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Strategic Decision-Making for Low-Sulfur Gasoline Production at RU III Plaju Using an Integrated AHP–TOPSIS Framework for the Pre-Feasibility Gate in Support of Indonesia's Net Zero Emissions 2060

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ABSTRACT
Indonesia's energy transition toward Net Zero Emissions (NZE) 2060 requires the refining sector to improve fuel quality while maintaining energy security and economic sustainability. One of the critical challenges faced by PT Kilang Pertamina Internasional Refinery Unit III (RU III) Plaju is the inability to consistently produce low-sulfur gasoline that meets Euro IV/V standards due to limited desulfurization capability. This condition creates a strategic decision challenge involving technical, economic, regulatory, and sustainability considerations. This study aims to determine the most feasible strategic alternative for low-sulfur gasoline production at RU III Plaju by developing an integrated decision-making framework for the pre-feasibility stage. The research applies a sequential mixed-methods approach combining SWOT analysis, IFE–EFE matrix evaluation, TOWS analysis, and Multi-Criteria Decision-Making (MCDM) using the AHP–TOPSIS framework. Expert judgments from refinery managers, engineers, and technical specialists were used to evaluate strategic alternatives based on strategic viability, economic viability, technical compliance, and regulatory sustainability criteria. The results indicate that the construction of a Hydrodesulfurization/Gasoline Sulfur Handling (HDS/GSH) unit is the optimal alternative, achieving the highest TOPSIS closeness coefficient of 0.8481. Sensitivity analysis confirms the robustness of this ranking under variations in criteria weights. The study concludes that the proposed AHP–TOPSIS framework provides a transparent, systematic, and reliable approach for strategic investment decisions, supporting RU III Plaju's long-term competitiveness and Indonesia's NZE 2060 objectives.

INTRODUCTION

Indonesia faces a complex energy transition that must balance three objectives at once — energy security, affordability, and reduced environmental impact — a challenge often called the energy trilemma. As Southeast Asia's largest economy and a major energy consumer, Indonesia still relies heavily on petroleum-based fuels, even as international pressure and domestic policy accelerate the shift toward a lower-carbon economy.

The Government of Indonesia has formally committed to Net Zero Emissions (NZE) by 2060 or sooner, announced at COP26 and reinforced through the Enhanced Nationally Determined Contribution (E-NDC), which sets 2030 targets through unconditional domestic and conditional international efforts (Burke et al., 2019). Decarbonization has thus become a strategic requirement shaping energy-sector investment, and state-owned enterprises, particularly PT Pertamina (Persero), are expected to lead in translating these commitments into operational and investment strategies.

The refining sector is central to this transition. Petroleum products remain essential to Indonesia's transport and industry, yet refineries face growing pressure — from both climate objectives and stricter fuel-quality regulation — to improve environmental performance while maintaining reliable supply. Operators must therefore invest in cleaner-fuel production and emissions reduction, not only in efficiency and profitability.

A key policy instrument is the adoption of Euro IV and Euro V fuel-quality standards: the Directorate General of Oil and Gas limits gasoline sulfur to a maximum of 50 parts per million (ppm). Because sulfur compounds drive sulfur-oxide emissions and secondary particulate formation during combustion, low-sulfur fuel is a prerequisite for cleaner transportation and reduced urban air pollution (Cohen et al., 2017).

Fuel-quality improvement matters beyond compliance. Air pollution is a major public-health problem in many Indonesian cities, including Palembang, where transport contributes substantially to poor air quality. Sulfur in gasoline and diesel forms pollutants linked to respiratory and cardiovascular disease, so the shift to low-sulfur fuels is also a public-health intervention with social and economic benefits through lower healthcare costs.

Implementation remains challenging. The transition has moved more slowly than anticipated, and compliance demands substantial capital, long lead times, and technical complexity, while policy and market uncertainty complicate long-term planning. Refinery managers must therefore weigh not only technical feasibility but also economic viability, strategic relevance, and resilience under different scenarios.

These challenges are acute at PT Kilang Pertamina Internasional Refinery Unit III (RU III) Plaju. Located in Palembang, South Sumatra, it is one of Indonesia's oldest and most strategically important refineries, supplying gasoline, diesel, aviation fuel, LPG, marine fuels, and petrochemicals to southern Sumatra. Its location and established distribution infrastructure make it an essential part of Pertamina's downstream operations (Heggelund, 2021).

However, RU III Plaju has significant structural limitations. It operates at relatively low process complexity and lacks dedicated gasoline desulfurization, which directly constrains its ability to consistently meet Euro IV/V sulfur specifications (Dinh, 2025). Its gasoline blending components remain above the allowable sulfur limit, creating a compliance gap that, as standards tighten, poses growing risks to competitiveness and operational sustainability and exposes the asset to gradual obsolescence as capital shifts toward cleaner-energy and low-carbon initiatives. Closing the sulfur gap is thus both a technical necessity and a strategic imperative for the refinery's relevance in Indonesia's future energy landscape.

While the technical problem is clear, the solution is not. Candidate alternatives include crude-selection optimization, product blending, asset repurposing, and investment in dedicated desulfurization — each with different costs, operational implications, and levels of regulatory compliance (Halff et al., 2019). Selecting among them cannot rest on technical performance or financial return alone.

This exposes a second issue: the adequacy of the decision process itself. Strategic refinery investments involve competing considerations — technical feasibility, economics, regulatory compliance, environmental impact, reliability, and corporate-strategy fit — yet evaluations are frequently dominated by financial criteria, overlooking strategic factors critical to long-term success. A framework relying mainly on financial indicators is therefore insufficient for a challenge like the low-sulfur gasoline decision at RU III Plaju.

Previous research offers partial precedents but no direct answer. Afrane et al. (2022) applied an integrated AHP–TOPSIS model to rank waste-to-energy technologies for a national energy system, showing the hybrid can carry technical, economic, and socio-environmental criteria simultaneously, but at the level of a country and of technology pathways rather than plant-level capital projects. Khajeh Hoseini et al. (2021) prioritized strategic parameters for an oil refinery using AHP, establishing that refinery strategy can be quantified from expert judgment, yet stopped at parameter prioritization without reaching an investment decision. Amiri et al. (2024) and Dinh (2025) confirm the robustness of AHP–TOPSIS for renewable-source and maintenance-strategy selection respectively, each testing rank stability by sensitivity analysis, while Nguyen Ngoc et al. (2024) and Lebepe and Mathaba (2025) report comparable behavior for hybrid AHP models. None addresses a regulation-driven product-quality constraint in which the wrong choice means not a lower return but the loss of the right to sell the product at all.

Three gaps follow. First, energy-sector MCDM applications cluster at the policy or equipment level, leaving the refinery-level decision of how to close a fuel-quality compliance gap largely unaddressed. Second, studies that do quantify refinery strategy stop at diagnosis and are not connected to the corporate gate at which capital is committed. Third, the pre-feasibility gate at PT Kilang Pertamina Internasional screens on the benefit–cost ratio alone, systematically disadvantaging a compliance-driven project whose principal benefit — the continued right to place gasoline on the market — is only partially monetized in a cash-flow model. The urgency is immediate: the 50 ppm ceiling is already in force, the RFCCU high-octane mogas component at RU III Plaju carries 170–230 ppm sulfur, a desulfurization unit takes 36 to 48 months to build, and the interim health cost is estimated at up to Rp 550 billion in avoidable annual healthcare spending by 2030 (Institute for Essential Services Reform, 2024; Syuhada et al., 2023).

The novelty of this study is threefold. It applies the SWOT–TOWS–AHP–TOPSIS chain to a plant-level fuel-quality compliance decision rather than to a policy or equipment problem; it derives the candidate strategies from a TOWS matrix built on quantified SWOT factors, so the alternative set is traceable to evidence rather than assumed; and it embeds the evaluation inside the existing corporate stage-gate at the pre-feasibility point, converting a single-criterion financial screen into an auditable multi-criteria gate that a reviewer can reproduce.

A more comprehensive framework is needed to integrate quantitative and qualitative considerations into a transparent, systematic process (Amiri et al., 2024). Multi-Criteria Decision-Making (MCDM) methods suit this because they evaluate alternatives across multiple dimensions simultaneously while making trade-offs explicit, and are widely used in energy, infrastructure, and industrial investment where financial measures alone are insufficient.

This study therefore develops an integrated decision framework for evaluating strategic alternatives for low-sulfur gasoline production at RU III Plaju, combining strategic analysis with MCDM to identify the most feasible alternative while improving the transparency of the pre-feasibility evaluation. By addressing both the technical capability gap and the decision-process gap, it aims to support better investment decisions, strengthen competitiveness, and contribute to Indonesia's decarbonization objectives.

METHOD

This study used a sequential mixed-methods approach combining qualitative and quantitative analysis to identify the most feasible strategy for producing low-sulfur gasoline at RU III Plaju (Creswell & Plano Clark, 2018). It began with problem identification, literature review, and data collection. Primary data came from expert questionnaires and discussions with refinery managers, engineers, and technical specialists; secondary data from operational reports, engineering studies, corporate documents, and regulations. The focus was reducing gasoline sulfur to meet Euro IV/V standards in support of Pertamina's NZE 2060 commitment.

The qualitative stage applied SWOT analysis to assess internal strengths and weaknesses and external opportunities and threats. Factors were quantified through the Internal (IFE) and External (EFE) Factor Evaluation matrices and mapped on the Internal–External (IE) matrix to fix the strategic position. Two quantities were elicited separately, following David et al. (2020). Importance weights were elicited at the industry level: each expert distributed 100 points across the twelve internal factors, and separately across the twelve external factors, judging how important each is to the competitive success of any refinery in the Indonesian downstream fuel industry, with the focal firm left unnamed. Ratings were elicited at the firm level for RU III Plaju using the four-point convention (strengths 3 or 4, weaknesses 1 or 2, external factors 1 to 4 by response quality). Each allocation was normalized to unity and averaged, so the weight of factor i is $w_i = (1/n)\ \Sigma_r\ [p_{r,i} / \Sigma_j\ p_{r,j}]$; each weight vector sums to 1.0000 by construction, with no multiplier or criticality tier applied. A TOWS matrix Weihrich, (1982) then paired the validated factors to generate four alternatives: crude selection and feedstock optimization, product blending, conversion to a fuel terminal, and construction of a Hydrodesulfurization/Gasoline Sulfur Handling (HDS/GSH) unit.

Both expert panels followed purposive sampling, the standard non-probability strategy in MCDM and qualitative research. Seven informants (T1–T7) supplied the SWOT and IFE/EFE input, selected to cover the functions bearing on the decision: refinery planning and supply chain, RFCCU/FCCU process engineering, engineering and development, crude supply, and secondary operations; two are based at corporate head office and one at a peer refinery, widening the frame beyond RU III Plaju. Each was interviewed individually in Bahasa Indonesia using a semi-structured guide, and the factors raised were consolidated and validated in a focus group discussion, so no factor entered on a single respondent's authority. The AHP pairwise comparisons and TOPSIS performance scoring were completed by eleven respondents (R1–R11) from the same functions plus management-level respondents from the wider PT KPI organization. Consistent with established AHP practice, panel size was governed by the consistency and domain relevance of expert judgment rather than respondent count; consistency is reported through the consistency ratio and tested through a full sensitivity analysis. Table 1 profiles the seven informants.

Table 1 Expert Panel Profile (SWOT and IFE/EFE Informants)

Code	Position	Function / unit	Experience	Interview
T1	Section Head, Refinery Planning	Refinery Business & Optimization, RU III Plaju	>15 yrs	20 Feb 2026, face-to-face
T2	Senior Specialist, RFCC & FCCU	Process Engineering & Improvement, Head Office	>15 yrs	21 Feb 2026, telephone
T3	Manager, Engineering & Development	Engineering & Development, RU III Plaju	>15 yrs	21 Feb 2026, face-to-face
T4	Senior Manager, Crude Oil Supply	Crude Oil Supply & Planning, Head Office	>15 yrs	22 Feb 2026, telephone
T5	Senior Group Leader, Secondary Process	Engineering & Development / Process Engineering, RU IV Cilacap	11–15 yrs	24 Feb 2026, telephone
T6	Lead of Process Engineering	Engineering & Development / Process Engineering, RU III Plaju	>15 yrs	25 Feb 2026, face-to-face
T7	Senior Engineer I, FCCU	Engineering & Development / Process Engineering, RU III Plaju	11–15 yrs	26 Feb 2026, face-to-face

Primary data were collected between February and July 2026. The semi-structured SWOT interviews ran from 20 to 26 February 2026, in person at RU III Plaju and by telephone for off-site informants, and factors were consolidated in a focus group discussion producing the validated 24-factor matrix. The industry-level weighting instrument was administered to the same panel on 13 July 2026, with all seven responses returned that day. Validation was applied at three points: content validity of the SWOT factors through the focus group, where each factor required corroboration by more than one informant; construct validity through separating the industry-level referent of the weight from the firm-level referent of the rating; and reliability through the response-independence check below and, in the AHP stage, the consistency ratio, required below 0.10. Capital-cost, operating-cost, and financial-return inputs are from internal company documents and are commercially confidential; they were applied in full but are reported here only in relative or qualitative terms.

Because the weight vector is the mean of individual allocations, its validity depends on independent judgments, so every pair of respondents was compared across all elicited vectors. Two coincidences were found and treated differently according to how far each instrument constrains the response. Informants T2 and T5, both RFCC/FCCU specialists, returned identical rating vectors; the four-point convention admits only 2^{12} = 4,096 internal rating configurations and the panel's ratings were tightly concentrated (median pairwise distance 4.5 units across twelve factors), so convergence on measurable plant conditions is consistent with independent judgment, and both — having confirmed independent completion — were retained. Informants T2 and T6 returned identical point allocations on both matrices; point allocation is unconstrained and the median pairwise distance between distinct respondents was sixteen units, making an exact coincidence far less likely. Independent completion could not be confirmed for T6 within the study period, so that response was excluded, giving a final panel of six (n = 6).

A sensitivity check confirms the exclusion does not affect the findings. The matrices were recomputed three ways: all seven responses (IFE 2.2186, EFE 2.3943), excluding T6 as adopted (IFE 2.2983, EFE 2.5133), and treating the converging responses as one voice, n = 4 (IFE 2.3675, EFE 2.5650). The IE cell (Cell V) and SWOT quadrant (Quadrant I) are invariant across all three, so the conclusions are robust to the treatment of the excluded response.

The quantitative stage used an integrated AHP–TOPSIS framework to evaluate and rank the alternatives (Afrane et al., 2022). AHP determined the relative importance of four criteria — Strategic Viability, Economic Viability, Technical Compliance and Reliability, and Regulatory and Sustainability Conformance — from expert judgment. The resulting weights were applied in TOPSIS to rank alternatives by relative closeness to the ideal solution (Chaube et al., 2024). Sensitivity analysis then varied the criteria weights to test robustness, and the highest-ranked alternative was translated into a business recommendation for validation through a management challenge session (David et al., 2020).

RESULT AND DISCUSSION

Analysis

This section presents the results and discussion. The analysis advances as a connected chain: qualitative SWOT evidence, quantified through the IFE/EFE matrices to establish the strategic position and isolate the priority problem, then the strategic posture, the formulation of alternatives, and their evaluation through AHP–TOPSIS, directed at producing and delivering low-sulfur gasoline in support of the NZE 2060 agenda.

1. Qualitative SWOT Analysis

The strategic position was mapped through a SWOT analysis built from semi-structured interviews with seven experts (T1–T7) from refinery management, RFCCU/FCCU process engineering, engineering and development, crude supply, and secondary processing. The factors were consolidated and validated in a focus group, producing a 24-factor matrix — six strengths, six weaknesses, six opportunities, and six threats. Table 2 presents it.

One qualification is recorded for transparency: twenty-three of the twenty-four factors emerged directly from the interviews as recurring, corroborated statements. Factor TQ2, the erosion of gasoline demand through vehicle electrification, did not arise from any informant and was added during focus-group consolidation from the regulatory-trajectory and electrification review, since its omission would have left a material external trend unrepresented.

Table 2 Validated SWOT Matrix of RU III Plaju (Author, 2026)

Strengths (Internal +)	Weaknesses (Internal −)
SQ1 Strategic market location (sole large refinery in Sumbagsel) SQ2 Mature physical infrastructure (jetty, storage, distribution) SQ3 Deep process engineering competency & tacit knowledge SQ4 Crude slate flexibility (diversified domestic crude) SQ5 RFCCU delivers high-octane HOMC (strong RON base) SQ6 Completed BED Study for GSH unit	WQ1 Process configuration gap vs Euro IV/V refineries WQ2 CAPEX allocation competition within PT KPI portfolio WQ3 Gasoline sulfur constrained by crude profile WQ4 HOMC sulfur 170–230 ppm (3.4–4.6× above limit) WQ5 Complete absence of naphtha HDS/GSH unit WQ6 Operational transition risk across the four strategies
Opportunities (External +)	**Threats (External −)**
OQ1 Structural BBM demand growth in Sumbagsel OQ2 RDMP institutional framework for integration OQ3 NZE 2060 & ESG green-financing access OQ4 Euro IV/V vehicle market penetration OQ5 Regulatory mandate as legitimate investment driver OQ6 Desulfurization technology	TQ1 Crude price volatility & supply constraints TQ2 EV adoption & energy-transition demand erosion TQ3 Other Pertamina refineries comply first (competition) TQ4 HDS/GSH execution timeline (36–48 months) TQ5 Existential risk of continued non-compliance TQ6 Dependency risk embedded in A2/A3

The qualitative evidence converges on a single theme. The strengths describe a mature, well-located, technically competent refinery that already holds a completed BED Study for a Gasoline Sulfur Hydrogenation (GSH) unit. The weaknesses expose a structural gap: the gasoline pool carries 170–230 ppm sulfur and there is no naphtha hydrotreating capability to remove it. The opportunities point to mature desulfurization technology, a clear regulatory mandate, and the NZE 2060 financing environment; the threats center on construction lead time and the existential consequence of continued non-compliance.

Two pathways are empirically distinguishable within the peer set, and the distinction bears on the alternatives evaluated later. Cilacap achieved Euro IV-equivalent gasoline by adding low-sulfur, high-octane blendstock via isomerization and platforming, with compliance partial rather than pool-wide. Balikpapan achieved Euro V by installing dedicated naphtha and cracked-naphtha hydrotreating. For a refinery whose gasoline pool is dominated by cracked naphtha, as at RU III Plaju, the industry record indicates that blending can move the pool toward Euro IV, but no peer has reached Euro V without dedicated desulfurization. This is drawn from public evidence independently of the expert panel.

2. Quantitative SWOT Analysis (IFE / EFE)

The IFE and EFE matrices were built from the weighting instrument using the six-member panel. The weights are the panel's mean normalized industry-level importance (summing to 1.0000), and the ratings are the panel's assessment of RU III Plaju, reported as the mean rounded to the four-point convention (David et al., 2020). Each weighted score is weight × rating. Tables 3 and 4 present the matrices.

Table 3 Internal Factor Evaluation (IFE) Matrix

Code	Key Factor	Weight	Rating	Score
SQ1	Strategic market location (sole large refinery in Sumbagsel)	0.0583	3	0.1750
SQ2	Mature physical infrastructure (jetty, storage, distribution)	0.0617	3	0.1850
SQ3	Deep process engineering competency & tacit knowledge	0.0867	4	0.3467
SQ4	Crude slate flexibility (diversified domestic crude)	0.0733	3	0.2200
SQ5	RFCCU delivers high-octane HOMC (strong RON base)	0.0750	4	0.3000

SQ6	Completed BED Study for GSH unit	0.0800	4	0.3200
WQ1	Process configuration gap vs Euro IV/V refineries	0.1133	1	0.1133
WQ2	CAPEX allocation competition within PT KPI portfolio	0.0600	2	0.1200
WQ3	Gasoline sulfur constrained by crude profile	0.0750	2	0.1500
WQ4	HOMC sulfur 170–230 ppm	0.1283	1	0.1283
WQ5	Complete absence of naphtha HDS/GSH unit	0.1367	1	0.1367
WQ6	Operational transition risk during configuration change	0.0517	2	0.1033
	TOTAL	**1.0000**		**2.2983**

Table 4 External Factor Evaluation (EFE) Matrix

Code	Key Factor	Weight	Rating	Score
OQ1	Structural BBM demand growth in Sumbagsel	0.0650	3	0.1950
OQ2	RDMP institutional framework for integration	0.0567	3	0.1700
OQ3	NZE 2060 & ESG green-financing access	0.0433	2	0.0867
OQ4	Euro IV/V vehicle market penetration	0.0650	3	0.1950
OQ5	Regulatory mandate as legitimate investment driver	0.1233	3	0.3700
OQ6	Desulfurization technology maturity	0.1017	4	0.4067
TQ1	Crude price volatility & supply constraints	0.0783	2	0.1567
TQ2	EV adoption & energy-transition demand erosion	0.0583	2	0.1167
TQ3	Other refineries comply first (Cilacap, Balikpapan)	0.0667	2	0.1333
TQ4	HDS/GSH execution timeline (36–48 months)	0.1300	2	0.2600
TQ5	Existential risk of continued non-compliance	0.1233	2	0.2467
TQ6	Dependency on external supply of compliant blendstock	0.0883	2	0.1767
	TOTAL	**1.0000**		**2.5133**

The total IFE score is 2.2983 and the total EFE score is 2.5133. Three observations follow from the internal matrix. First, the three heaviest internal weights fall on WQ5, the absence of a naphtha hydrodesulfurization unit (0.1367); WQ4, HOMC sulfur of 170–230 ppm against the 50 ppm ceiling (0.1283); and WQ1, the process-configuration gap relative to compliant refineries (0.1133) — three facets of a single structural deficiency carrying roughly thirty-eight percent of the total internal weight. Second, the strengths are real but spread across factors of moderate weight, the heaviest being SQ3, engineering competency (0.0867). Third, the rating profile conforms to the convention without exception, confirming the factor set is correctly specified in direction.

Two internal factors returned zero rating variance. WQ4 was rated a major weakness by all six informants — a measured condition, since 170–230 ppm against a 50 ppm ceiling is not open to interpretation — and WQ3 uniformly, reflecting the mass-balance relationship between crude sulfur and gasoline sulfur established in the fluid catalytic cracking literature (Sadeghbeigi, 2020). Unanimity on verifiable technical facts indicates a well-specified factor rather than insufficient variance.

On the external side, the heaviest weight falls on TQ4, the 36–48 month execution timeline for a desulfurization unit (0.1300), then OQ5, the regulatory mandate as an investment driver (0.1233), and TQ5, the existential risk of non-compliance (0.1233). The panel thus identifies time, not capital, as the dominant external constraint: the ceiling is already in force, selective hydrodesulfurization of FCC naphtha is a mature technology (Shafiq et al., 2022) — hence OQ6 carries a weight of 0.1017 and a rating of 4 — and the binding difficulty is the interval between an investment decision and a compliant product. The cost of deferral is therefore measured in years of non-compliance rather than foregone return.

3. Strategic Position Internal-External Matrix and SWOT Quadrant

The Internal–External (IE) matrix uses the absolute IFE and EFE totals to locate the refinery's overall position, while the SWOT quadrant diagram uses the internal and external postures to indicate strategic direction. The component scores underlying both are summarized in Table 5.

Table 5 Component Scores and Net Postures (from Tables 3 and 4)

Factor group	Weighted score	Axis	Net posture
Strengths (S)	1.5467	Internal +	
Weaknesses (W)	0.7517	Internal −	
Total IFE	2.2983	X-axis	S − W = +0.7950
Opportunities (O)	1.4233	External +	
Threats (T)	1.0900	External −	
Total EFE	2.5133	Y-axis	O − T = +0.3333

With coordinates (IFE 2.2983, EFE 2.5133), RU III Plaju falls in central Cell V, "hold and maintain" (David et al., 2020): an IFE total of 2.00–2.99 denotes an average internal position and an EFE total of 2.00–2.99 a medium external position. In this posture the refinery must protect its market position while developing product capability.

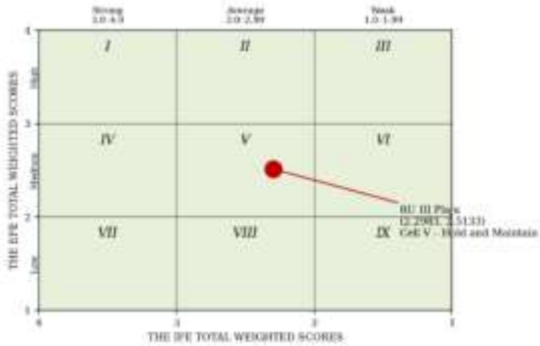

Figure 1 Internal–External (IE) Matrix – RU III Plaju

Plotting the net postures gives the coordinate (S − W = +0.7950, O − T = +0.3333) in Quadrant I, the aggressive quadrant (Figure 2). This indicates a favorable balance of strengths over weaknesses and opportunities over threats, supporting an aggressive strategy that uses strengths to capture opportunities (the SO family) — a quantitative endorsement of proactive structural investment rather than a defensive posture. The modest vertical coordinate (+0.3333) reflects that the execution-timeline and non-compliance threats temper the opportunity, so the window for action is time-limited.

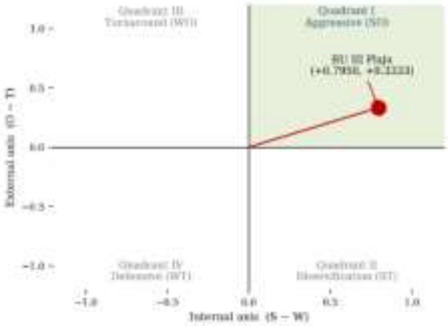

Figure 2 SWOT Quadrant Diagram – Strategic Position of RU III Plaju

The two instruments measure different things, and the apparent tension is diagnostic. The IE matrix measures absolute position: at (2.2983, 2.5133) the refinery sits at the center, neither strong enough to grow freely nor weak enough to retreat — the signature of a structural decision point. The SWOT quadrant measures net direction, and with both postures positive the balance favors a deliberate, aggressive structural move while the regulatory and financing window remains open. The aggregate is depressed not by diffuse weakness but by a few heavily weighted weaknesses in a single domain: because WQ4 and WQ5 are critical for Euro IV/V compliance and cannot be offset by strengths, the strategic intent resolves to one objective —

to produce and deliver gasoline compliant with Euro IV/V (50 ppm maximum) under Keputusan Dirjen Migas No. 110.K/MG.01/DJM/2022, in support of NZE 2060.

4. TOWS Matrix

The IFE and EFE matrices fix the position but do not generate options. To derive the alternatives evaluated in AHP–TOPSIS, the validated SWOT factors were paired systematically in a TOWS matrix (Weihrich, 1982), each quadrant pairing an internal with an external factor group to generate one strategic alternative. The pairings are set out in Table 6.

The TOWS matrix generates the alternatives but does not evaluate them — it produces four internally coherent strategies without indicating which is preferable. The AHP criteria are literature-derived and SWOT-validated rather than SWOT-generated, following the A'WOT logic of Kurttila et al. (2000). The matrix thus converts a diagnostic position into a decision set that AHP–TOPSIS then ranks.

Table 6 TOWS Matrix – Factor Pairings and Derived Strategic Alternatives

Quadrant	Factor pairing	Strategic logic	Derived alternative
SO – Maxi-Maxi	SQ4 (crude slate flexibility), SQ3 (engineering competency) × OQ1 (regional demand growth), OQ5 (regulatory mandate)	Exploit existing crude selection flexibility and in-house technical capability to reduce sulfur intake at source, capturing regulated demand without new capital assets	A1 – Crude Selection and Feedstock Optimization
ST – Maxi-Mini	SQ5 (high-octane HOMC), SQ2 (mature infrastructure) × TQ4 (long execution timeline), TQ6 (dependency on external blendstock)	Use the existing high-octane pool and blending infrastructure to move product toward specification during the interval in which a capital project cannot yet deliver, mitigating the timeline threat	A2 – Product Blending
WO – Mini-Maxi	WQ1 (configuration gap), WQ2 (CAPEX competition) × OQ1 (regional demand), OQ2 (RDMP framework)	Where the configuration gap cannot be closed economically, convert the weakness into a different value proposition by exiting refining and serving regional demand through distribution assets	A3 – Repurpose as a Fuel Terminal
WT – Mini-Mini	WQ5 (absence of an HDS/GSH unit), WQ4 (HOMC sulfur 170–230 ppm), WQ1 (configuration gap) × TQ5 (existential non-compliance risk), TQ3 (peers compliant first), OQ6 (mature desulfurization technology)	Eliminate the structural weakness that generates the existential threat directly, by installing the desulfurization capacity that the peer refinery attaining Euro V has already demonstrated to be the effective mechanism	A4 – Construction of an HDS/GSH Unit

Two features warrant comment. First, the three heaviest internal factors (WQ5, WQ4, WQ1) all appear in the WT pairing, and the two most threatening external factors (TQ4, TQ5) in the ST and WT pairings, so the matrix concentrates the most heavily weighted factors in the two alternatives, A2 and A4, that address the sulfur constraint directly. Second, the WT quadrant conventionally yields a defensive strategy, yet here it yields a capital investment — because continued non-compliance is not a competitive threat to be survived by contraction but a regulatory threat that can be eliminated only by removing its cause.

Business Solution Proposed

The proposed business solution has two intertwined components: a process innovation that replaces the financial-only decision gate at RU III Plaju with a structured MCDM framework embedded in the existing project workflow, and the outcome that this framework produces — a transparent, ranked, and defensible recommendation among the candidate strategies. This section establishes why the existing gate is inadequate, presents the proposed framework and its benefits, and introduces the candidate strategies.

1. The Existing Project Decision Framework and Its Limitations

Capital projects at RU III Plaju follow a linear stage-gate procedure, each transition passing a management go/no-go review. The eight stages are Initiation (conceptual study), Pre-Feasibility Study (Pre-FS), Basic Engineering Design Package (BEDP), Front-End Engineering Design (FEED), Cost Estimate, Feasibility Study for the Final Investment Decision (FS for FID), EPC Bidding, and Project Execution. Minor changes that do not alter plant configuration go through a Management of Change (MoC) procedure; substantive capital projects follow the full route. Figure 3 illustrates it.

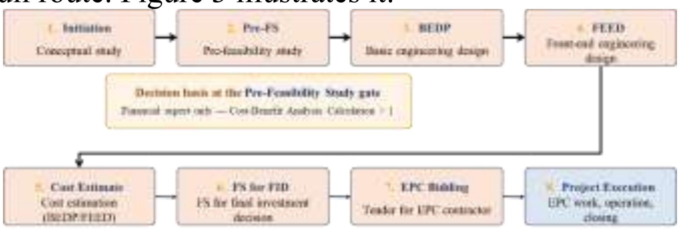

Figure 3 Existing Project Decision Framework (Stage-Gate / MoC)

The decisive screening occurs at the Pre-FS gate, which in the existing framework rests on a single financial criterion — a cost–benefit analysis requiring a benefit–cost ratio above one. For a project justified mainly by regulatory compliance and strategic continuity, this is structurally inadequate: it cannot weigh regulatory permanence, strategic fit, technical-compliance certainty, or sustainability against cost; it assesses a proposal in isolation, giving no repeatable way to compare fundamentally different alternatives such as a feedstock change against a new unit; and the expert judgment it uses stays informal, untested for robustness, and hard to audit or defend. In short, it answers only whether a proposal is financially positive, not whether it is the best response to the compliance problem.

2. The Proposed MCDM-Based Decision Framework

The proposed framework keeps the eight-stage procedure unchanged but restructures the decision logic inside the Pre-FS stage: in place of the financial-only test, a structured six-stage MCDM sequence culminates in a top-management go/not-go validation. Figure 4 presents it.

Figure 4 Proposed Project Decision Framework with Structured MCDM Embedded in the Pre-FS Stage

The six stages form a logical chain. Stage 1 conducts the SWOT analysis and quantifies it through the IFE and EFE matrices to establish the position and isolate the priority problem. Stage 2 applies TOWS matching to translate the position into concrete alternatives. Stage 3 uses AHP to derive criteria weights from structured expert judgment, with a consistency-ratio check (Saaty, 1980). Stage 4 applies TOPSIS to rank the alternatives by closeness to the ideal solution. Stage 5 performs the sensitivity analysis. Stage 6 brings the ranked, evidence-backed result to top management for final validation, after which a "go" proceeds to BEDP and a "not go" returns the proposal for reassessment.

The design replaces a one-dimensional financial hurdle with a transparent, multi-criteria, auditable ranking in which every weight and score is documented and reproducible. Because alternatives are scored on common criteria, fundamentally different options become directly comparable, and the sensitivity analysis shows the choice is not an artifact of a single weighting. Crucially, the financial test is not discarded: economic viability is retained as one criterion family, so the MCDM gate is a strict superset of the legacy gate — any proposal that passes it also satisfies the original cost–benefit logic while gaining strategic, technical, and regulatory scrutiny.

3. Comparison of the Two Frameworks

Table 7 consolidates the contrast between the existing financial-only gate and the proposed MCDM framework across the dimensions that matter for a product-quality compliance decision.

Table 7 Existing Financial-Only Gate versus Proposed MCDM Framework

Dimension	Existing Stage-Gate (CBA only)	Proposed MCDM Framework
Decision basis	Single criterion: benefit cost ratio > 1 at the Pre-FS gate	Four weighted criteria families (SV, EV, TC, RS) with eight sub-criteria
Criteria coverage	Financial return only	Strategic, economic, technical-compliance, and regulatory / sustainability
Alternative comparison	assessed on its own, without comparison to other options	Explicit ranking of all alternatives on a common scale
Expert judgment	Informal and undocumented	Structured elicitation (Saaty 1–9 scale), consistency-checked
Robustness test	None	Sensitivity analysis on every criterion weight
Auditability/ traceability	Low	High because every weight and score documented
Fit to regulation-driven projects	Weak	Designed for product-quality / compliance decisions

4. Proposed Alternative Strategies

Applying Stage 2 TOWS matching to the validated SWOT factors yields four candidate strategies for closing the sulfur-compliance gap. They differ in technical content and governance class: A1 and A2 are incremental improvements implementable under MoC, while A3 and A4 are high-capital options requiring Pertamina's standard project procedure. Table 8 presents the four by activity, benefit, and constraint; they are described without ranking, the evaluation following in the next section.

Table 8 The Four Proposed Strategies – Activity, Benefit, and Constraint

Strategy	Detailed activity	Benefits	Constraints
A1 Crude Selection / Feedstock Optimization	Shift the crude slate toward sweeter (low sulfur) grades and optimize RFCCU feedstock so the HOMC carries less sulfur. No new hardware; implemented via the MoC procedure.	Minimal capital outlay; fast to implement. Uses existing assets; keeps the refinery operating. Partial reduction of HOMC sulfur.	Cannot guarantee 50 ppm the FCC concentrates sulfur in naphtha regardless of feed. Permanent reliance on costly, supply-limited sweet crude. Not durable against future tightening. Small environmental gain.
A2 Product Blending	Blend high-sulfur RFCCU gasoline with externally procured low-sulfur blendstock to bring the pool average below 50 ppm, using the existing blending and tankage system. Implemented via the MoC procedure.	Low capital; fast to implement. Leverages the existing blending system; keeps the refinery operating. Can meet the pool-average specification.	Permanent dependence on external blendstock supply and price. Blending and volume losses. Compliance contingent on continuous supply, not structural. Limited environmental contribution.
A3 Repurpose as Fuel Terminal	Cease the non-compliant gasoline-producing operation and convert the site into a fuel injection / distribution terminal importing finished compliant gasoline. Follows the standard project procedure.	Removes the sulfur problem by exiting in-house production. Retains strategic location and a distribution role. Lower process-integration risk than a new unit.	Abandons the refining mission and its strategic value. High conversion CAPEX plus lost refining margin. Compliance by abandonment, not capability. Major operational transition risk; weak sustainability narrative.
A4 Build HDS / GSH Unit	Install a selective HDS / GSH unit to hydrotreat the FCC naphtha and remove sulfur while preserving octane, integrated with existing hydrogen supply and the RFCCU. BED Study completed; follows the standard project procedure.	Permanent, structural compliance to the 50 ppm limit. Durable against future tightening. Preserves and strengthens the strategic role and independence. Strong NZE / environmental contribution.	Highest CAPEX, Modest benefit–cost ratio. Long lead time and integration complexity, 36–48 months. Execution risk against the regulatory deadline.

Multi Criteria Decision Making – Analytical Hierarchy Process (AHP)

With the four strategies established, they must be weighed against multiple conflicting considerations. AHP is used not to score the alternatives directly but to derive the criteria weights from structured expert judgment. The decision is organized into a four-level hierarchy: the goal, four main criteria, eight sub-criteria, and the four alternatives, which are scored in TOPSIS.

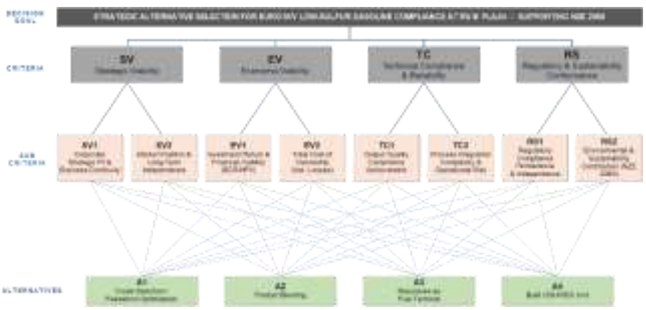

Figure 5 AHP Decision Hierarchy for the RU III Plaju Low-Sulfur Gasoline Decision

1. AHP Criteria

The four main criteria are literature-derived dimensions for appraising strategic capital projects, instantiated and validated by the dominant SWOT factors: Strategic Viability (SV), Economic Viability (EV), Technical Compliance and Reliability (TC), and Regulatory and Sustainability Conformance (RS). Each decomposes into two sub-criteria, giving the eight summarized in Table 9.

Table 9 AHP Decision Hierarchy – Main Criteria and Sub-Criteria

Main criterion	Sub-criteria
SV – Strategic Viability	SV1 Corporate Strategic Fit & Business Continuity; SV2 Market Position & Long-Term Independence
EV – Economic Viability	EV1 Investment Return & Financial Viability (BCR/NPV); EV2 Total Cost of Ownership (incl. losses)
TC – Technical Compliance & Reliability	TC1 Output Quality Compliance Achievement; TC2 Process Integration Complexity & Operational Risk
RS – Regulatory & Sustainability Conformance	RS1 Regulatory Compliance Permanence & Independence; RS2 Environmental & Sustainability Contribution (NZE 2060)

Pairwise comparison data were collected through a structured questionnaire completed by eleven experts (R1–R11) spanning RU III Plaju process engineering, operations, planning and supply chain, crude supply, and refinery management, plus management-level respondents from the wider PT KPI organization. Using Saaty's nine-point scale, each respondent judged every pair of criteria at the main and sub-criterion levels, giving ten comparisons per respondent (six among main criteria, four within sub-criterion blocks). Each was elicited in two steps: direction (which is more important, or equal) and intensity on the 1–9 scale.

2. Pairwise Comparison Model and Criteria Weights

Individual judgments from the eleven experts were aggregated by the geometric mean method, which preserves the reciprocal structure of the comparison matrix and is standard for group AHP (Forman & Peniwati, 1998). The main-criteria matrix was highly consistent (CR = 0.0028, well below the 0.10 threshold). Technical Compliance and Reliability is the most important criterion (41.41%), followed by Strategic Viability (33.26%), Economic Viability (17.16%), and Regulatory and Sustainability Conformance (8.17%).

The same procedure applied to the sub-criteria; with two per category the matrices were perfectly consistent (CR = 0). Corporate Strategic Fit and Business Continuity outweighed Market Position and Long-Term Independence; Investment Return and Financial Viability outweighed Total Cost of Ownership; Output Quality Compliance Achievement outweighed Process Integration Complexity and Operational Risk; and Regulatory Compliance Permanence outweighed Environmental and Sustainability Contribution.

Combining local and main-criteria weights gives the global weights used in TOPSIS. Output Quality Compliance Achievement (TC1) is the single most important sub-criterion at 31.76% of the total weight, followed by Corporate Strategic Fit and Business Continuity (SV1) at 23.27%; together they account for more than half of the decision weight, mirroring the priority problem and governing constraint from the SWOT analysis. Two consistency figures are reported: the mean CR of the eleven individual respondents was 0.084, while the aggregated geometric-mean group matrix is 0.0028 — both below the 0.10 threshold (Saaty, 1980) — so the consistency is not an artifact of aggregation alone.

3. TOPSIS Evaluation and Ranking of the Alternatives

The four alternatives were then evaluated by TOPSIS, which identifies the most preferable alternative by its proximity to an ideal solution and distance from a non-ideal one (Hwang & Yoon, 1981). Rather than comparing alternatives against one another, the eleven-member panel scored each directly against the eight sub-criteria on a five-point scale; the ratings were aggregated by the geometric mean, as in the AHP stage, and weighted using the AHP-derived global weights.

The consolidated decision matrix shows clear differences. A4 (Build HDS/GSH Unit) performed strongest across most strategic, economic, regulatory, and sustainability criteria. A1 (Crude Selection/Feedstock Optimization) and A2 (Product Blending) scored lower, reflecting limited ability to provide a long-term solution, while A3 (Repurpose as Fuel Terminal) was moderate — notably on regulatory and sustainability aspects — but of less strategic value than A4. Scoring drew on the BED study and available financial information to keep judgments realistic.

The scores were normalized, weighted by the AHP global weights, and used to establish the positive (A^{+}) and negative (A^{-}) ideal solutions, from which Euclidean distances and closeness coefficients were computed. The ranking is A4 > A3 > A1 > A2. A4 achieved the highest closeness coefficient (0.8481), the only alternative above the 0.50 benchmark, driven by its strong performance on the two most influential criteria — Output Quality Compliance Achievement (TC1) and Corporate Strategic Fit (SV1) — while remaining economically and operationally acceptable. A4 is therefore the most feasible and comprehensive solution, its robustness examined in the next section.

The interpretation matters more than the ranking. A4's lead comes not from one dominant score but from the coincidence of the two heaviest global weights with the only option whose compliance is structural: A4 removes sulfur at source, whereas A2 depends on the price and availability of purchased blendstock, A1 on a sweet-crude slate the market may not supply, and A3 achieves compliance by ceasing to refine. The rejected alternatives fail on different criteria — A1 and A2 on Output Quality Compliance Achievement, since neither guarantees 50 ppm under all feeds; A3 on Corporate Strategic Fit, since compliance by exit is compliance without capability. Notably, A4 clears the corporate benefit–cost hurdle of unity only narrowly, so a financial-only screen would misjudge the only durable answer to a binding regulatory constraint as a weak project.

Sensitivity Analysis

Because the ranking rests on the panel's criteria weights, its robustness was tested by sensitivity analysis on those weights, following the weight-perturbation approach of Triantaphyllou and Sánchez (1997): one weight is changed by a fixed factor, the rest renormalized to sum to one, and TOPSIS recomputed. The vector-normalized decision matrix is weight-independent and reused unchanged, so scenarios differ only in the weight vector. Two analyses were run: a ±20% perturbation of every criterion, and a threshold (weight-elasticity) analysis sweeping each weight across its range.

1. Weight Perturbation

Each of the eight criteria was perturbed by +20% and −20%, giving sixteen scenarios. Table 10 reports the closeness coefficients of the four alternatives in every scenario, and Figure 6 plots them.

Table 10 Closeness Coefficients Perturbation of Each Criterion Weight

Criterion	Change	CC A1	CC A2	CC A3	CC A4	Winner
TC1	−20%	0.2810	0.1584	0.3081	0.8271	A4
TC1	+20%	0.2026	0.1223	0.3923	0.8697	A4
SV1	−20%	0.2262	0.1486	0.3734	0.8402	A4
SV1	+20%	0.2568	0.1308	0.3315	0.8577	A4

EV1	−20%	0.2414	0.1406	0.3580	0.8469	A4
EV1	+20%	0.2395	0.1404	0.3487	0.8496	A4
SV2	−20%	0.2398	0.1419	0.3619	0.8458	A4
SV2	+20%	0.2416	0.1387	0.3443	0.8509	A4
TC2	−20%	0.2251	0.1171	0.3539	0.8770	A4
TC2	+20%	0.2582	0.1642	0.3539	0.8199	A4
RS1	−20%	0.2412	0.1412	0.3541	0.8474	A4
RS1	+20%	0.2399	0.1396	0.3536	0.8489	A4
EV2	−20%	0.2399	0.1402	0.3542	0.8480	A4
EV2	+20%	0.2415	0.1408	0.3536	0.8482	A4
RS2	−20%	0.2406	0.1405	0.3539	0.8481	A4
RS2	+20%	0.2406	0.1405	0.3539	0.8481	A4

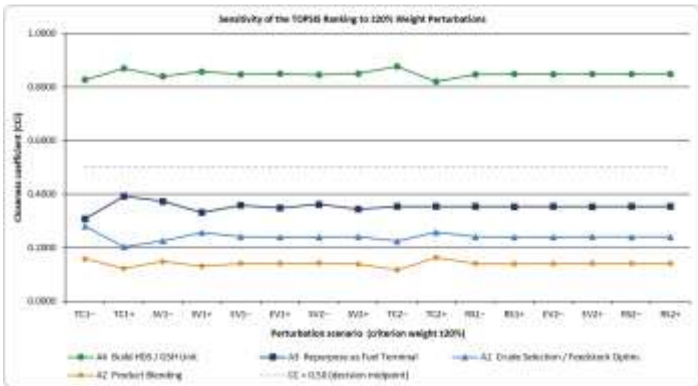

Figure 6 Closeness Coefficients of the Four Alternatives across the Sixteen Perturbation Scenarios

In all sixteen scenarios the ranking is unchanged: A4 first, A3 second, A1 third, A2 fourth. A4's closeness coefficient stays within 0.8199–0.8770, never approaching the runner-up A3 (0.308–0.392). The widest swing comes from perturbing TC2, process integration complexity: raising its weight lowers A4 to 0.8199, lowering it raises A4 to 0.8770. Even the least favorable case leaves A4 well above the 0.50 midpoint and far ahead of every other option.

2. Threshold (Weight-Elasticity) Analysis

To locate where the ranking would change, each weight was swept from 0 to 1 with the rest renormalized, recording the value at which A4 loses first place. Table 11 reports the results.

Table 11 Rank-Reversal Thresholds for the Top-Ranked Alternative (A4)

Criterion	Base weight	Rank-reversal threshold
TC1	0.3176	No reversal (any weight 0–1)
SV1	0.2327	No reversal (any weight 0–1)
EV1	0.1137	No reversal (any weight 0–1)
SV2	0.0998	No reversal (any weight 0–1)
TC2	0.0964	Weight ≥ 0.356 (≈ 3.7× base)
RS1	0.0648	No reversal (any weight 0–1)
EV2	0.0582	No reversal (any weight 0–1)
RS2	0.0167	No reversal (any weight 0–1)

For seven of the eight criteria, no weight between 0 and 1 reverses A4's first place. The exception is TC2, process integration complexity, which would need a weight of at least 0.356 — about 3.7 times its base weight of 0.0964 — before the ranking changed. A secondary criterion would thus have to become the dominant consideration before the recommendation altered, which is not plausible for a compliance-driven investment.

Final Evaluation of the Proposed Decision Framework

The analysis can be read as both a recommendation and a test of the framework. The MCDM sequence produced a single, traceable line of reasoning: SWOT established the position and isolated the sulfur-compliance gap; TOWS generated four alternatives; AHP weighted the criteria (CR = 0.0028); TOPSIS placed A4, the HDS/GSH unit, first (closeness coefficient 0.8481); and the sensitivity analysis confirmed the ranking is stable. Carried into Stage 6, this supports a Go recommendation for A4. That validation — endorsement by RU III Plaju Unit management before the proposal goes to PT KPI Head Office — is the next step and had not been convened at the time of writing.

Against the framework it replaces, the MCDM gate outperforms the financial-only test. The legacy gate would have screened on benefit–cost ratio alone, unable to weigh regulatory permanence, strategic fit, or technical-integration risk, with no transparent basis for comparing a feedstock change against a new unit. The MCDM gate evaluated all four alternatives on common, weighted, documented criteria; retained economic viability among them, preserving financial discipline; and subjected the result to a consistency check and robustness test, producing an auditable decision. Once validated, the recommended decision proceeds to the BEDP stage.

Situated against the literature, the contribution is methodological and contextual. That a hybrid AHP–TOPSIS structure yields a ranking stable under weight perturbation is consistent with Afrane et al. (2022), Amiri et al. (2024), Dinh (2025), Nguyen Ngoc et al. (2024), and Lebepe and Mathaba (2025). The present case differs in the nature of the decision, not the mechanics: in those studies criteria trade off along a continuous efficiency frontier, whereas here one criterion — Output Quality Compliance Achievement — behaves as a threshold an alternative either crosses or not. That is why the ranking survives a ±20% perturbation of every weight and why seven of eight criteria admit no rank-reversal threshold: A4's dominance is a structural property of the alternative set, not an artifact of weighting. It is also why the WT quadrant yields an investment rather than the retrenchment a conventional reading of Weihrich (1982) predicts — a divergence Khajeh Hoseini et al. (2021) do not meet because their analysis stops at parameter prioritization.

Theoretically, the framework operationalizes a multi-attribute response to bounded rationality. A decision maker cannot hold four criteria, eight sub-criteria, and four alternatives at once, and the legacy gate resolves that by discarding all criteria but one. AHP–TOPSIS instead decomposes the judgment into pairwise comparisons small enough to be made reliably (Saaty, 1980) and recomposes them, retaining rather than suppressing the criteria a financial screen discards. The criteria are literature-derived and SWOT-validated rather than SWOT-generated, following the A'WOT logic of Kurttila et al. (2000). The consequence is auditability: every weight, score, consistency ratio, and rank-reversal threshold is traceable to a documented respondent or a reproducible computation — the property a corporate gate requires and informal consensus cannot supply (Triantaphyllou & Sánchez, 1997).

Three strategic implications follow. First, the decision is no longer whether to invest but when: with the ceiling already binding and a 36–48 month execution window, each year of deferral is a year of non-compliance no later decision can recover. Second, A2 and A4 are complements in time, not substitutes: A4 is the structural answer but cannot deliver a compliant product during construction, and the ST pairing identifies blending as the interim bridge — a single-winner reading of the TOPSIS ranking would discard that sequencing. Third, the governance implication is procedural: A4 is a high-capital option entering the corporate standard project procedure, so the Pre-FS gate is where the multi-criteria evaluation must be embedded to influence the outcome.

The recommended alternative's risk profile is asymmetric. Technology risk is low: selective hydrodesulfurization of FCC naphtha is commercially mature and the BED study is complete. Economic risk is binding: the benefit–cost ratio clears unity only narrowly, and because the cost basis is a pre-feasibility estimate, a capital overrun routine at this stage would erode that margin, so the project is sensitive to cost estimation before anything else. Schedule risk compounds this, the 36–48 month execution period being the most heavily weighted external factor (TQ4, 0.1300). Demand risk runs the other way over a longer horizon, as gasoline-demand erosion through electrification (TQ2) shortens the earning period. The controls are procedural: re-estimate capital cost at FEED grade before the final investment decision, hold schedule contingency explicitly at each gate, and retain A2 as the bridging measure so compliance is not hostage to the construction schedule.

The environmental dimension is part of the investment case, and precisely the value a benefit–cost screen cannot register. Sulfur in gasoline oxidizes to SO_2 on combustion and forms secondary particulate sulfate, so the reduction is a step change: Indonesian-market gasoline typically carries 150–400 ppm sulfur against a Euro IV ceiling of 50 ppm, and the RU III Plaju RFCCU high-octane component 170–230 ppm. The Institute for Essential Services Reform (2024) estimates that full Euro 4 adoption could avoid up to Rp 550 billion (about US$34.7 million) in annual healthcare costs by 2030, through projected reductions of 86% in pneumonia, 69% in ischemic heart disease, and 84% in chronic obstructive pulmonary disease. The wider basis is well established: ambient air pollution caused an estimated 4.2 million deaths globally in 2015 (Cohen et al., 2017), and the burden is documented across 45 major Indonesian cities (Syuhada et al., 2023). RU III Plaju supplies the Sumbagsel market, where land transport dominates local emissions. None of this benefit accrues as refinery revenue, which is why a financial-only gate cannot see it and why Regulatory and Sustainability Conformance is an explicit criterion.

Implementation Plan for the Proposed Decision Framework

The framework was demonstrated on a single live decision; to deliver value beyond it, the framework must be adopted as a standard part of the project decision process at RU III Plaju and, over time, across PT KPI. Because it changes an established governance procedure, adoption must be earned: the implementation plan is structured so management actively challenges the framework against the incumbent process at each step. Table 12 sets out the five phases. As a new evaluation framework rather than an approved project, it must first be endorsed by RU III Plaju Unit management and then proposed to PT KPI Head Office, so the Phase 1 management challenge session precedes and conditions any later project-stage approvals.

Table 12 Phased Plan to Adopt the Proposed MCDM Framework as a Standard Decision Process

Phase	Key activities	Management's role (the challenge)	Outcome / gate
1. Proposal & Management Challenge	Present the framework and the gasoline-compliance case to the project governance forum, document the method, criteria, weights, and the side-by-side comparison with the existing financial-only gate.	Challenge the criteria set, the weighting basis, the choice of AHP–TOPSIS, and the claim of superiority over the current gate, state the conditions for acceptance.	Mandate to run a controlled pilot
2. Parallel Back Test vs. Existing Process	Run the framework in parallel with the current Pre-FS gate on the present decision and on one or two recent capital decisions, compare transparency, completeness, and outcome.	Scrutinize whether the framework reproduces sound financial screening, and whether the added dimensions would have changed or strengthened past conclusions.	Evidence pack, decision to proceed
3. Refinement & Re-Challenge	Incorporate feedback, adjust the criteria, the elicitation procedure, and the governance interface so the framework fits the eight-stage workflow without adding bureaucracy.	Re-challenge the revised framework and confirm that earlier objections have been resolved.	Framework endorsed in principle

4. Formal Endorsement & Procedure Integration	Embed the framework through a Management of Change on the project decision procedure, define roles, templates (SWOT, AHP questionnaire, TOPSIS workbook), and the decision-record format.	Approve the procedure revision and assign process ownership.	Approved standard procedure (revised Pre-FS gate)
5. Training, Roll-out & Continuous Improvement Ongoing	Train engineers, planners, and management on the method and tools, apply it to qualifying projects, periodically review criteria and weights and audit decision quality.	Sponsor roll-out, review periodic audits and approve updates.	Institutionalized framework

Note: Durations are indicative planning estimates, the gating factor at each phase is management's acceptance at the challenge point, not elapsed time.

The sequence reflects a simple reality: a decision procedure is only as useful as the confidence management places in it. Three features lower resistance. First, the framework extends the existing gate rather than replacing it, retaining the benefit–cost test as one criterion. Second, it is introduced through the company's own Management of Change mechanism, a familiar and auditable route. Third, acceptance is staged: the framework can first run as a decision-support overlay alongside the current gate and become the formal gate only after parallel back-tests prove its value. Once institutionalized, it converts a one-off analysis into a repeatable, auditable standard, and its first validated output — the recommendation to build the HDS/GSH unit (A4) — proceeds into the normal project workflow.

CONCLUSION

This study concludes that RU III Plaju faces a significant challenge in meeting Euro IV/V low-sulfur gasoline standards, given sulfur levels above regulatory limits and the absence of dedicated desulfurization. An integrated AHP–TOPSIS framework was developed, combining technical, strategic, economic, and sustainability criteria into a transparent, consistent evaluation, and identified a dedicated Hydrodesulfurization/Gasoline Sulfur Handling (HDS/GSH) unit as the most feasible and robust alternative, outperforming the others across all sensitivity scenarios. Beyond RU III Plaju, the study shows that AHP–TOPSIS can strengthen pre-feasibility decision-making by incorporating multiple strategic considerations rather than relying on financial evaluation alone.

Three limitations qualify these conclusions. First, the weights and performance scores rest on an expert panel from a single refinery; a different panel could return different weights, and although the ranking is stable under ±20% perturbation, the underlying subjectivity remains. Second, the cost and performance inputs are pre-feasibility-grade estimates from the BED study and internal sources, not FEED-grade, and should be read as guideline rather than committed figures. Third, the framework was demonstrated on one decision at one refinery, so its transferability is argued rather than proven, and the management challenge session for formal adoption falls outside the study period. Future work should re-run the evaluation with FEED-grade cost data, extend the panel across several PT KPI refineries to test whether the criteria weights are stable beyond one site, and compare the AHP–TOPSIS ranking against outranking methods such as PROMETHEE or VIKOR to establish whether the recommendation is method-independent.

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