - P90, P50 and P10- along with one deterministic calculation outcome, have been obtained. These probabilistic distributions represent varying confidence levels in achieving a specific NPV. The P90 value represents the 90% confidence level of the project generating an NPV of MMUS$50.8 within the ±20% key parameters variation, signifying a highly conservative estimate. Similarly, P50 represents a 50% probability of achieving an NPV of MMUS$111.9, reflecting the most likely scenario. Meanwhile, P10 represents a 10% probability of attaining an NPV of MMUS$173.9, representing an optimistic case with higher potential returns but lower certainty. The deterministic value from the calculation lies slightly higher than the P50 in the range of P48.3, it shows the confidence level of 48.3% to obtain an NPV at MMUS$113.7. Similarly, IRR CDF suggests a 90% confidence level that the project could generate IRR of 14.82%, this number is sufficient to justify the project's prospective, whereas the P50 and P10 probabilistic outcome offer higher IRR. In overall, the project is considered as a very good investment with high return and thick buffer on positive NPV and IRR are expected.

Time-dependent Project Evaluation

Operating in PSC Gross Split term, PetroComp is regulated to have the license of operating until 2045. Total period of time for above evaluation is limited to 2045 with first production is assumed in 2030. However, a risk of project execution delay and potential of acceleration are possible. Therefore, using the chosen development scenario of Case 1, a time-dependent project evaluation is performed to evaluate the significance of project's onstream time to the project's value which can be generated within the PSC period until 2045. Project's first investment is assumed in 2 years before the onstream year, similar with the basecase used in Case 1.

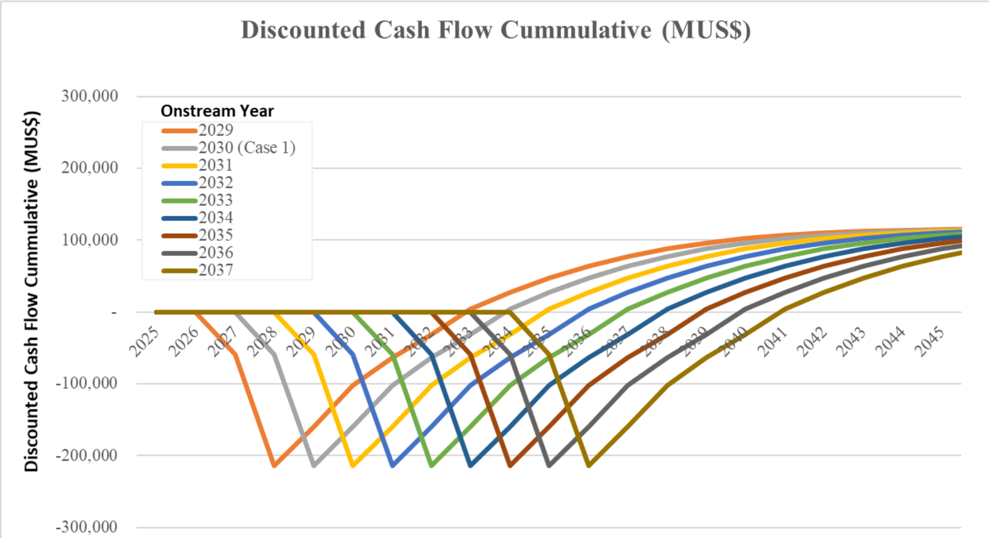

Figure 9. DCF cummulative profile in relation to project's onstream year

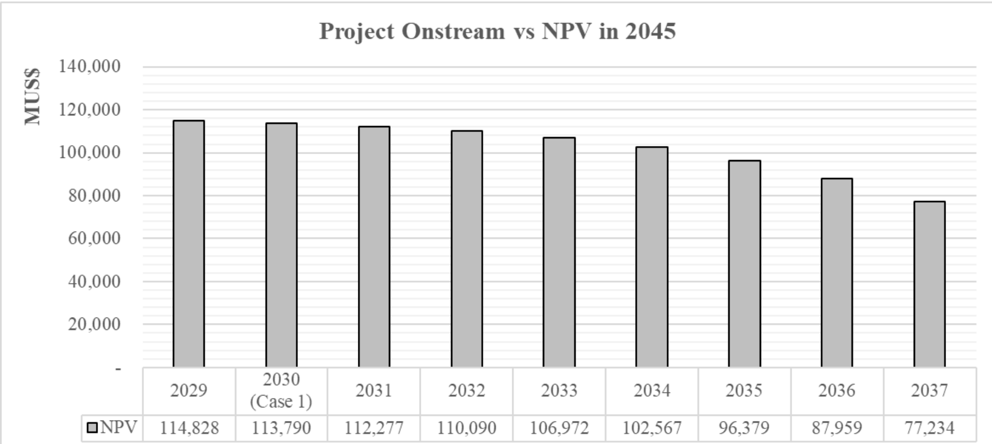

Figure 10. Project's NPV in relation to the onstream year

Based on the evaluation above, delaying a project's onstream until 2034 only affect the project's NPV by 10%. However, project's NPV starts to degrade exponentially if it is postponed later than 2035 because of monetization cut off until the end of PSC period in 2045. This evaluation provide a very good insight for the Contractor regarding the impact on project timing to the project's valuation. Minimizing factors which could risk the project in a potential delay will maximize and secure the project's valuation.

5. Conclusions

DCF method applied in this study confirms that Case 1, simple onshore processing and separate-flare development concept, offers the most viable and value-driven development scenario for the Jala field. Its substantial potential sales and revenue outweigh the relatively low investment.

CCUS mechanism and offshore-focus development concept for Jala field, represented in Case 2 and Case 3, are concluded not attractive and burden the project's valuation because of its massive investment requirement. CCUS application offers slightly higher gas and condensate sales, however it is outweighed by the investment significance. CCUS development is difficult to be justified considering the given monetization option – without carbon trading and tax mechanism.

Sensitivity analysis concludes that production sales rate or reserve and gas price are the most sensitive parameters to the project's valuation. PetroComp should focus on high production capability and settling a good negotiation position on gas price to maximize the investment return. Uncertainty analysis using Monte Carlo simulation performed in this study conclude the robustness of the investment offers positive value for the company. A time-dependent evaluation suggests that PetroComp should manage the project's onstream timeline before 2034 by reducing risk of delay to maximize and secure the project's value.

In overall, Jala field development is feasible, promising a substantial gas production growth for PetroComp and multi-industry development impact in Eastern Indonesia for Government of Indonesia.

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