Strategic Decision Making for Facility Optimisation in Indonesia's Gunung Kemala Oil Field Using AHP

Agung Wibowo[*] and Pri Hermawan

School of Business and Management, Institut Teknologi Bandung, Bandung, Indonesia

[*]*E-mail: 29123385@mahasiswa.itb.ac.id*

Abstract

The focus of this research is the strategic optimisation of surface production facilities under capital and governance constraints, in Indonesia's brownfield oil assets of Gunung Kemala (GNK), within a state-owned-enterprise (SOE) governance context. An integrated Multi Criteria Decision Making (MCDM) model is formulated, jointly involving Value-Focused Thinking (VFT) to organise policy objectives, Kepner–Tregoe (KT) Decision Analysis to filter "Must" criteria and "Want" criteria, and the Analytical Hierarchy Process (AHP) for ranking four strategic alternatives: i.e., constructing a new facility, upgrading current facilities, utlisation of idle assets and renting third-party infrastructures. The raw data was obtained through conversation, focused group discussion and expert pairwise comparison with seven experts from domain knowledge. The comparison results reveal that utilization of idle assets appears as the biggest preferred alternative (global priority weight = 0.547) and compared to greenfield & brownfield expansions. This dominance derives from the capital efficiency, faster deployment time, reduced regulatory exposure and better alignment with asset-governance constraints. This research presents an integrated VFT–KT–AHP decision framework that is designed specifically for the brownfield bottle necks in emerging-market upstream settings. It expands the traditional AHP application from technical based ranking to incorporate issues in governance feasibility and asset utilization strategies as an internal capital allocation decision logic, providing a solution model that is applicable with other SOE oriented energy systems.

Keywords: Strategic Decision Making, Brownfield Asset Optimisation, Operation Strategy, AHP, VFT, KT Decision Analysis Indonesia Oil and Gas

INTRODUCTION

The dynamics of global market volatility, energy-transition regulations and policies, and geopolitical uncertainties continue to pose significant challenges to the global oil and gas sector. Fluctuations in oil prices have materially influenced investment decisions and production planning in recent years. According to the International Energy Agency (IEA, 2024), global oil consumption is projected to reach 103.9 million barrels per day (bpd) by 2025, with Asia, particularly China, being the main driver of this growth. At the same time, a market surplus of approximately 600,000 bpd is projected for 2025 due to increasing global supply, especially from the United States, Iran, and Venezuela (IEA,

2024). While OPEC+ production cuts remain critical for market stability, oil and gas companies face mounting strategic trade-offs between sustaining conventional production and accelerating investment in low-carbon energy systems. Despite the ongoing energy transition, oil and gas continue to account for a substantial share of global energy consumption, making the maximization of output from existing fields a key pillar of long-term energy security.

In Indonesia, declining reservoir quality and aging production infrastructure have contributed to a sustained reduction in crude oil output. According to the Ministry of Energy and Mineral Resources (ESDM, 2024), Indonesia's crude oil production averaged 577,630 bpd in 2024, significantly below the national budget target of 635,000 bpd. For 2025, the government has set a production target of 600,000 bpd and articulated a long-term goal of achieving 1 million bpd by 2030 as part of its National Strategic Project (ESDM, 2024; SKK Migas, 2024). However, deteriorating field conditions and limited exploration success rates have made these ambitions increasingly difficult to realize. Consequently, policy and operational focus has shifted toward enhancing production from mature fields through surface-facility upgrades and enhanced oil recovery (EOR) technologies. Within this national context, maintaining output from Pertamina-operated assets has become a strategic imperative for safeguarding Indonesia's energy security.

Beyond technical constraints, facility-investment decisions in Indonesia's upstream sector are embedded within a distinctive institutional and governance setting. As a state-owned enterprise (SOE), PT Pertamina Hulu Rokan (PHR) operates under a dual mandate: achieving commercial efficiency and asset returns while simultaneously fulfilling national energy-security and production targets set by the Government of Indonesia and regulated by SKK Migas. This governance structure introduces non-market trade-offs that are rarely captured in conventional engineering-economic optimisation studies, including regulatory approval lead times, capital-expenditure ceilings, local-content requirements, and public accountability for production shortfalls.

Moreover, Indonesia's upstream portfolio is dominated by brownfield assets characterized by mature reservoirs and aging surface facilities, which constrain the feasibility of large-scale greenfield investments. Under such conditions, managerial decisions increasingly revolve around capital discipline, asset-utilisation governance, and time-to-market considerations rather than purely technical optimality. These dynamics are not unique to Indonesia but are also observed across emerging-market energy economies where SOEs play a dominant operational role and fiscal space for upstream investment is limited. In this context, the optimisation of production facilities represents a strategic managerial decision problem rather than merely an engineering design exercise.

PHR, a subsidiary of PT Pertamina Hulu Energi (PHE), is responsible for managing the Sumatra working areas, which have historically been a cornerstone of Indonesia's oil production. Contributing more than 200,000 bpd of oil and approximately 800 MMscfd of gas, the Rokan Block accounts for around 36% of PHE's total oil output (PHE, 2024). One of the key operational areas within PHR is Zone 4, which comprises mature oil fields in South Sumatra that have been in production for over four decades. These fields face structural challenges, including reservoir depletion and aging

production infrastructure. In 2024, Zone 4 achieved only 89% (approximately 28,000 Bopd and 540 MMscfd) of its production target, underscoring the need for strategic interventions to enhance operational performance (SKK Migas 2024; PHR Zone 4, 2024). One such initiative is the Gunung Kemala (GNK) Structure Development, which aims to unlock additional oil reserves and sustain production levels.

This business challenge is situated within the Indonesian government's long-term oil and gas production targets for 2030, which seek to achieve 1 million Bopd and 12 Bscfd under the Long-Term Plan (LTP) and National Project Strategy (PSN) framework. For PHR, particularly in Zone 4, this creates a strategic tension between a declining baseline production trend and rising production expectations embedded in corporate key performance indicators (KPIs). GNK is one of the oil and gas structures in the Prabumulih Field, one of the largest producing fields in PHR Zone 4. Located approximately 3 km northwest of Prabumulih City, GNK was discovered in 1937 and has been producing since 1939, with a Plan of Field Development (POFD) approved in 2012. The structure produces oil and gas from the Talang Akar Formation (TAF).

Currently, GNK produces from two active wells with an oil production rate of approximately 49 Bopd and 0.57 MMscfd of gas. Production fluids from the East GNK wells are routed to the SP-3 GNK gathering station for separation and subsequently transported to PPP Prabumulih, from which oil is pumped to the Plaju refinery (UP Plaju). The proposed field development in the East GNK area involves production infill drilling in structurally elevated zones that have not yet been drained. Following a 3D seismic re-evaluation (upgraded from earlier 2D data), subsurface analysis has identified substantial additional hydrocarbon potential. Drilling activities initiated in 2023 are projected to increase production to approximately 2,000 Bopd.

The central operational problem now confronting PHR Zone 4 is how to accommodate the anticipated production increase from GNK development given the limitations of aging and capacity-constrained surface facilities. The existing facilities can handle only 3,000 Bopd and 3.5 MMscfd, while the estimated production increase for 2025 is 18,000 Bwpd, 5,335 Bopd, and 12.5 MMscfd (PHR Zone 4, 2024). This creates a strategic decision trade-off between alternative surface-facility investment and utilisation options under tight capital, regulatory, and time constraints. Accordingly, a structured and systematic decision-making approach is required to identify and prioritise the most value-creating strategy.

This study aims to identify viable alternative solutions for optimizing surface production facilities at the GNK Structure, specifically within the bounds of current capital, regulatory, and operational constraints. By addressing these limitations, the research seeks to accommodate increased oil and gas production effectively. Furthermore, the study utilizes an Analytical Hierarchy Process (AHP) evaluation to determine the most feasible implementation strategies for the selected optimization alternatives.

Despite the growing strategic importance of brownfield optimisation in emerging-market energy systems, prior studies on surface production facilities in Indonesia's upstream sector have largely emphasised technical design, engineering feasibility, or single-criterion economic evaluation. Relatively limited attention has been given to the strategic and managerial dimensions of capital-allocation decision-making, particularly

under the institutional constraints faced by state-owned enterprises (SOEs) operating within regulatory regimes such as SKK Migas. As a result, there remains a research gap in systematically integrating asset-utilisation governance, capital discipline, multi-stakeholder preferences, and regulatory trade-offs into a coherent decision-support framework for surface-facility investment. This study addresses that gap by reframing surface production facility optimisation at the GNK Structure not merely as an engineering problem, but as a strategic decision-making challenge embedded within Indonesia's SOE governance and national energy-security context.

To address these research questions, the study is designed to first identify and structure the strategic objectives and decision criteria that govern surface production facility investments, specifically within the regulatory framework of Indonesia's SOEs and SKK Migas. This foundational step leads to a robust evaluation of alternative optimization strategies using an integrated Value-Focused Thinking (VFT)–Kepner–Tregoe (KT)–Analytical Hierarchy Process (AHP) framework. By doing so, the study aims to determine the most value-creating strategy, balancing capital efficiency, asset utilization, and operational feasibility against implementation speed and risk exposure.

Furthermore, this research offers significant contributions to both theory and practice. It extends the application of Multi-Criteria Decision Making (MCDM) frameworks to upstream energy investment within SOE-dominated emerging markets. Critically, it provides empirical evidence that optimizing asset-utilization governance, specifically through the use of idle assets, can outperform traditional greenfield or brownfield expansion strategies under tight constraints. Ultimately, this study provides a transferable strategic-decision template for brownfield optimization that is highly applicable to comparable oil and gas assets across Indonesia and other emerging economies.

Beyond its empirical case context, this study offers explicit methodological and practical novelty. Methodologically, it introduces an integrated VFT–KT–AHP decision architecture that moves beyond stand-alone AHP ranking by embedding value elicitation (VFT) and feasibility screening ("Must–Want" logic from KT) into a single coherent decision-support workflow for brownfield facility optimisation. This architecture is specifically designed to address production ramp-up bottlenecks under capital, regulatory, and time constraints in emerging-market upstream systems. Practically, the study develops a governance-oriented implementation playbook for utlisation of idle assets that translates multi-criteria rankings into executable investment logic, linking asset redeployment decisions to capital discipline, regulatory feasibility, and operational-risk containment. This dual novelty differentiates the study from prior applications of AHP in oil and gas facility planning that have primarily focused on technical design optimisation or cost–benefit ranking in isolation.

LITERATURE REVIEW

Decision making is an important element, especially in strategic management and in the upstream oil and gas industry, which faces challenges such as resource limitations with

declining trends, energy price fluctuations in line with global market trends, as well as pressures on cost efficiency and the sustainability of oil and gas production. The challenge is complicated, it encompasses technological feasibility, economic reason, time restrictions, operational risk, and idle asset availability. Thus, a Multi-Criteria Decision Making (MCDM) framework is the most applicable method. MCDM approaches give a logical framework to examine competing options when decision criteria are contradictory, qualitative and quantitative in character, as Thakkar (2021) puts it. For GNK, no one ruling standard exists, careful analysis of trade off's across multiple components will assist to identify the most effective optimization strategy.

To enhance the decision making process, this study at the first stage combines the AHP with KT method, particularly in the prioritization phase. KT differentiates between "Must" and "Want" requirements. "Must" criteria are unnegotiable norms; substitutes falling short of even one of these requirements are instantly discarded. Examples include asset readiness, regulatory compliance, or certain technical thresholds. Value-based preferences, the "desirability" criterion will assist distinguish other feasible solution possibilities by means of factors like cost efficiency, implementation speed, or scalability. Starting with "Must" criteria (logical filtering), this comprehensive strategy finds and screens options. Once options clear this gate, the "Want" criteria are then organized into a hierarchy, assessed via pairwise comparisons in AHP, and weighted using stakeholder judgment. According to Saaty (2008), AHP "is a theory of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales". Particularly in the context of GNK, where decisions affect operational profitability as well as national output objectives, it adds quantitative rigor, traceability, and agreement to qualitative factors. Combining KT and AHP fits with Contingency Theory, which stresses that no universal solution applies to decision making. The integration guarantees that only technically and operationally feasible choices are taken into account (KT), and that they are assessed in a methodical, participative, and strategic way (AHP), therefore enabling a strong, multi stakeholder decision process appropriate for large oil and gas projects.

The main decision making tool of this study is the AHP among the academically approved MCDM tools, AHP is one of the most popular. It breaks down difficult issues into a hierarchical framework and lets stakeholders evaluate criteria and options using paired judgments. The AHP, according to Saaty (2008), "is a theory of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales." Operational settings such PHR Zone-4, where choices call for the cooperation and agreement of several technical and management professionals, have great relevance in this capacity. AHP also guarantees consistency, traceability, and openness by means of Consistency Ratio (CR) measures. AHP offers a balanced combination of qualitative insight and quantitative rigor as compared to other techniques like the Delphi methodology (which is qualitative and exploratory) or Cost Benefit Analysis (which emphasizes just financial metrics). Selecting the best approach to manage GNK's future output depends on the company being able to assess the trade offs clearly and give top priority to the most value driven option.

A review of studies has shown an increase the use of MCDM approaches on complex investment and operational problems related to oil and gas industry. Zavadskas

et al. (2022) and Wang et al. (2023) present a model based on AHP, which is applied to assist the definition of plant configuration and infrastructures investment criteria by combining economic, technical and operating aspects. Liu et al. (2021) illustrate that the hybrid AHP method enhances robustness in decision-making for oil field development strategy selection under uncertainty and Rahman and Karmaker (2023) develop decision support systems based on interdisciplinary linkages of sustainability with costs effectiveness criteria in the optimisation of upstream infrastructure. However, in most of these applications AHP was used as a single performing ranking tool and concentrated essentially on technical or cost–benefit optimisation without adequately considering governance constraints and asset-use strategy.

Table 1. Summary of Recent MCDM and Strategic Decision Making Studies in Oil & Gas and Energy Systems 2021-2026 (Author, 2025)

No.	Author(s)	Context	Method	Key Findings	Identified Gap
1	Zavadskas et al. (2022)	Energy facility planning (global)	MCDM review	MCDM tools enhance infrastructure investment quality	Lacks governance & SOE context
2	Liu et al. (2021)	Oilfield development strategies	AHP–TOPSIS	Hybrid MCDM improves robustness under uncertainty	No asset-utilisation lens
3	Wang et al. (2023)	Oil & gas production facilities	AHP–DEA	Multi-criteria evaluation supports configuration choice	Purely technical ranking
4	Rahman & Karmaker (2023)	Upstream infrastructure	MCDM framework	Links sustainability & cost-efficiency	Ignores regulatory feasibility
5	Iledare et al. (2021)	Brownfield redevelopment	Policy analysis	Brownfield optimisation critical for mature fields	No formal MCDM integration
6	Hassan & Chen (2024)	Capacity debottlenecking	Strategy framework	Capital discipline dominates expansion logic	No decision-architecture model
7	Chawla & Kumar (2023)	Production bottlenecks	Systems modelling	Time-to-market key in mature fields	Lacks governance trade-offs
8	Trigeorgis & Reuer (2022)	Strategic asset redeployment	Real options theory	Reversible investment enhances flexibility	No upstream empirical case
9	Klingebiel & Joseph (2022)	Capital-intensive industries	Strategic management	Staged investment logic reduces risk	No facility-optimisation context

10	Barney & Mackey (2021)	Asset orchestration	Strategy theory	Redeployment drives competitive advantage	No energy-sector application
11	Paltsev & Capros (2021)	Energy transition economics	Scenario modelling	Transition raises investment uncertainty	No facility-level decisions
12	Raval & Truby (2023)	Upstream investment risk	Energy economics	Policy uncertainty reshapes CAPEX logic	No MCDM operationalisation
13	Hong & Lee (2024)	Energy policy uncertainty	Energy economics	Regulatory risk alters project rankings	No SOE context

Concurrently, the brownfield optimisation literature illustrates the increasing strategic significance of mature oil and gas field redevelopment influenced by capacity constraints and declining reservoir performance. Iledare et al. (2021) and Hassan and Chen (2024), stress that brownfield decisions are more based on the concept of capital discipline rather than decision to commit large scale green field investment. Chawla and Kumar (2023) also suggest that debottlenecking through production systems in mature fields would require multi-disciplinary technicaleconomical frameworks with time-to-market and operational viability as main components. However, little attention has been paid in previous literature to the systematic reformation of investment trade-offs under utilization of idle asset and regulatory feasibility within SOE-dominated upstream systems.

Resource redeployment and the effective utilization of surplus capacity From a strategic-management standpoint, asset redeployment and utilization of idle asset have been conceptualized as dynamic capabilities that allow organizations to adjust to market turbulence. Trigeorgis and Reuer (2022) and Klingebiel and Joseph (2022) connect real-options logic to staged investment/reversible commitment strategies in capital-intensive industries, with Barney & Mackey's (2021) theorisation of asset orchestration as a primary source of competitive advantage under resource constrains. However, despite these conceptual development, there has been relatively little empirical application of the same in the context of optimization within upstream oil and gas facilities, particularly outside developed economies, or where facilities are owned/operated by SOEs. To fill this void, this study directly incorporates asset-utilisation governance and regulatory feasibility into a VFT–KT–AHP decision framework.

As shown in Table 1. summarises recent peer-reviewed studies (2021–2026) on MCDM, brownfield optimisation, asset redeployment, and strategic investment under uncertainty in the energy and upstream oil and gas sectors. The table highlights that while existing studies have advanced technical and economic evaluation frameworks, they largely overlook governance constraints, asset-utilisation strategy, and SOE specific institutional trade-offs. This study extends the literature by addressing these gaps through an integrated VFT–KT–AHP decision architecture and a governance-oriented implementation playbook for idle-asset mobilization.

The construction of decision criteria in this study follows the epistemological logic of Value-Focused Thinking (VFT) as articulated by Keeney (1992), which emphasises the primacy of fundamental objectives over alternative driven analysis. Rather than deriving criteria from predefined technical parameters, the research first elicited stakeholder values through structured cross-functional discussions, allowing participants to articulate underlying strategic concerns before considering specific facility options. These value statements were organised into a means–ends hierarchy distinguishing fundamental objectives (e.g., capital sustainability, production continuity, governance compliance) from instrumental objectives (e.g., minimise CAPEX exposure, accelerate implementation time, reduce regulatory friction). Through iterative clustering and validation, these objectives were then operationalised into measurable evaluation constructs within the AHP hierarchy. For instance, fiscal discipline under SOE capital ceilings was translated into CAPEX, OPEX, and cost-efficiency indicators under the Cost dimension; time-sensitive production ramp-up objectives were captured through production gain and implementation lead time under the Benefit dimension; and institutional and operational exposure concerns were structured into execution complexity, operational reliability, and HSE risk under the Risk dimension. This structured transformation from value articulation to quantifiable criteria ensures conceptual coherence between strategic intent and analytical measurement. Importantly, the hierarchy embeds governance constraints explicitly within the evaluation architecture, thereby extending conventional AHP applications that often rely on technically predefined criteria. By preserving traceable alignment between stakeholder values, institutional realities, and quantitative prioritisation, the integrated VFT–KT–AHP framework advances decision architecture transparency and strengthens the methodological legitimacy of the ranking outcome.
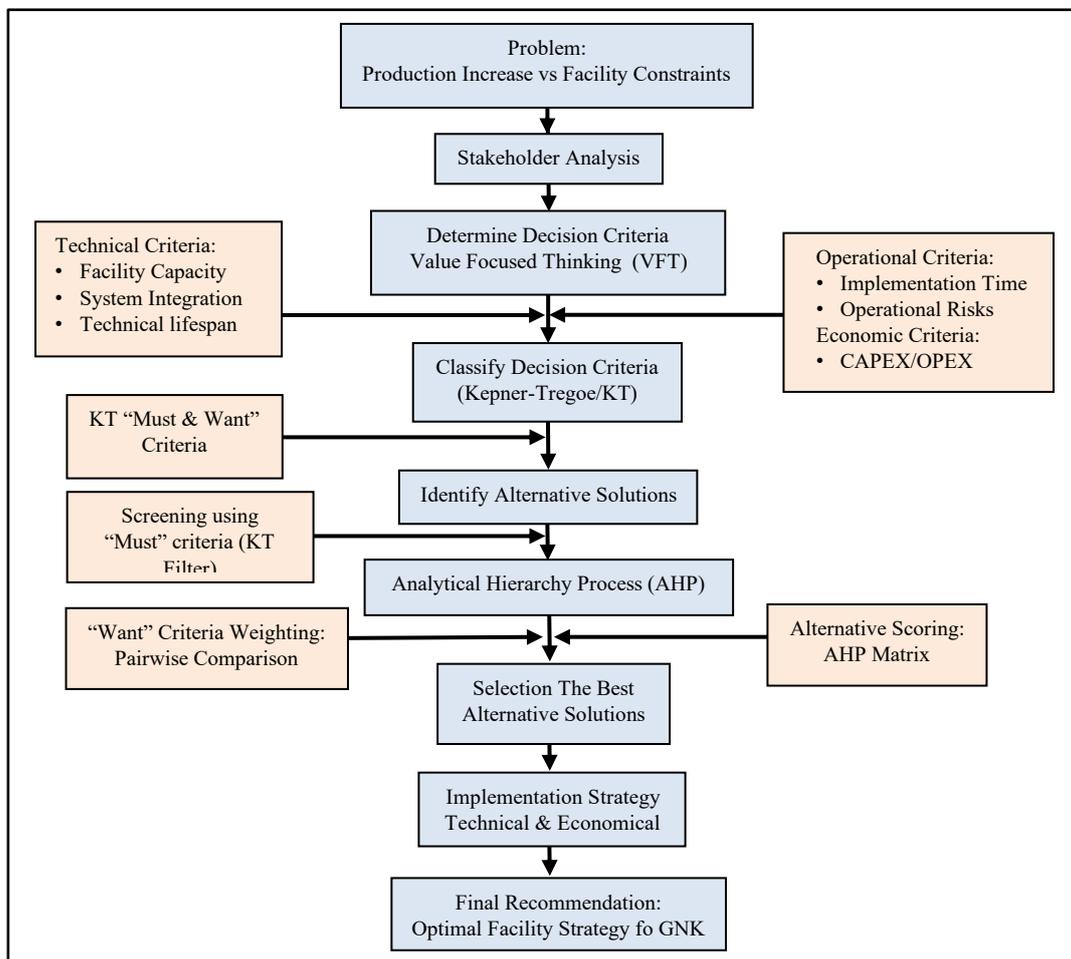
METHODOLOGY

According to Dawson (2019), a research methodology is the primary principle that will guide your research. It becomes the general approach in conducting research on your topic and determines what research method you will use. We'll need to consider a few things when deciding on the best approach for our topic. Issues could be developments such as the scope of our study or ethical dilemmas that may involve the quality of our research. Research methodology is described as the design for conducting the studies in a systematic manner to ensure validity and reliability, and the results meet the objectives of the study. It is a particular approach to dealing with, processing, and viewing the information the author received. The goal of research methodology is to plan, carry out, and analyze the research study in order to answer the research question. Depending on the research question, the research method might be quantitative, qualitative, or a blend of the two. This chapter will divide research technique into three parts. The first part talks about the steps you need to take to answer a research topic. The second portion goes into more depth about how the data was gathered, such as through qualitative and quantitative research, semi-structured interviews, focus groups, questioners, and surveys to find

criteria and weights. The third portion talks about how the authors use AHP method to look at, evaluate, and understand data in order to discover the best strategy option.

This research applies an organized decision making technique that contains both qualitative type and quantitative method to solve the production increases versus facility constraints problems dramatically in the GNK Structure. The first step is to take a stakeholder analysis, so that all views are taken into account. It then identifies decision criteria based on the VFT framework that resonates with their corporate strategic values. These criteria are a part of "Must" (essential elements) & "Want" features classification in the KT methodology. Candidate options are selected using the KT "Must" filter and their merits compared by means of pairwise comparisons based on "Want" criteria with the AHP.

Figure 1. Research Design

Problem:
Production Increase vs Facility Constraints

↓

Stakeholder Analysis

↓

Technical Criteria:
• Facility Capacity
• System Integration
• Technical lifespan

→ Determine Decision Criteria
Value Focused Thinking (VFT) ←

Operational Criteria:
• Implementation Time
• Operational Risks
Economic Criteria:
• CAPEX/OPEX

↓

KT "Must & Want" Criteria → Classify Decision Criteria
(Kepner-Tregoe/KT)

↓

Screening using "Must" criteria (KT Filter) → Identify Alternative Solutions

↓

"Want" Criteria Weighting: Pairwise Comparison → Analytical Hierarchy Process (AHP) ← Alternative Scoring: AHP Matrix

↓

Selection The Best Alternative Solutions

↓

Implementation Strategy Technical & Economical

↓

Final Recommendation: Optimal Facility Strategy fo GNK

Source: Author, 2025

AHP model calculates the priority weights of each alternative using technical, operational, economic criteria such as facility capacity, system integration, implementation time, CAPEX/OPEX and operation risks. The one with the highest sum is chosen as the best alternative. The third step includes mandates to develop a technical & economic program which culminates in the data led and deliverable recommendation on surface production facility optimization at GNK.

Data Collection Method

This research will adopt both the primary data and secondary data. Main data will be gathered from employee of PHR Zone-4 in several division related, with discussion in Focus Group Discussion (FGD). The secondary data that will be used are gathered from company's literature, company's website, company presentation as well as others available online sources. This research uses secondary and primary data and is a collection of two research questions that are going to be addressed. Secondary sources consisted of reports (either internal planning/technical reports or open literature reports), feasibility studies, background seismic re-evaluation reports, and historical production and facility capacity reports. These sources were employed to derive alternative solutions and to also be able to assess the operational limitations and the risk and economic feasibility. In parallel with the desk research, the primary data were obtained from in-depth interviews from internal staff who were experts in evaluating and decision making (data on identifying the decision criteria, "Must" and "Want", carrying out the pairwise comparisons for the AHP weighting, and feasibility and quality of alternatives).

FGD's were then used to confirm preliminary results using interviews, and to identify and form a consensus around criteria for prioritization and to assess the risks and options for adopting the alternative. The decision criteria were determined based on VFT method and the alternatives were assessed using the (AHP). This hybrid methodology makes certain that a best effort solution is both practical to implement, technically and financially, in the GNK domain.

Expert Selection and Data Reliability

This study relies on expert judgment as the primary input for pairwise comparisons within the AHP framework. Seven Subject Matter Experts (SME's) participated in the evaluation process. The selection criteria were based on (1) direct involvement in GNK facility planning and operations, (2) minimum 10 years of professional experience in upstream oil and gas operations, and (3) cross-functional representation across subsurface development, production engineering, project management, and operations. The expert panel consisted of:

1. Senior Production Manager (18+ years experience)
2. Senior Subsurface Development & Planning Manager (18+ years)
3. Senior Project Manager (18+ years)
4. Senior Field Manager (18+ years)
5. Operations & Surface Facilties Manager (18+ years)
6. Project Engineering & Planning Manager (18+ years)
7. Production Operation Manager (18+ years)
8. Senior Engineer Project Technical Planning (10+ years)

This cross-functional composition was designed to minimise single-discipline bias and reflect the multi-stakeholder nature of facility investment decisions in SOE-governed upstream environments. To mitigate individual subjectivity bias, pairwise comparison matrices were aggregated using the geometric mean method, consistent with established

AHP group-decision practice (Saaty, 2008). The geometric mean ensures proportional balance across judgments and prevents dominance by extreme individual scores.

Furthermore, CR were calculated for all criteria, sub-criteria, and alternative matrices. All CR values were below the acceptable threshold of 0.10, indicating reliable internal judgment consistency. This supports the methodological robustness of the collective expert assessment.

Data Analysis Method

The method for data analysis in the current study combines qualitative and quantitative approaches to systemically assess and rank alternative solutions to production facility optimization in the GNK Structure. This is implemented in a multi method decision matrix which is a MCDM model incorporating VFT, KT filtering, and the AHP. As a summary, in this part, the overall integrated research methodology (VFT-KT-AHP) was introduced to tackle the strategic decision-making issues in designing GNK's surface production facilities. The process driven method also ensures that the choices are assessed on well defined stakeholder-oriented standards, verifiable data, and a logical process of prioritization. Analysis results and guidance from the AHP scoring, risk analysis and economic evaluation will be provided in the next chapter with a view to identify the most practical and effective strategy to be implemented, not only in theory, but also in alignment with operational, technical, and financial constraints specific to the GNK development context.

Figure 2. Data Collection and Analysis Method
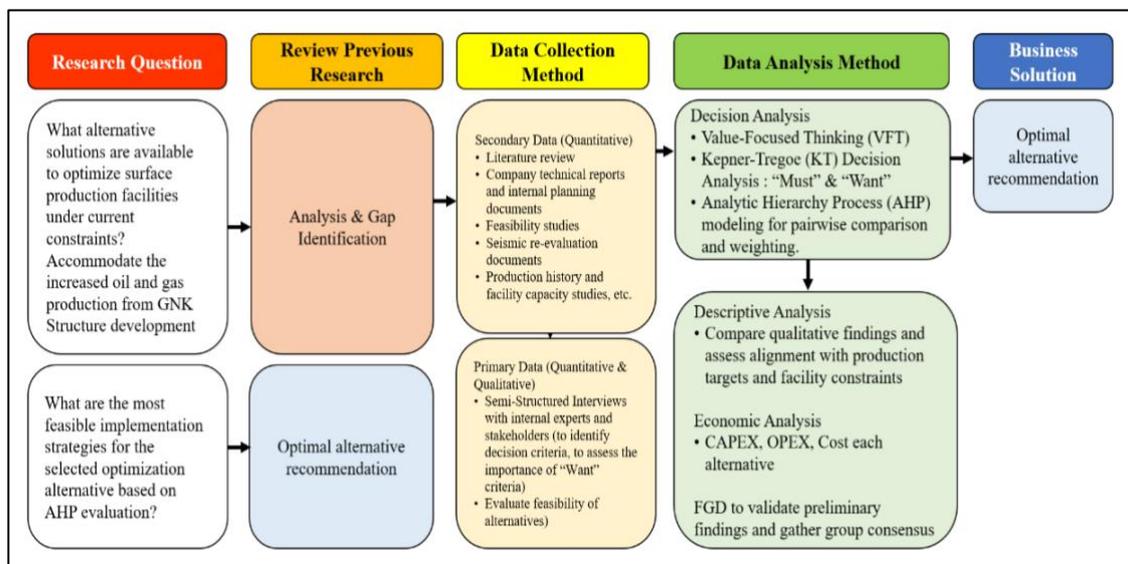
Source: Author, 2025

Computational Procedure and Replicability

To enhance methodological transparency, the AHP computational process followed standardised steps consistent with Saaty (2008). First, individual pairwise comparison matrices were collected from each expert using the 1–9 fundamental scale. Second, group

aggregation was performed using the geometric mean method to derive a consolidated comparison matrix for each criteria level.

Eigenvector priorities were calculated by normalising the principal right eigenvector of each aggregated matrix. The Consistency Index (CI) was computed as $(\lambda\max - n)/(n - 1)$, where $\lambda\max$ represents the maximum eigenvalue and n the matrix size. The Consistency Ratio (CR) was then obtained by dividing CI by the Random Index (RI) corresponding to matrix size. All CR values were below the accepted threshold of 0.10, confirming acceptable consistency. Global priority weights were derived by multiplying local alternative weights by corresponding criteria weights through hierarchical synthesis.

RESULTS & DISCUSSION

Identification and Screening of Strategic Alternatives

In response to research questions 1: *What alternative technologies exist for the optimisation of surface production facilities within given constraints?* Four strategic options obtained using formatted FGD's among the subsurface, production, engineering and project management participants. These options are : 1) building of a new facility (greenfield expansion), 2) restructuring one or more existing premises (brownfield enhancement), 3) utilization of idle assets within the organisation, and 4) hire of third party premises. The alternatives were first pre-filtered by the KT Decision Analysis framework prior to entering the AHP evaluation stage. The compulsory ("Must") requirements were regulatory (such as meeting regulatory and standards requirements), minimum processing capability, ease of implementation, and being available within the timeline for production ramp-up. All four options met the obligatory requirements and all were then taken into account in multi-criteria evaluation.

The process of generating strategic alternatives was a key step in moving from articulating stakeholder values and decision criteria to the development of feasible engineering and operations alternatives. By way of triangulating these two sources of evidence, the participants brought the relevant practical insight from their technical knowledge, operational experience and project history. This grassroots engagement provided that the final products were not only informed by field realities, but responsive to strategic desires. During the structured FGD sessions, experts were asked to evaluate alternatives against strategic, financial, and operational constraints, rather than purely technical performance indicators. This approach ensured that the decision hierarchy reflected managerial realities, including capital ceilings, regulatory approval timelines, and implementation feasibility under production ramp-up pressure.

Figure 3. VFT Process of GNK Surface Production Facilities Strategy
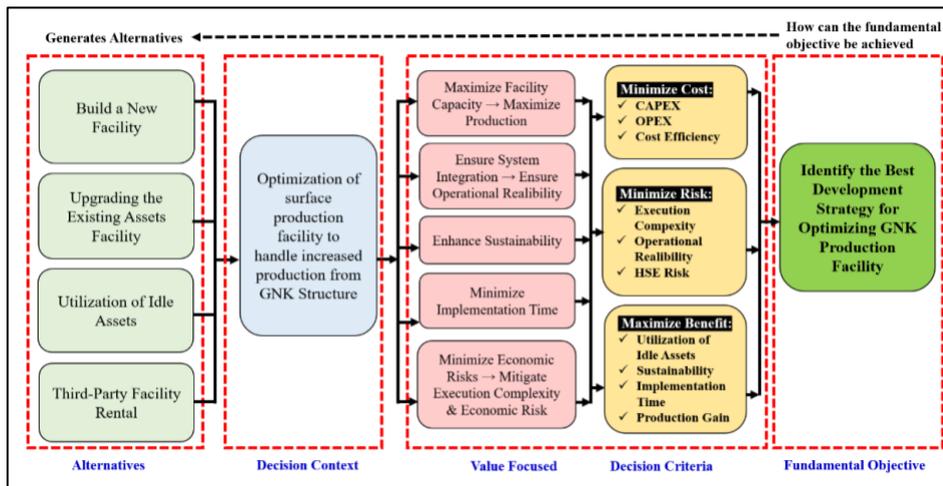
Source: Author, 2025

Based on the value dimensions identified through the VFT approach, KT Decision Analysis was used as a means to make these abstract values more concrete and measurable by turning them into decision criteria. This was to ensure that each of the decision points considered by stakeholders mapped to either a hard requirement ("Must") or preference that could be objectively assessed against other similar benefits ("Want"). A set of evaluation aspects was developed through facilitated discussions, interviews and validation workshops, and the resulting list was reviewed and culled. "Must" criteria were those that stood for cut points, unarguable thresholds, or regulations. These were screening gates, any option that fell short of one or more "Must's" would be eliminated, no matter its end objective performance. Meanwhile, those attributes that influenced stakeholder preference and were accepted for trade-offs were classified as "Want" criteria. These would be used to create the weights and scores at the AHP modeling stage in the subsequent step. It was important to draw the line between "Must" and "Want" to maintain a sense of feasibility and aspiration, ensuring that the decisions we made were rational and justifiable. The participants in the focus group discussion and semi-structured interviews concluded that numerous critical variables should serve as the basis for creating alternatives using VFT, as outlined in Figure 4.

Figure 4. Critical Considerations ("Must" and "Want") for Generating Alternatives
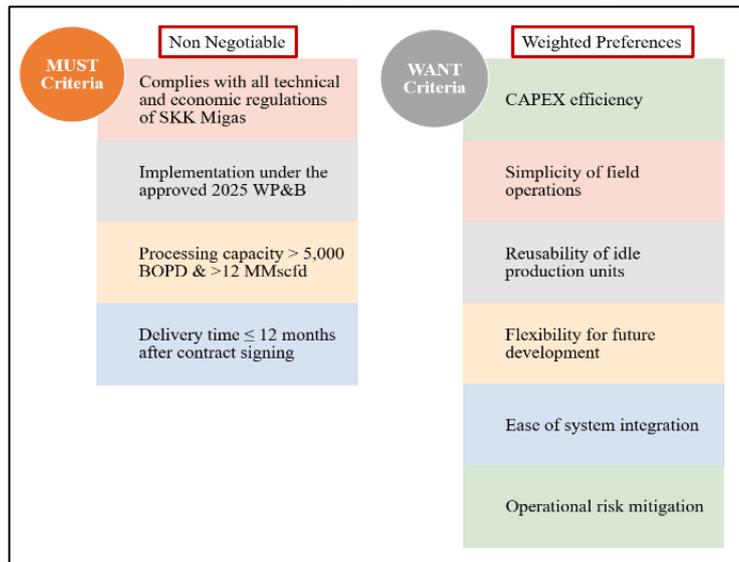
Source: Author, 2025

In the FGD, participants were asked to consider: "What can we realistically do to manage an increase in GNK production with our existing capacity, time, and investments? Several strategic alternatives were identified through structured expert consultation, such as previous initiatives in related sectors and lessons from previous mobilization initiatives. "Must" criteria Framing the brainstorming around the "Must" criteria constraining ideas to the maximum extent possible while still allowing for creative thinking. The four strategic options were subsequently integrated with internal benchmarking and feasibility cross checks.

(1) Alternative 1 : Build a New Facility

A new facility often known as Central Processing Unit (CPF)/Gathering Station (GS/SP) in oil and gas operations is a surface facility designed to receive, gather, and process the production fluids (oil, gas, and water) from multiple wells. The construction of a new GS/SP or a surface facility for production from the GNK Structure (SP), represents a greenfield development whose objectives are to stand-alone for additional oil and gas production from the GNK development, not to use stranded facilities. This facility would consist of new separators, production tanks, gas compressor, water treatment injection plant (WTIP) and gas sweetening units to reach out GSA (Gas Sales Agreement) parameters. This would give high capacity and long term security, but negative cash and a longer lead time. Building this new facility will take approximately 3 years (1 year for procurement, 2 years for EPCI work) and cost around 20 million USD.

(2) Alternative 2 : Upgrading the Existing Assets Facility

Another option that came out of the interviews and FGD's would be to extend the existing production facility to cope with the additional load from the GNK development. This method is based on the leverage of current capabilities, to reinforce the contribution of existing facilities, in order to enhance the level of facilities utilization and integration capabilities through upgrades and extensions. This brownfield alternative has low to moderate CAPEX, has shorter lead times and takes

advantage of the existing assets. Upgrading this existing facility this will take approximately 2 years (6 months for procurement, 1.5 years for delivery time new unit and several installation work) and cost around 20 million USD.

(3) Alternative 3 : Utilization of Idle Assets

A promising alternative identified in the interviews/FGD was to utilise unused processing units in PHR Zone 4. Utilize/mobilize idle assets from other parts of the PHR/PHE asset base or from other oil and gas company in Indonesia. This model makes effective use of wasted resource and delivers cost savings, but has integration and refurbishment risks associated with it. This mechanism was developed from VFT and further developed in the spirit of KT Decision Analysis by mapping organizational values into actionable paths toward acceptable states. This strategy uses resources that aren't being used enough to speed up the deployment of GNK facilities, even if integration and refurbishment can be hard. The buying cost of equipment will be zero, as it will be purchased from previously unused items. Potential expenses could be such as : survey & detailed engineering costs, material cost for supplement if less to meet requirement, mobilization costs, dismantle & installation costs, permit and certification, supervision team, and total cost estimated to be around 1 million USD with time period of around 6 months.

(4) Alternative 4 : Third-Party Facility Rental

One strategic option that has been identified in the expert interviews and FGD meetings was to hire processing capacity from a third-party source in the vicinity of the GNK development. This approach attempts to avoid greenfield construction by using existing capacity in the facilities owned by the third-party contractor/vendors. This alternative similar with alternative-2 (upgrading the existing assets facility), the differences being that you buy a new several unit for upgrading instead of renting a several units. both in buy new unit. To sum up, Alternative 4 represents a strategic solution which can achieve immediate monetization while effectively combining high enough technical integration with low operational costs, but the solution's potential long-term sustainability is questioned given the high operational costs and it's reliance on external infrastructure. This alternative will take approximately 8-12 months and cost around 2 million USD/year rental (depends on how many units rental).

Criteria Weighting and Consistency Assessment

The AHP hierarchy was structured into four levels: the overall goal (optimal surface facility strategy), three main criteria (Cost, Benefit, and Risk), ten sub-criteria, and four alternatives. Pairwise comparison matrices were developed using Saaty's nine-point scale and aggregated through the geometric mean approach to reflect consensus judgments.

Table 2. Description of Criteria and Sub-Criteria from AHP Hierarchy Structure

Criteria	Sub-Criteria	Description
COST		It is the total cost of arrangements and packages, including CAPEX and OPEX. Cheaper, or more efficient in the cost per unit of output sense, alternatives are perceived as more economically favourable.

	CAPEX	Capital Expenditure, an initial investment required for constructing or expanding production facilities (e.g., New Facility, Separator, Compressor).
	OPEX	Operational Expenditure, Long-term operational costs including utilities, maintenance, chemicals, and labor.
	Cost Efficiency	The effectiveness of cost relative to production output (e.g., cost per barrel/unit).
BENEFIT	It is concluded that benefits are evaluated in terms of utilization of idle asset the operational sustainability, implementation time and possible production increase. Favored candidates are those that can be placed into production rapidly using existing infrastructure and that can contribute to long-term production objectives.	
	Utilization of Idle Assets	Reuse of dormant but functional equipment to reduce investment and speed up implementation.
	Sustainability	Facility's ability to operate reliably over time and adapt to future operational or regulatory changes.
	Implementation Time	Time required to make the facility fully operational; shorter times are preferred.
	Production Gain	Expected increase in oil and gas output resulting from each proposed alternative.
RISK	The risk parameter includes execution complexity, operational reliability, and HSE (Health, Safety, and Environmental) risks. Options with less complicated implementation, more predictable operation, and less risk to safety and the environment are considered more operationally viable.	
	Execution Complexity	Technical and coordination difficulties in implementing the alternative, such as space constraints or integration challenges.
	Operational Reliability	The ability of the facility to operate consistently without unexpected shutdowns.
	HSE Risk	Health, Safety, and Environmental risks including system pressure, area access, and compliance with HSSE regulations.

Source: Author's calculation based on FGD and expert pairwise comparison data, 2025

As shown in Table 2, presents the priority weights of the three main criteria. The results indicate that Cost carries the highest relative importance, followed by Benefit, and then Risk. This weighting structure reflects the strategic salience of capital discipline and financial constraints in the GNK brownfield context.

At the sub-criteria level, CAPEX and cost efficiency received the highest weights within the Cost dimension, while production gain and utilization of idle assets were prioritised within the Benefit dimension. Within the Risk dimension, implementation time and execution complexity were weighted more heavily than HSE and operational reliability risk, reflecting managerial emphasis on delivery speed under production ramp-up targets. CR's were calculated for all pairwise comparison matrices. All CR values were

below the acceptable threshold of 0.10, indicating satisfactory internal consistency in expert judgments. These results confirm the methodological robustness of the weighting process.

Final Alternative Ranking

Four strategic alternatives that satisfied all mandatory ("Must") feasibility criteria were subsequently evaluated using the AHP. These alternatives represent distinct capital-allocation logics: greenfield expansion, brownfield upgrading, utilization of idle assets, and third-party facility rental. The evaluation focuses exclusively on alternatives that are technically feasible and institutionally compliant, ensuring that the AHP stage operates within realistic governance constraintsThere are four steps in this process: Problem Definition and Structure, Pairwise Comparison, Prioritization and Synthesis, Check for Consistency.

Figure 5. AHP Hierarchy Structure of GNK Facility Optimization
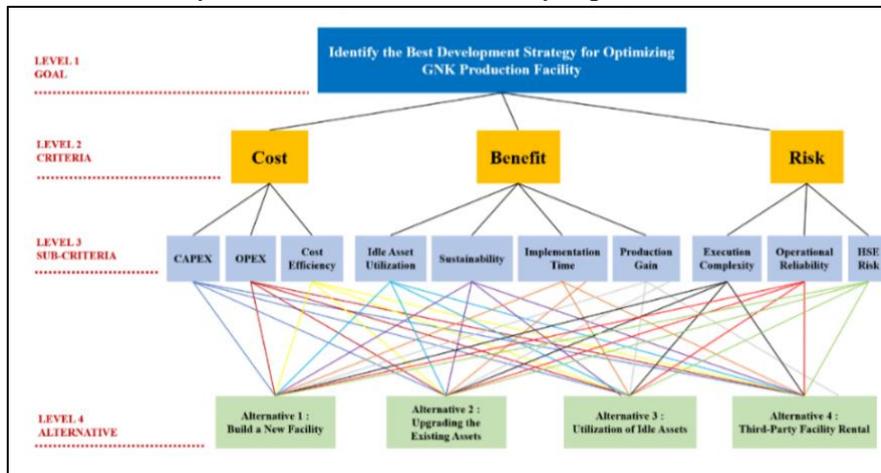
Source: Author's calculation based on FGD and expert pairwise comparison data, 2025

Table 3. Complete Pairwise Comparison Form

Parameter	Rating	Parameter
Criteria		
Cost	9 7 5 3 1 3 5 7 9	Benefit
Cost	9 7 5 3 1 3 5 7 9	Risk
Benefit	9 7 5 3 1 3 5 7 9	Risk
Sub Criteria – Cost		
CAPEX	9 7 5 3 1 3 5 7 9	OPEX
CAPEX	9 7 5 3 1 3 5 7 9	Cost Efficiency
OPEX	9 7 5 3 1 3 5 7 9	Cost Efficiency
Sub Criteria – Benefit		
Idle Asset Utilization	9 7 5 3 1 3 5 7 9	Sustainability
Idle Asset Utilization	9 7 5 3 1 3 5 7 9	Implementation Time
Idle Asset Utilization	9 7 5 3 1 3 5 7 9	Production Gain
Sustainability	9 7 5 3 1 3 5 7 9	Implementation Time

Parameter	Rating	Parameter
Sustainability	9 7 5 3 1 3 5 7 9	Production Gain
Implementation Time	9 7 5 3 1 3 5 7 9	Production Gain
Sub Criteria – Risk		
Execution Complexity	9 7 5 3 1 3 5 7 9	Operational Reliability
Execution Complexity	9 7 5 3 1 3 5 7 9	HSE Risk
Operational Reliability	9 7 5 3 1 3 5 7 9	HSE Risk
Alternative – Cost (CAPEX)		
Build a New Facility	9 7 5 3 1 3 5 7 9	Upgrading the Existing Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Utilization of Idle Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Alternative – Cost (OPEX)		
Build a New Facility	9 7 5 3 1 3 5 7 9	Upgrading the Existing Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Utilization of Idle Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Alternative – Cost (Cost Efficiency)		
Build a New Facility	9 7 5 3 1 3 5 7 9	Upgrading the Existing Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Utilization of Idle Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Alternative – Benefit (Idle Asset Utilization)		
Build a New Facility	9 7 5 3 1 3 5 7 9	Upgrading the Existing Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Utilization of Idle Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Alternative – Benefit (Sustainability)		
Build a New Facility	9 7 5 3 1 3 5 7 9	Upgrading the Existing Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental

Parameter	Rating	Parameter
Utilization of Idle Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Alternative – Benefit (Implementation Time)		
Build a New Facility	9 7 5 3 1 3 5 7 9	Upgrading the Existing Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Utilization of Idle Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Alternative – Benefit (Production Gain)		
Build a New Facility	9 7 5 3 1 3 5 7 9	Upgrading the Existing Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Utilization of Idle Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Alternative – Risk (Execution Complexity)		
Build a New Facility	9 7 5 3 1 3 5 7 9	Upgrading the Existing Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Utilization of Idle Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Alternative – Risk (Operational Reliability)		
Build a New Facility	9 7 5 3 1 3 5 7 9	Upgrading the Existing Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Utilization of Idle Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Alternative – Risk (HSE Risk)		
Build a New Facility	9 7 5 3 1 3 5 7 9	Upgrading the Existing Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Build a New Facility	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Utilization of Idle Assets
Upgrading the Existing Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental
Utilization of Idle Assets	9 7 5 3 1 3 5 7 9	Third-Party Facility Rental

Source: Author's calculation based on FGD and expert pairwise comparison data, 2025

Figure 6. The Fundamental Scale Value of Pairwise Comparison

Source: Saaty, 2008

The last stage in this decision-making process that combines results from all levels of the hierarchy and picks an optimal strategic alternative for GNK production facility. This process involves a summary step, add up all the principal points from each level. You start with the main criteria (Cost, Benefit and Risk), then its respective sub-criteria, and finally each alternative. The global weight of each alternative is determined by multiplying the weight given to each sub-criteria with that alternative's priority score under this same criterion, and then summing across all criteria. As shown in Table 3., "Utilization of Idle Assets" ranks highest with an overall weighted value of 0.547. This alternative is especially superior in the category of Cost, performing well in sub-criteria including CAPEX (0.678), OPEX (0.597) and Cost Efficiency (0.676). These findings are clear-cut proof of its advantage at reducing both capital and operating costs while remaining feasible overall. The second best alternative was "Upgrading the Existing Assets", with an overall performance factor of 0.322.

Table 4. The Final Result and Ranking of All Alternatives

Criteria	Weight	Sub-criteria	Weight	Alternatives			
				Build a New Facility	Upgrading the Existing Assets	Utilization of Idle Assets	Third-Party Facility Rental
Cost	**0.370**	CAPEX	0.174	0.060	0.147	0.678	0.175
		OPEX	0.302	0.101	0.217	0.597	0.186
		Cost Efficiency	0.524	0.066	0.148	0.676	0.176
Benefit	**0.479**	Utilization of Idle Asset	0.239	0.150	0.319	0.513	0.169
		Sustainability	0.093	0.456	0.365	0.335	0.300

		Implementation Time	0.420	0.094	0.213	0.586	0.200
		Production Gain	0.487	0.535	0.456	0.289	0.255
Risk	**0.151**	Execution Complexity	0.184	0.445	0.481	0.313	0.206
		Operational Reliability	0.416	0.426	0.336	0.331	0.333
		HSE Risk	0.400	0.581	0.389	0.292	0.319
Total Weight				**0.283**	**0.322**	**0.547**	**0.245**
Alternatives Ranking				**3**	**2**	**1**	**4**

The magnitude of the global priority difference between utilization of idle assets (0.547) and the second-ranked alternative (0.322) indicates a structurally dominant solution rather than a marginal preference. This substantial gap suggests that, under current capital and governance constraints, incremental asset redeployment significantly outperforms expansion-oriented strategies. The result reflects the compounded weight of capital efficiency, shorter lead time, and regulatory feasibility within the decision hierarchy. It performs well in the Benefit category, particularly at Sustainability (0.365) and Production Gain (0.456), which leads to an indication that moderate investment can provide long lasting operational improvements. "Build a New Facility" ranks third at 0.283, missing out on higher standing due to its high cost and longer lead-times for implementation. Last of all is "Third-Party Facility Rental", whose weighted coefficient is 0.245 and which with most part performs weakly across the ratings but has moderate risk levels. These results confirm that "Utilization of Idle Assets" is the optimal choice, given its closest match to strategic objectives. Cost-effectiveness and timely completion are two priority areas that make this choice an attractive one. Not only does it make use of existing infrastructure and resources, it also keeps exposure to capital investment as low as possible and deployment risks moderate under current operational conditions. So that the results addresses Research Question 2: *What is the most feasible implementation strategy based on AHP evaluation?*

Figure 7. Final Score Result Hierarchy Structure of GNK Facility Optimization
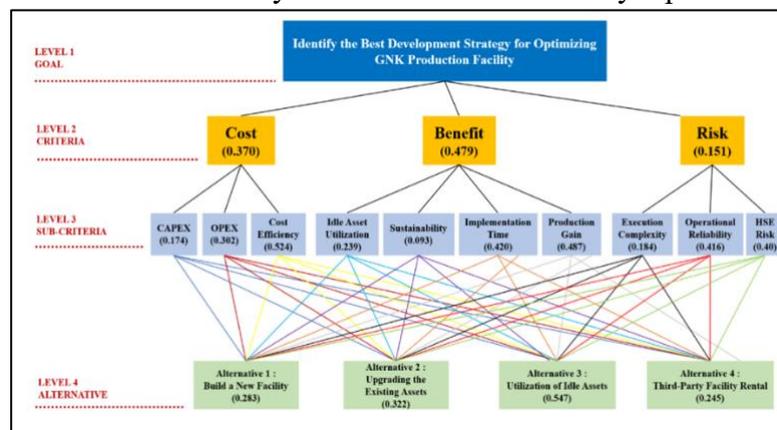
Source: Author, 2025

The Utilization of Idle Assets has been found to be the most viable solution, based on this integrated assessment point result (AHP). Another option is to use of idle or underdeveloped equipment within Pertamina Group or its subsidiaries in the form of existing surface production such as separators, scrubbers, tanks and compressors. These assets would be renovated and deployed to support GNK's production needs. The justification for this business solution are:

- Cost Efficiency

  CAPEX estimated only about 1 Million USD, this is the lowest capital investment alternative amongst the others. By repurposing legacy utilization of idel assets, we can massively reduce the need for new build or acquisition. OPEX is also low since the systems are self managed and there are no third-party leasing fees.

- Faster Implementation

  Based on engineering estimates and historical mobilization timelines, the idle asset strategy is expected to be implemented in 6 months compared to the delays involved in constructing brand new plants (12 -18 months). This delivers a critical edge for GNK's high margin near term production ramp up strategy and enables early revenue recognition from additional production.

- Technical Feasibility

  Assets to be used are chosen for technical compatibility with GNK production parameters (pressure regimes, flow rates, fluid composition). A preliminary internal audit has noted equipment with a life span of 5–10 years, available for an expedited mobilization after a minor refurbishment and integrity testing.

- Strategic Alignment

  This solution demonstrates PHR's disciplined capital approach and business optimization efforts in line with SKK Migas initiatives to reutilize assets and improve costs. It also fits with the wider corporate goal of hitting the 2025 production goals without relying on high risk, high CAPEX developments.

- Stakeholder Support

  Based on FGD and structured interviews with SMEs from the major functions impacted (subsurface development, production, project engineering, and operations) in this scenario the idea received solid backing for being pragmatic and scalable in the current operational environment.

- Risk Mitigation

  This option facilitates lower risk than other solutions, including permitting, procurement delays, and construction risks. SKK Migas re-certification and HSSE risk assessment which are eased up by the fact that compliance is managed internally as part of asset ownership.

Lastly, The Utilization of Idle Assets is surfaced as a viable cost effective option that can be operationalized in decreasing the asset break even contribution margin which directly addresses the root cause business problem: optimizing GNK's surface production facilities with limited available resources and timeliness. It is also cost effective utilizing current corporate assets, reduces time of project completion and aligns well with overall strategic and tactical motives.

Sensitivity and Robustness Analysis

Given the inherently judgment based nature of criteria weighting in the AHP, a structured robustness assessment was conducted to evaluate the stability of the ranking outcome under plausible preference perturbations. Three sensitivity scenarios were simulated: (1) a 10% increase in the Cost criterion weight with proportional downward adjustment of Benefit and Risk weights; (2) a 10% increase in Benefit weight; and (3) a 10% reduction in Cost weight with reallocation primarily toward Risk to reflect a more risk sensitive managerial stance. Across all scenarios, utilization of idle asset consistently remained the top-ranked alternative, with no evidence of rank reversal. In the base model, the global priority gap between utilization of idle assets (0.547) and the second-ranked alternative (0.322) is 0.225; under all simulated weight variations (±10%), the minimum dominance margin remained above 0.17, indicating a structurally significant stability buffer rather than a marginal preference outcome. This robustness arises from the alternative's convergent strength across multiple high-weight criteria, particularly capital efficiency, shorter implementation lead time, and regulatory feasibility under SOE governance constraints, thereby reducing sensitivity to single-criterion fluctuations. From a methodological standpoint, the absence of rank instability under reasonable weight perturbations mitigates concerns regarding subjective bias and reinforces the decision-architecture integrity of the integrated VFT–KT–AHP framework. Consequently, the selection of utilization of idle assets should be interpreted as a resilient strategic solution supported by multi-criteria dominance rather than as an artefact of specific weighting assumptions.

Why Utilisation of Idle Asset Dominates: Strategic Mechanisms and Theoretical Implications

The dominance of the utilisation of idle asset alternative in the AHP results is not merely a numerical artefact of weighting, but reflects a set of reinforcing strategic mechanisms that are particularly salient in brownfield, SOE-governed upstream contexts. First, under capital discipline constraints, utlisation of idle assets minimises upfront capital expenditure (CAPEX) while preserving optionality for future scale-up. Unlike greenfield facility construction, which locks the organisation into high sunk costs and long payback horizons, utlisation of idle assets enables staged investment and reversible commitment, aligning with real-options logic in capital budgeting under uncertainty.

Second, from a time-to-market perspective, utilisation of idle asset compresses implementation lead times by circumventing lengthy procurement, permitting, and construction cycles. In production ramp-up environments such as GNK, where incremental barrels have immediate revenue and national energy-security value, speed of execution becomes a first-order strategic criterion rather than a secondary operational consideration. This temporal advantage explains why implementation time and operational feasibility emerge as dominant sub-criteria in the composite AHP weighting.

Third, in terms of risk governance, utilisation of idle assets reduces both execution complexity and regulatory exposure. Because relocated assets have prior operational histories and compliance clearances, they face fewer regulatory approval uncertainties

than newly engineered facilities. This characteristic is especially material in Indonesia's upstream regulatory regime, where SKK Migas approval timelines and capital ceilings introduce non-market risks that are not captured by conventional engineering-economic models.

From a strategic-operations perspective, these mechanisms collectively explain why utlisation of idle assets outperforms greenfield and brownfield expansion alternatives despite their superior long-term capacity profiles. The preferred alternative therefore reflects a dominance of capital efficiency, execution speed, and governance feasibility over pure technical optimality. This finding supports the proposition that, in mature-asset environments, operations strategy is increasingly shaped by asset orchestration and redeployment capabilities rather than by capacity expansion alone.

Relative to prior decision-making and operations-strategy literature, this study extends existing AHP-based facility-planning models in three important ways. First, whereas most prior studies apply AHP as a stand-alone ranking tool, this research embeds AHP within a broader VFT–KT architecture that explicitly links stakeholder values, feasibility constraints, and strategic trade-offs into a single decision logic. Second, while conventional facility-optimisation studies emphasise cost minimisation or production maximisation, this study introduces asset-utilisation governance and regulatory feasibility as explicit strategic criteria. Third, in contrast to technology-centric optimisation frameworks, the findings demonstrate how SOE governance structures and institutional constraints systematically reshape the relative attractiveness of investment alternatives. Taken together, these contributions reposition facility optimisation from a technical engineering exercise to a strategic managerial capability, with implications for how upstream firms in emerging-market economies structure capital-allocation processes, manage production bottlenecks, and mobilise underutilised assets under uncertainty.

Strategic Mechanisms Underlying Idle-Asset Dominance

The dominance utilisation of idle asset emerges not only from its final global priority weight (0.547) but from the cumulative hierarchical convergence embedded within the AHP structure. At the first level, the weighting of main criteria assigns the highest relative importance to Cost, followed by Benefit and Risk, reflecting stakeholder prioritisation of capital discipline under SOE budget constraints. Within the Cost dimension, utilisation of idle asset scores strongly on CAPEX and cost efficiency due to minimal new capital commitment and reduced infrastructure expenditure. Under the Benefit dimension, although greenfield expansion offers higher theoretical long-term capacity, utlisation of idle assets performs competitively in production gain while significantly outperforming alternatives in implementation time. Within the Risk dimension, the alternative demonstrates lower execution complexity and regulatory exposure compared to major construction projects or third-party contractual arrangements. Through eigenvector normalisation and hierarchical synthesis, these local advantages across high-weight sub-criteria compound multiplicatively, resulting in a structurally dominant global priority rather than a single-criterion advantage. This convergence reflects the resolution of strategic trade-offs within capital-intensive operations systems, where cost efficiency, speed, and governance feasibility collectively outweigh expansion capacity. Consistent

with operations strategy trade-off theory and real-options logic, utlisation of idle assets embodies a flexible, staged investment pathway that preserves optionality while mitigating irreversible capital commitment. From an asset orchestration perspective, the outcome illustrates how redeployment capability functions as a dynamic resource configuration advantage in mature brownfield portfolios. Thus, the AHP process does not simply rank alternatives statistically; it analytically reveals how multi-level criteria interactions favour institutionally aligned, capital-flexible solutions under uncertainty.

Theoretical Positioning and Contribution

This study contributes to operations strategy and decision-architecture theory in three ways.

First, from an operations strategy perspective, the findings demonstrate that facility optimisation in mature brownfield assets is shaped not solely by capacity expansion logic but by capital discipline and time-to-market considerations. This aligns with the strategic trade-off view in operations management, where cost, flexibility, and delivery speed become dominant priorities under resource constraints.

Second, the results support real-options reasoning in capital-intensive industries (Klingebiel & Joseph, 2022; Trigeorgis & Reuer, 2022), suggesting that managers under uncertainty prefer staged and reversible investment strategies. utilisation of idle asset represents a low-commitment pathway that preserves strategic flexibility while enabling production ramp-up.

Third, the integration of VFT, KT screening, and AHP extends conventional MCDM applications. Rather than applying AHP as a stand-alone ranking mechanism, this study embeds value elicitation and feasibility filtering within a coherent governance-oriented decision architecture. This advances decision-support theory by incorporating institutional constraints explicitly into multi-criteria capital allocation models.

Boundary Conditions and Generalisability

While the empirical case is specific to the GNK Structure under Indonesia's SOE governance framework, the integrated VFT–KT–AHP architecture is transferable under certain conditions. The framework is particularly applicable to:

- Mature brownfield upstream assets facing capacity bottlenecks.
- Capital-constrained environments where expansion investment is limited.
- Governance contexts involving regulatory approval processes and multi-stakeholder accountability.
- Organisations with identifiable idle or underutilised assets available for redeployment.

However, in greenfield exploration contexts with abundant capital or in fully deregulated private-sector environments where regulatory constraints are minimal, expansion-oriented alternatives may dominate. Therefore, the dominance utilisation of idle asset observed in this study should be interpreted within the boundary conditions of capital discipline, institutional oversight, and mature asset portfolios. Future research may test

this decision architecture across comparative upstream assets, private operators, or renewable energy infrastructure to evaluate contextual variation in ranking outcomes.

Policy and Governance Implications

Beyond managerial implications, the findings carry broader governance relevance for SOE-regulated upstream sectors. The results suggest that brownfield optimisation through structured utlisation of idle assets may provide a fiscally prudent pathway toward achieving national production targets without large-scale capital injection.

For regulators such as SKK Migas, streamlined asset redeployment procedures and accelerated internal transfer approvals could materially improve production responsiveness. In capital-constrained national oil companies, decision architectures that explicitly integrate governance feasibility and capital discipline can enhance investment transparency and accountability.

Therefore, this study contributes not only to operational decision-making but also to policy-level discussions on capital allocation efficiency and institutional alignment in emerging-market energy systems.

CONCLUSION

Taking a structured approach that started with interviews, brainstorming and the use of VFT, seven initial solutions were distilled to four feasible alternatives using KT's Musts and Wants criteria. The four alternatives were analyzed using structured AHP methodology with 7 SME's and assessed in terms of three main criteria: Cost, Benefit, Risk and backed up by 10 sub-criteria. The CR was less than 0.1 for each chain of pairwise comparisons, indicating that the consistency ratio supports this evaluation. The weighted synthesis identified Utilization of Idle Assets as the number one alternative (global priority score 0.547). Quick win and in strategic alignment with business priorities.

The most feasible implementation strategies for the selected optimization alternative (Utilization of Idle Assets) based on the AHP evaluation must focus on efficient execution strategies to realize its potential. Five essential steps: (1) Identified idle asset equipment assets that suitable with GNK fluid characteristics, (2) Refurbish & mobilize selected equipment through Pertamina or SKK Migas internal asset transfer mechanism, (3) Engineering design integration in temporary tie in facilities, (4) Cost and time estimation, (5) Regulatory compliance from SKK Migas approvals & HSSE assurance. This step by step plan makes sure that assets are reused efficiently, that production ramp up deadlines are met, and that capital efficiency targets are met. The overall cost of the project is expected to be around USD 1 million, and it will take around six months to implement. This makes it a timely, scalable, and cost effective way to help with the development of the GNK Structure.

REFERENCE

Barney, J. B., & Mackey, T. B. (2021). Asset orchestration and resource redeployment in dynamic environments. Journal of Management Studies, 58(6), 1545–1571. https://doi.org/10.1111/joms.12685

Chawla, R., & Kumar, A. (2023). Managing production bottlenecks in brownfield oil and gas operations. Journal of Natural Gas Science and Engineering, 111, 104913. https://doi.org/10.1016/j.jngse.2023.104913

ESDM. (2024). Laporan kinerja Kementerian Energi dan Sumber Daya Mineral 2024. Kementerian Energi dan Sumber Daya Mineral Republik Indonesia.

Hassan, M., & Chen, G. (2024). Capacity debottlenecking strategies for mature oil and gas fields. Energy Strategy Reviews, 49, 101120. https://doi.org/10.1016/j.esr.2024.101120

Hong, S., & Lee, J. (2024). Strategic investment under policy uncertainty in the oil and gas sector. Energy Economics, 125, 106876. https://doi.org/10.1016/j.eneco.2024.106876

Iledare, O. O., Pulsipher, A., & Olatubi, W. (2021). Brownfield redevelopment strategies in mature oil provinces. Energy Policy, 149, 112017. https://doi.org/10.1016/j.enpol.2021.112017

International Energy Agency. (2024). Oil 2024: Analysis and forecast to 2025. IEA Publications. https://www.iea.org/reports/oil-2024

Keeney, R. L. (1992). Value-Focused Thinking: A Path to Creative Decisionmaking. Harvard University Press. DOI: 10.1002/mcda.4020020108

Klingebiel, R., & Joseph, J. (2022). Real options logic and strategic flexibility in capital-intensive industries. Academy of Management Review, 47(1), 53–74. https://doi.org/10.5465/amr.2019.0457

Liu, H., Zhang, X., & Wu, Y. (2021). A hybrid AHP–TOPSIS approach for selecting oilfield development strategies under uncertainty. Journal of Petroleum Science and Engineering, 205, 108803. https://doi.org/10.1016/j.petrol.2021.108803

Paltsev, S., & Capros, P. (2021). Energy transitions: Economics, risks, and uncertainties. Energy Policy, 152, 112181. https://doi.org/10.1016/j.enpol.2021.112181

Pertamina Hulu Energi. (2024). PHE annual report 2024: Sustaining energy for the nation. PT Pertamina Hulu Energi.

Pertamina Hulu Rokan Zone 4. (2024). Internal operational report: Gunung Kemala (GNK) structure development and surface facility capacity analysis. PT Pertamina Hulu Rokan.

Rahman, M. M., & Karmaker, C. L. (2023). A decision support framework for oil and gas infrastructure optimisation using MCDM techniques. Journal of Cleaner Production, 386, 135751. https://doi.org/10.1016/j.jclepro.2022.135751

Raval, A., & Truby, J. (2023). Upstream investment risk: Policy uncertainty and the reshaping of CAPEX logic. Energy Economics, 118, 106512.

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. International Journal of Services Sciences, 1(1), 83–98. DOI: 10.1504/IJSSci.2008.01759

SKK Migas. (2024). Laporan tahunan SKK Migas 2024: Menuju target 1 juta BOPD 2030. Satuan Kerja Khusus Pelaksana Kegiatan Usaha Hulu Minyak dan Gas Bumi.

Thakkar, J. J. (2021). Multi-criteria decision making: Concepts and techniques. Springer.

Trigeorgis, L., & Reuer, J. J. (2022). Strategic asset redeployment: Real options theory and reversible investment. Strategic Management Journal, 43(6), 1085–1110.

Wang, L., Zhang, Y., & Li, X. (2023). Multi-criteria evaluation of oil and gas production facility configurations using AHP–DEA. Expert Systems with Applications, 213, 118942.

Zavadskas, E. K., Turskis, Z., Antucheviciene, J., & Zakarevicius, A. (2022). Multi-criteria decision-making in energy facility planning: A review. Energy Policy, 162, 112788. https://doi.org/10.1016/j.enpol.2022.112788