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Business Strategies for The Most Complex Indonesian Oil Refinery

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ABSTRAK

Oil (crude) refineries are a fundamental infrastructure of the primary energy in the world. Fuel oil and its derivative products are important commodities needed by society and industry and have always been a concern for every government in the world because of its strategic values (economic, political, and security factors). In Indonesia, the oil and gas industry play a very important role for the nation. In the early days of independence, crude oil was the prima donna of exports commodities and as the foundation of development in Indonesia. But over time, when massive development took place and Indonesia's economy continued to grow into a developing country followed by population growth, this sector was in the spotlight because it was the culprit for contributing to Indonesia's massive import value. Various efforts were made by the Indonesian government to realize energy self-sufficiency so as not to depend entirely on imports, for example through Pertamina as a state-owned enterprise to build the Balongan Refinery. The Balongan refinery was designed and built using the most advanced technology and configurations at the time so that it could process low-cost heavy/very heavy crude oil into a variety of fuels, petrochemicals, and other products. Despite having a highly advanced configuration (11.9 NCI) that far exceeds other domestic refineries as well as refineries in Asia, the Balongan Refinery is under economic pressure from various external factors, such as rising crude oil prices and the preference for higher-priced product types by the market. This research seeks to address and formulate the strategies for the Balongan Refinery to improve its operating performance and economics. The important aspects of the strategy that were researched and evaluated, which were then proposed as the main findings in this study, were the strategy of utilizing potential crude oil alternatives and the strategy of diversifying superior products referring to product price trends in the market. This study also found that flexibility in the selection and processing of potential crude oil by means of an adaptive approach to the actual conditions faced, do not just be strict with design figures, at attractive prices is the key to ensuring the operational and business sustainability of the Balongan Refinery.

Keywords: Alternative Crude Oil, Production Pattern Optimization, Refinery Business Strategy, And Refinery Profitability.

INTRODUCTION

Indonesia’s journey in the oil and gas (O&G) industry has deep historical roots, with initial crude oil reserves discovered in Telaga Said, North Sumatra, in 1883 (Mulhadiono, 2020). This discovery catalyzed the development of a domestic O&G infrastructure, starting with the construction of pipelines and the Pangkalan Brandan Refinery in 1892. Over the decades, Indonesia became a prominent oil exporter, joining OPEC in 1962 to play a role in shaping global oil policies (Atris, 2020). However, as domestic demand increased and production

faced challenges, Indonesia's status shifted from an exporter to a net importer by the early 2000s. This evolution reflects the nation's ongoing efforts to meet energy needs amid changing economic and resource conditions (Dickinson, 2022).

The global energy sector is undergoing rapid transformation influenced by ever-changing economic, environmental, and technological factors (Matyushok et al., 2021; Rufaidah, 2024). In this context, oil refineries, which play an important role in the energy supply chain, face diverse challenges (Dalei & Joshi, 2023). For example, fluctuations in crude oil prices, strict environmental regulations, and the rise of alternative energy sources have put pressure on refineries around the world to adapt to these dynamics (Sukarno & Setiawati, 2020; Susanto & Saputra, 2023). The complexity of managing refinery operations, especially in developing countries, confirms the need for innovative strategies to ensure economic continuity and environmental sustainability (Omorodion, 2021).

A major milestone in Indonesia's O&G sector is the development of Balongan Refinery, part of Pertamina's Refinery Unit (RU) VI, which has been operational since 1994. Strategically located in Indramayu, West Java, approximately 200 kilometers east of Jakarta (capital city of Indonesia), Balongan was designed to process heavy crude oils from domestic sources, such as Duri and Minas. Its advanced configuration enables the refinery to convert these challenging crude types into high-value products like gasoline, diesel/gasoil, and LPG (Liquified Petroleum Gas), positioning Balongan as a vital asset for both local and international markets. With its location close to major urban centers, Balongan plays a crucial role in ensuring energy security for Jakarta and surrounding regions (Ilic & Ponomarenko, 2021).

The Balongan Refinery's cutting-edge technology and processing capabilities allow it to handle heavy or even superheavy crudes that would typically yield low-value residues in common refineries (Hakim et al., 2023). Equipped with a "bottom upgrading concept," Balongan transforms these challenging feedstocks into valuable products. The heart of the refinery, such as the Residue Catalytic Cracker (RCC) unit and hydrotreating units, enable the conversion of heavy residue into high-quality products like HOMC (High Octane Mogas Component), LPG, and propylene, essential for the fuels and petrochemical sectors. Balongan's modernization efforts reflect Indonesia's commitment to enhancing its refining capacity to support energy independence and economic growth in an evolving global energy landscape.

The study focuses on two main variables: the optimization of alternative crude oil sources and product diversification to adjust to market demand. By utilizing advanced configurations such as the Nelson Complexity Index (NCI), the Balongan Refinery has the technical capability to process both heavy and very heavy crude oil, potentially lowering procurement costs and increasing profitability (PARK, 2020). However, a systematic approach to identifying suitable crude oil blends and improving production flexibility is essential. The

urgency of this research is emphasized by the increasing energy needs in Indonesia and the importance of the Balongan Refinery in ensuring energy security for the country. As a major supplier for Jakarta and the surrounding area, optimizing the refinery's operations is essential to meet the increasing demand and reduce dependence on imports.

The main objective of this study is to identify alternative crude oil sources that are in accordance with the technical and economic parameters of the Balongan Refinery, propose strategies to optimize production flexibility to respond to market demand for high-value products and improve the operational efficiency and overall profitability of the refinery. The findings of this study are expected to provide benefits for industry practitioners and policymakers. By providing implementable insights in crude oil procurement and production strategies, this research contributes to a broader discourse on energy sustainability and economic resilience in Indonesia's oil and gas sector.

Literature Review

By the design, Balongan refinery has world–tier Nelson Complexity Index (NCI) with score of 11.9 NCI. Refineries with an NCI typically higher than 5 are classified as deep converting or fully integrated refineries. With higher NCI, Balongan refinery shall perform better than the peer refinery with lower NCI because Balongan refinery has all necessary processing units to convert opportunity crudes into high valuable products (Leite et al., 2019). Herce et al., (2022) mentioned that NCI is key parameter for a refinery, and it is still relevant for reviewing refineries' complexity because if offers valuable insights into the influence of the refined products mix, particularly the production of gasoline and diesel fuels, energy consumption, and other relevant performance parameters. As fundamental metric calculations of refinery complexity, the NCI is calculated by comparing the secondary conversion capacity to the primary distillation capacity (Yáñez et al., 2021).

Thus, quick-estimation NCI can be used to assess how many secondary units or how much capacity secondary process units are installed in a refinery. From this information, it indirectly provides information related to the amount of investment (capital expenditure) and operational costs (operation expenditure) in the refinery which all have relevance to unit capacity and the number of secondary process units. Unlike the primary process unit which only uses a physical process based on temperature differences through distillation so that the type of product produced is limited according to the distribution of product fractions in crude oil raw materials, secondary process units use physical processes and chemical processes so that it is possible to change and rearrange product fraction molecules into other products in accordance with the desired product maximization target (Bjärkefur et al., 2020).

Refineries with higher on the NCI are valued higher relative to their peers because of their ability to handle lower quality crude oil with lower price or produce more value–added (more valuable) products and dur to their greater

complexity, high NCI refineries are more costly to build and operate (Chen, 2022).

Due to global markets fluctuations in raw material (crudes) prices and products, Balongan refinery is experiencing pressure on its business profitability. In recent years, Duri crude within years a reference for Balongan's design feedstock has experienced a significant price increasement because it can be used to produce MFO (Marine Fuel Oil) Low Sulphur (0.5%wt sulfur content) which is being sought after by the market because of the 2020 IMO (International Marine Organization) regulatory. Oil and Energy Trends (2020) saw the heavy sweet crude grades had spot price differentials spike to record highs, reflecting the boost in demand for VLSFO (Very Low Sulfur Fuel Oil) (Mehdi & Fattouh, 2021). For example, a 550 000-barrel cargo of Australia's Pyrenees crude for loading in early March 2020 was sold at a premium of around $31/bbl to Platts Dated Brent, FOB—the highest premium on record for the heavy sweet Australian grade. In this case, analysts said the high premium reflected its value for blending into the low sulfur fuel oil pool, rather than the refining value of the crude.

Consequently, compared to other refineries owned by Pertamina, the Balongan Refinery experienced economic pressure due to high weighted prices on average, (3.5% more expensive than the average crude cost of all Pertamina Refineries, 2021). As a reference, the cost of crude procurement raw materials accounts for 76% of the total cost of the Balongan Refinery.

In terms of products slate, the Balongan Refinery also experienced unfavorable conditions. Gasoline prices are always lower than Diesel prices. From 2022–2023 perspective, Gasoline, which is most of the Balongan Refinery's products, is 17.7 and 9.8 USD/bbl lower than Diesel prices, respectively. And unfortunately, the Balongan refinery does not have the flexibility to switch production to Diesel. Common in this refining industry, certain petroleum products cannot be produced immediately according to market demand, but only according to the refinery facilities' constraints (Lim & Lee, 2020).

RESEARCH METHODS

A conceptual framework in research serves as a structure that outlines the key concepts, variables, and relationships that guide the research. It provides a roadmap for researchers to organize their thoughts, define their research problem, and develop hypotheses. Conceptual frameworks are essential as they help in identifying research gaps, informing data collection and analysis, and guiding the interpretation of results. According to Stern, (2000), a conceptual framework is crucial for advancing theories in various fields, such as environmentally significant behavior. It helps in structuring the understanding of complex phenomena and aids in the development of new theories. Cohen & Shang, (2015) emphasize the importance of selecting an appropriate conceptual framework for research, especially in areas like infection control, where the framework can significantly impact the effectiveness of the study.

In this research, conceptual frameworks are built by emphasizing the identification of potential crude alternatives as the main foundation in focusing on designing a suitable business strategy for the Balongan Refinery to deal with changes in the external environment (in the framework reflected in step 1 to step 7). Then, the research continued with brainstorming related to product slate adjustment as part of the flexibility of the Balongan Refinery to balance the portion of Gasoline vs Diesel production (with the aim of increasing Diesel yield or brainstorming potential product development) (reflected from step 9 and onwards).

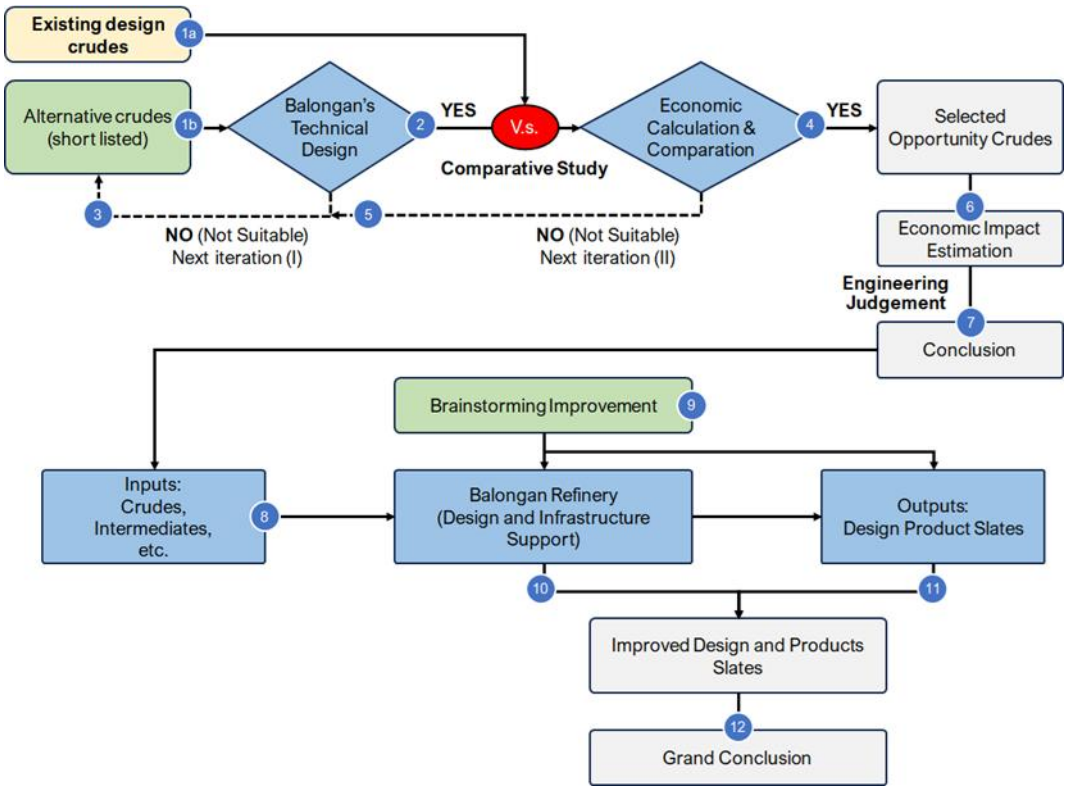

Figure 2. Conceptual Framework for Developing Business Strategies for The Balongan Refinery

The researcher used mixed research methods, which utilized qualitative analysis methods that focused on discussing aspects of business strategy as well as quantitative analysis methods that were utilized to perform technical and economic calculations that required absolute value in the analysis. The mixed methods approach provides a more comprehensive and nuanced way to investigate the research questions aligned in this study. By embracing a diversity of approaches and utilizing the strengths of each, researchers can increase the depth and breadth of their analysis, resulting in more profound and impactful findings (Levitt et al., 2018).

RESULTS AND DISCUSSION

This study focuses on identifying alternative crude sources suitable for the Balongan Refinery, with an emphasis on technical and economic feasibility. The

initial selection involved screening potential crude options based on essential parameters such as API gravity and sulfur content. To ensure the refinery's requirements were met, economic projections were also assessed using Gross Product Worth (GPW) and Gross Refinery Margin (GRM) methodologies. This process aimed to evaluate whether any alternatives could match or surpass Duri crude's profitability and compatibility with Balongan's refining capabilities.

Despite an extensive evaluation of numbers of new alternatives crudes and finally narrowed down to 14 superheavy crude options, the initial screening revealed that none met the stringent sulfur content requirement of 0.35%wt, where the threshold figure for sulfur content is taken directly from the design figure. This limitation prompted a re-evaluation of the sulfur threshold, as the high sulfur content hindered the selection of viable alternatives for Balongan's operational standards. By relaxing the sulfur content limit to 0.47% wt where this figure is a new threshold that considers the quality of other crude blending that has superior sulfur quality, the analysis expanded to include crudes that otherwise held potential in terms of yield and economic value but were initially excluded due to sulfur constraints. This modification allowed for a broader range of superheavy crudes to be considered while still maintaining quality control aligned with Balongan's processing configuration (Korde & Paulus, 2017).

Following the threshold adjustment, Ebok and Gryphon crudes emerged as promising candidates. Both alternatives underwent blending trials with Minas crude, which has a lower sulfur content, to achieve a balanced mixture suitable for Balongan's operations. Specifically, a blend ratio of 65% Ebok or Gryphon with 35% Minas crude was calculated to maintain the sulfur content within acceptable limits, allowing the combined feedstock to meet the refinery's specifications. This blending approach not only aligned with Balongan's design requirements but also optimized the economic and technical viability of these alternative crude options

The economic analysis further underscored the suitability of Ebok and Gryphon crudes. Calculations of GPW indicated that both alternatives offered positive margins when compared to Duri crude, demonstrating their potential to provide profitable returns. Although a full GRM analysis was constrained by the limited availability of price data, the positive GPW differentials for Ebok and Gryphon suggest these crudes could be valuable substitutes. This careful selection and adjustment process supports Balongan Refinery's objectives, ensuring operational efficiency while adapting to evolving crude supply dynamics.

The further research focused on optimizing Balongan's production by analyzing internal capabilities and external factors, using a SWOT-based approach to identify strategies. Balongan's high Nelson Complexity Index (NCI) of 11.7 and skilled operators enable it to produce quality products, such as Pertamina Turbo and Avtur (Jet A1). However, challenges from aging infrastructure, limited Gasoil capacity, and workforce experience gaps impact efficiency. To address these, investment in infrastructure and skill development was prioritized to enhance operational flexibility and align with market needs.

Table 1. SOWT Analysis for Balongan Refinery Product Optimization

Internal factor	**Strength:** a. The (NCI) of Balongan Refinery is 11.7 indicating its secondary units have capability to produce high quality products. b. The Balongan Refinery has succeeded in producing several superior products such as Pertamina Turbo and Avtur through process modifications and work procedures. c. The Balongan Refinery is operated by experienced operators who are specially educated using qualified and sophisticated training facilities, such as Operator Training Simulator (OTS).	**Weakness:** a. The 30-year-old Balongan Refinery is relatively old, so that the level of efficiency is still below compared to new refineries that have just been completed. b. The Balongan Refinery is intended to maximize Gasoline production and has limited Gasoil (Diesel) production. c. There is an age gap for workers who are dominated by the age of 30 years (±40%) with lower experience than senior workers.
External factor	**Opportunities (O):** a. The Balongan Refinery location is close to the capital city of Jakarta so that it is very easy to access the market with high fuel demand. b. In addition to fuel products, the Balongan Refinery is located near an industrial area that also requires various petrochemical products and their derivatives. c. New proven technology comes online that can be used to transform and modernize the Balongan Refinery efficiently and effectively.	**Threats (T):** a. The supply issues of superheavy crudes and other intermedia such as Naphtha and LSWR (Low Sulfur Waxy Residue) after the RDMP Balikpapan project. b. The fluctuation of superheavy crude and pressure on selling price of the final products, especially Gasoline due to the raise of Electric Vehicles (EV), especially starting at the capital city and its surrounding. c. The stringent fuels regulation that drives higher operating cost of Balongan Refinery, and in the end, it further suppresses the profit margin of the refinery.

By adopting the SWOT Analysis Process Matrix approach (S-O, W-O, S-T, and W-T strategy), strategies were formulated to capitalize on Balongan's proximity to Jakarta's fuel market and potential for technology upgrades. A key quick-win strategy identified was to increase Gasoil production over Gasoline, given its higher demand and pricing advantages (Mbah et al., 2018). This approach offers immediate gains while longer-term investments in petrochemical capacity are considered to strengthen Balongan's market position and profitability.

CONCLUSION

This study shows that Balongan Refinery's selection process effectively identifies suitable crude alternatives for its complex refining operations. By screening crude options against the refinery's design standards and evaluating economic projections using Gross Profit Worth (GPW) and Gross Refinery Margin (GRM), the study offers a refined method for selecting high-value crude alternatives. This approach incorporates landed costs, providing a more accurate comparison to the refinery's baseline, Duri crude. The findings demonstrate that adjusting sulfur thresholds for each crude blend rather than applying a rigid limit referring to its design threshold allows for greater flexibility, especially with superheavy crudes that contain lower sulfur content. As a result, two promising alternatives, Ebok and Gryphon crudes—were identified, meeting technical and economic criteria, with both yielding positive GPW compared to Duri. This flexible strategy in sulfur management, paired with advanced refining, supports Balongan's economic objectives and enhances its ability to process a broader range of crudes This analysis identified key strengths and challenges for Balongan Refinery, highlighting its advanced secondary units (NCI 11.7) and skilled workforce, which enable high-quality product output, including Pertamina Turbo and Avtur. However, the refinery faces limitations from aging infrastructure, restricted Gasoil production, and an experience gap within its workforce, all which impact efficiency and adaptability. Strategically located near Jakarta, a major fuel market, Balongan is well-positioned to leverage new refining technologies, though it must navigate risks like fluctuating heavy crude supplies, the rise of electric vehicles, and increasing environmental regulations. A SWOT-based approach led to prioritizing infrastructure upgrades and a quick-win strategy to boost Gasoil production, capitalizing on favorable pricing and demand, while also considering long-term investments in petrochemical capacity. With a series of optimizations that have been carried out above, including replacing some of the Duri crude with Ebok & Gryphon Crude and processing the LCO stream into Diesel, an increase in gross margin was obtained.

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