# Midstream Development Options Analysis in Gelama Merah Development Field

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***Abstract* — This study presents a comprehensive analysis of midstream development options for the Gelama Merah Oil Field, focusing on optimizing transportation and processing strategies. The Gelama Merah Field, located in Sabah Basin, is characterized by complex reservoir conditions and remote accessibility, necessitating careful evaluation of transportation and processing alternatives. Various options, including pipeline transportation, trucking, and floating production systems, are assessed for their technical feasibility, economic viability, and environmental impact. Additionally, the study considers factors such as reservoir characteristics, production rates, infrastructure availability, and market conditions to identify the most suitable midstream development strategy. The analysis provides valuable insights for stakeholders and decisionmakers to optimize midstream operations and maximize the field's production potential.**

**Keywords—Development Strategy, Midstream Operations**

## I. Introduction

The midstream sector of the oil and gas industry plays a critical role in the transportation and storage of hydrocarbons, connecting upstream production sites to downstream refineries and markets. As global energy demand continues to rise, the need for efficient and cost-effective midstream infrastructure has become increasingly important. This has led to a growing interest in the analysis of midstream development options, which involves evaluating various strategies and technologies to optimize the transportation, storage, and distribution of oil and gas products. By carefully examining factors such as pipeline routing, capacity expansion, terminal location, and regulatory requirements, companies can make informed decisions that enhance the reliability, safety, and economic viability of their midstream operations. This introduction sets the stage for a comprehensive discussion on the challenges, opportunities, and best practices associated with midstream development in the oil and gas industry.

## II. Literature Review

The natural gas supply chain is commonly divided into production, midstream, and distribution sectors; this study considers only facilities in the midstream sector; a related paper discusses similar work in production mentioned by (Wang, 2022). Based on the works of (Jenna A. Brown, 2023), the midstream sector is commonly further divided into gathering and processing (G&P) and transmission and storage (T&S) segments. Midstream facilities are more complex and often have larger structures and buildings than production and distribution facilities. Nearly all midstream facilities include gas compression equipment augmented by inlet and interstage separators that remove liquids from gas streams and tanks to store liquids. In many cases, the largest methane emitters at midstream facilities are compressors and compressor drivers stated by (Zimmerle, 2022).

(Kalita, 2020), stated that the oil and gas industry is usually divided into three major sectors upstream, midstream and downstream. The upstream sector includes oil and gas exploration and production. It includes searching for potential underground or underwater crude oil and natural gas fields, drilling exploratory wells, and subsequently drilling and operating the wells that recover and bring the crude oil and or raw natural gas to the surface. The midstream sector involves the transportation, storage, and wholesale marketing of crude or refined petroleum products. The downstream sector commonly refers the refining of petroleum. Moreover, (Kalita, 2020) mentioned that the studies the differences between upstream, midstream, and downstream sector of oil and gas industry. The upstream sector which is commonly known as the exploration and production section covers all activities related to searching for, recovering, and producing crude oil and natural gas from underground underwater fields.

## III. Overview of Midstream Options

### A. Pipeline Tie-Back

The nearest Central Processing Platform (CPP) in the Sabah offshore is located on the Samarang Platform, approximately 15-20 km from the current Gelama Merah platform location. Tie-back to the currently existing platform is preferable, as it reduces the cost of processing on the GM primary and injection wells itself and the cost of leasing a Float Production Storage Offloading (FPSO) vessel for the whole 20-year cycle. It would not be necessary to have similar processing facilities in GM primary and injection wells, as it will increase CAPEX, OPEX, and deck load on the platform, except for the equipment for gas lifting and water injection in the future.

Moreover, connecting to the Samarang Platform offers logistical advantages, such as shared maintenance resources, spare parts, and operational expertise, which can enhance the overall efficiency and reliability of the production operations. Additionally, leveraging existing infrastructure reduces environmental impact by minimizing the need for new construction and associated resource consumption. This approach aligns with sustainable development goals and regulatory requirements, making it a viable and environmentally responsible option for the long-term development strategy of the Gelama Merah field.

### B. Central Processing Platform (CPP) with Production via Float Production Storange Offloading (FPSO)

A Central Processing Platform (CPP) with production via a Floating Production Storage Offloading (FPSO) system is a key component of offshore oil and gas production operations. The CPP serves as a central hub for processing hydrocarbons produced from multiple wells in a field. It is typically located in a strategic position to facilitate the efficient gathering, processing, and transportation of oil and gas to shore or other facilities. The CPP is equipped with various processing facilities, including separators, heaters, pumps, and control systems, to separate the produced fluids into oil, gas, and water components. These components are then processed further to meet quality specifications and regulatory requirements before being transported offsite. The CPP also includes storage facilities for temporarily holding the processed oil and gas before offloading.

The FPSO is a floating production facility that is typically located near the CPP. It is equipped with production, storage, and offloading facilities to handle the processed oil and gas from the CPP. The FPSO is connected to the CPP via subsea pipelines, allowing for the transfer of hydrocarbons between the two facilities. The combination of a CPP and FPSO offers several advantages for offshore oil and gas production. It allows for the development of remote and deep water fields that are not accessible by conventional fixed platforms. It also offers flexibility in field development, as additional wells can be tied back to the CPP and FPSO as production increases. Additionally, the FPSO can be disconnected and moved to another location once production from a field declines, allowing for efficient resource utilization.

### C. Production via Float Production Storange Offloading (FPSO) with Wellhead Platform

Production via Floating Production Storage Offloading (FPSO) with a Wellhead Platform is a comprehensive offshore oil and gas production system that combines the benefits of both FPSOs and wellhead platforms. This system involves the utilization of a floating production facility (FPSO) for the processing, storage, and offloading of hydrocarbons, along with a wellhead platform for the drilling, production, and initial processing of oil and gas from individual wells. The FPSO serves as a central hub for receiving production from the wellhead platform and other subsea wells. It is equipped with processing facilities such as separators, pumps, and storage tanks to separate and store oil, gas, and water. The FPSO also provides living quarters for personnel and utilities for day-to-day operations.

On the other hand, the wellhead platform is a fixed offshore structure located near the subsea wells. It houses the wellheads, production tubing, and control systems for monitoring and controlling the production of oil and gas from individual wells. The wellhead platform is connected to the FPSO via subsea pipelines for the transfer of produced hydrocarbons. The combination of an FPSO with a wellhead platform offers several advantages for offshore oil and gas production. The wellhead platform allows for the direct drilling and production from individual wells, providing flexibility in field development and production optimization. The FPSO, on the other hand, offers storage and processing capabilities, allowing for the efficient handling and export of produced hydrocarbons.

## IV. Midstream Development Options

### A. Tie-back Platforms

The initial alternative involves the utilization of a tie-back platform in figure 1, which serves as a conduit for transporting oil from oil and gas separation facilities in the fields, or from gathering centers to port terminals for tanker loading, or from supply points to refineries and other market destinations. A pipeline emerges as the preferred method for oil transportation over long distances, spanning continents or regions. The discernible advantage lies in its lower unit operating costs compared to alternative transportation modes. Furthermore, pipelines are considered the safest and most environmentally friendly means of oil transportation.

Tieback platforms in the oil and gas industry refer to offshore platforms that are strategically located near existing infrastructure, such as processing facilities or pipelines, to efficiently utilize shared resources and infrastructure. These platforms are typically used to develop new oil and gas fields that are near existing infrastructure, allowing for cost-effective development and production operations. Tieback platforms are designed to accommodate the specific requirements of the new wells and the production characteristics of the field. They often include production equipment, such as separators, pumps, and control systems, as well as facilities for personnel accommodation and support services. The design and location of tieback platforms are critical considerations, as they must be able to withstand the harsh offshore environment and provide safe and reliable operations.

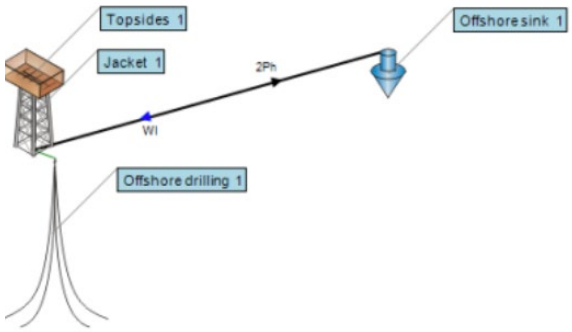


*Figure 1:Tie-ins from GM to Samarang*

### *B. CPP with Production via FPSO*

The second option entails the installation of a Central Processing Platform (CPP) with production facilitated by a Floating Production Storage Offloading (FPSO) system. This alternative is considered when bypassing the initial option. The principal role of an FPSO is to accept hydrocarbons from subsea wells, undertake processing to segregate oil, gas, and water constituents, and maintain the processed oil in storage tanks located onboard. The isolated gas is frequently employed as fuel on the FPSO, with surplus gas either reinjected into the reservoir to stimulate oil retrieval or transmitted via gas export pipelines. Water co-produced with the oil is typically subjected to treatment and released overboard in compliance with environmental standards. A multiphase pipeline is to be used to evacuate crude oil to a rented FPSO. The FPSO will be used to refine this crude oil. An oil tanker will be used to export the oil in the interim.

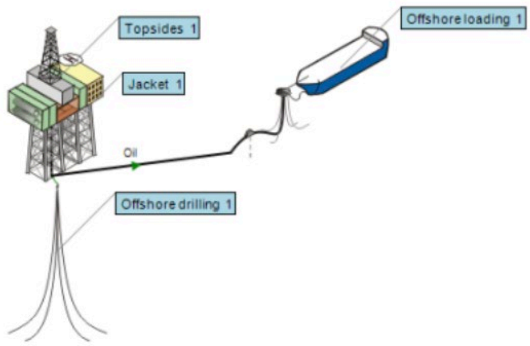


*Figure 2 : CPP attached with FPSO*

### *C. FPSO with Wellhead Platform*

Both Floating Production Storage Offloading (FPSO) vessels and wellhead platforms are integral to offshore oil and gas production. FPSOs are particularly suitable for fields with minimal infrastructure, deep water sites, or challenging environments, providing flexibility and cost-effectiveness. Wellhead platforms, on the other hand, are indispensable for facilitating drilling and production activities, offering a stable platform for equipment and personnel. The selection between these facilities depends on various factors, including field characteristics, economic considerations, and environmental impacts.

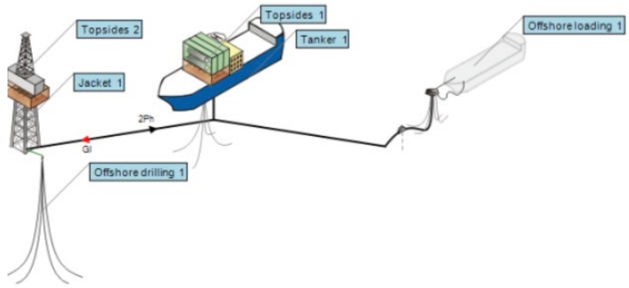


*Figure 3 : FPSO with Wellhead Platform*

## V. PIPELINE SIZING

Pipeline sizing in midstream oil and gas operations in the Gelama Merah region involves determining the optimal diameter for pipelines to efficiently transport oil and gas from the production wells to processing facilities or export terminals. The sizing process considers factors such as the flow rate of the hydrocarbons, the distance to be covered, the terrain, and the pressure drop allowable in the system. In the Gelama Merah Development Field, where the reservoirs are located offshore, pipeline sizing is critical to ensure that the produced oil and gas can be transported safely and economically to the onshore processing facilities or export terminals. Additionally, the sizing of pipelines in this region must also consider environmental factors and regulatory requirements to minimize the impact on the surrounding ecosystem.

### *A. Internal Diameter 2 inch and 3 inch*

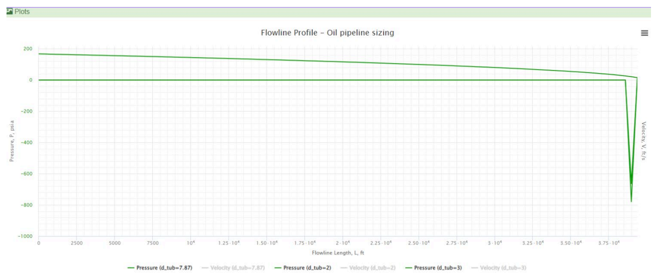


*Figure 4 : Oil Pipeline Internal Diameter 2 inch and 3 inch*

For a 2-inch internal diameter pipeline, the capacity would be lower compared to a 3-inch pipeline. A smaller diameter pipeline can result in higher pressure drop, which may require higher pumping costs to maintain the desired flow rate. Additionally, a smaller pipeline diameter may limit the flow rate and throughput of the pipeline, which can impact the overall efficiency and economics of the transportation system.

On the other hand, a 3-inch internal diameter pipeline would offer higher capacity and lower pressure drop compared to a 2-inch pipeline. This can result in lower pumping costs and higher flow rates, making it a more efficient option for transporting oil over longer distances or higher volumes. In conclusion, the choice between a 2-inch and 3-inch internal diameter pipeline for oil transportation would depend on various factors such as the required flow rate, distance, terrain, and economics of the project. It is essential to conduct a detailed engineering analysis to determine the optimal pipeline size based on these factors.

## B. Internal diameter 3 inch (failed)

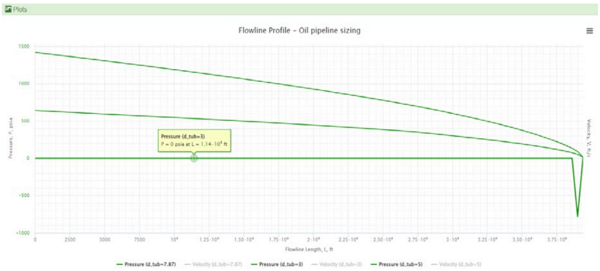


*Figure 5 : Internal Diameter 3 inch (failed)*

A 3-inch internal diameter is relatively small for an oil pipeline, suggesting that it may be intended for low-flow applications or specific operational requirements. The failure of the internal diameter could result in a significant reduction in the pipeline's capacity to transport oil, leading to operational challenges and potential disruptions in oil flow. The specific consequences of the failed internal diameter would depend on factors such as the flow rate of oil, the distance the oil needs to travel, the operating pressure of the pipeline, and the properties of the oil being transported. In response to a failed internal diameter, several actions may be taken, including repairing or replacing the affected section of the pipeline, reevaluating the pipeline's design to accommodate the reduced diameter, or implementing operational changes to mitigate the impact of the failure.

## C. Internal diameter 4 inch and 5 inch

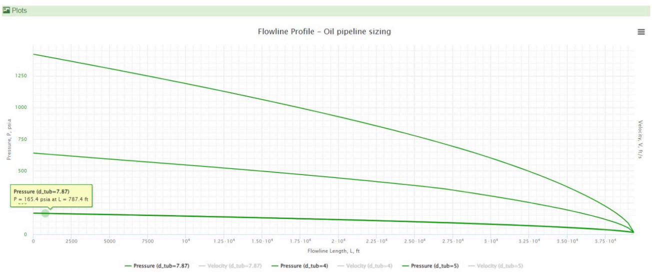


*Figure 6 : Internal Diameter 4 inch and 5 inches*

A 4-inch pipeline typically has an internal diameter of about 102 millimeters, while a 5-inch pipeline has an internal diameter of approximately 127 millimeters. The choice between a 4-inch and 5-inch pipeline depends on various factors such as the flow rate requirements, the distance over which the oil needs to be transported, and the pressure drop permissible in the system. A 5-inch pipeline, with its larger internal diameter, can generally accommodate higher flow rates compared to a 4-inch pipeline. It also tends to have lower pressure drops, which can be beneficial for long-distance oil transportation. However, a 5-inch pipeline may be more expensive to install and operate compared to a 4-inch pipeline, due to its larger size and the higher costs associated with materials and construction. Additionally, the choice between the two sizes may also be influenced by factors such as space constraints, environmental considerations, and regulatory requirements.

In summary, the selection of a 4-inch or 5-inch pipeline for oil transportation depends on a careful evaluation of various factors, including flow rate requirements, distance, cost considerations, and operational constraints, to ensure optimal performance and efficiency of the pipeline system.

# VI. RESULTS AND DISCUSSION

Table 1 outlines the outcomes of employing different development strategies for the Gelama Merah Oil Field, including three distinct plans: tie-back platforms, CPP + FPSO, and FPSO + Wellhead platforms. The objective of these strategies was to evaluate the capital expenditure (CAPEX) involved. Based on table 1, the CAPEX for the tie-back platform is only 224.768 MM USD, making it a more cost-effective choice for minimizing total expenditure throughout the development phase. By connecting new wells to existing infrastructure, operators can avoid the high costs associated with constructing new processing facilities, pipelines, and additional infrastructure, resulting in significant cost savings for oil and gas projects.

Furthermore, the second option emerges as a viable alternative should the first-choice encounter challenges in its implementation. The CPP + FPSO option incurred the second-highest capital expenditure, totalling 437.344 MM USD, as estimated by Questor for the storage planning process. This approach involves renting a FPSO from a service provider to store the crude oil, among other functions. The cost of this development plan is relatively high due to the utilization of a FPSO, which offers the advantage of flexibility as it can be disconnected and relocated to another site once production from a field diminishes, thus ensuring efficient resource management.

Conversely, the FPSO + Wellhead platforms option recorded the highest expenditure, amounting to 448.348 MM USD. Despite its costly nature, this option serves as a control system for monitoring and managing the production of oil and gas from individual wells. The wellhead platform is linked to the FPSO via subsea pipelines for the transfer of produced hydrocarbons.

When one compares the development plans and related costs, the tie-back platform option works better than the other two. In comparison to the CPP + FPSO and FPSO + Wellhead platforms, the tie-back platform approach emerges as the superior option.

*Table 1 : Results of Different Development Plans*

| Development Plans | CAPEX (MM USD) |
|---|---|
| Tie-back platform from GM to Samarang | 224.768 |
| Central Processing Platforms (CPP) + Float Production Storage Offloading | 437.344 |
| Floating Production Storage and Offloading (FPSO) + Wellhead platform | 448.348 |

From the graph, we could analysis of each size of pipeline specifically for 2-inch, 3-inch, 4 inch and 5 inch respectively. Firstly, a 2-inch pipeline is a cost-effective solution for applications with low flow rates and short distances. Despite its smaller diameter, it can efficiently transport fluids such as oil and gas over shorter distances. However, due to its limited capacity, it may experience higher pressure drops compared to larger diameter pipelines. This limitation makes it suitable for small-scale applications where the flow requirements are minimal. While the initial cost of a 2-inch pipeline may be lower than larger options, it is important to consider the potential for higher operating costs over time due to increased energy consumption associated with higher pressure drops.

Meanwhile, a 3-inch pipeline offers a balance between flow capacity and pressure drop, making it suitable for moderate flow rates and distances. It provides better performance than a 2-inch pipeline, with lower pressure drops and higher flow rates. While the cost of a 3-inch pipeline is higher than a 2-inch pipeline, it is generally more cost-effective than larger diameter options for applications with moderate flow requirements. The 3-inch pipeline is commonly used in various industries where a balance between performance and cost is essential.

Furthermore, a 4-inch pipeline provides a higher flow capacity and lower pressure drops compared to smaller diameter pipelines, making it suitable for medium flow rates and longer distances. The larger internal diameter allows for more efficient transportation of fluids such as oil and gas over extended distances. While the cost of a 4-inch pipeline is higher than smaller options, it offers improved performance and efficiency, which can result in long-term cost savings. The 4-inch pipeline is commonly used in mid-sized applications where higher flow rates are required but where the cost of larger diameter pipelines is prohibitive.

Finally, a 5-inch pipeline offers the highest flow capacity and lowest pressure drops among the options considered, making it suitable for high flow rates and long-distance transportation. The larger diameter allows for the efficient transport of fluids over extended distances with minimal pressure losses. While the cost of a 5-inch pipeline is the highest among the options, it provides the best performance and efficiency, making it ideal for applications where high flow rates are required. The 5-inch pipeline is commonly used in large-scale industrial applications where performance and efficiency are paramount.

## VII. Conclusion

In conclusion, the analysis of midstream development options for the Gelama Merah Development Field has provided valuable insights into the various strategies available for optimizing hydrocarbon production in this offshore region. The evaluation of tie-back platforms, CPP + FPSO, and FPSO + Wellhead platforms has highlighted the importance of considering technical feasibility, economic viability, and environmental impact in selecting the most suitable development strategy.

The tie-back platform option emerged as the most cost-effective choice, leveraging existing infrastructure to minimize total expenditure, and demonstrating its potential to efficiently develop the field. While the CPP + FPSO option offers flexibility and the ability to centralize processing, its higher capital expenditure underscores the need for careful cost-benefit analysis. Similarly, the FPSO + Wellhead platforms option, despite providing control and monitoring advantages, presents the highest expenditure, warranting thorough consideration of its benefits against costs.

Moving forward, detailed engineering studies and ongoing monitoring will be crucial to optimize the selected midstream development strategy and ensure its successful implementation. The insights gained from this analysis will not only inform decision-making for the Gelama Merah Development Field but also provide valuable lessons for the broader oil and gas industry in developing offshore fields efficiently and sustainably.

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