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Identifying Competitive Advantages of Gas Turbine Generators in MOPU: Maleo Field Case Study

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A B S T R A C T

This study examines whether implementing a Gas Turbine Generator (GTG) on a Mobile Offshore Production Unit (MOPU) at the Maleo Field, operated by Supraco Lines, can create a competitive advantage. The research is driven by anticipated field development involving gas and condensate, presenting an opportunity to optimize internal energy resources and decrease reliance on diesel-based power generation. A qualitative case study methodology was employed, utilizing semi-structured interviews, non-participant observation, and document analysis. Six purposively selected informants contributed expertise in engineering, offshore installation management, departmental leadership, procurement, health, safety, and environment, and academic strategy. Data analysis involved coding, data reduction, data display, conclusion drawing, and source triangulation, guided by the Resource-Based View and VRIO framework. The results indicate that GTG implementation can create strategic value by reducing dependence on diesel logistics, enhancing operational reliability, lowering emissions, and increasing maintenance efficiency. The rarity of this advantage arises from the unique combination of GTG technology, gas-condensate availability, and offshore MOPU operational conditions. Barriers to imitation include platform constraints, technical modifications, safety requirements, and accumulated operational knowledge. Organizational support is demonstrated through cross-functional coordination, operator competence, adaptation of standard operating procedures, monitoring, maintenance planning, and risk governance. In summary, GTG represents a potential source of sustainable competitive advantage and supports adaptive offshore operations and a sustainability-oriented business strategy.

KATA KUNCI

Gas Turbine Generator, Keunggulan Kompetitif, MOPU, VRIO, Operasi Lepas Pantai

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A B S T R A K

Penelitian ini mengidentifikasi keunggulan kompetitif penerapan *Gas Turbine Generator* (GTG) pada *Mobile Offshore Production Unit* (MOPU) Lapangan Maleo yang dioperasikan oleh Supraco Lines. Penelitian dilatarbelakangi oleh pengembangan lapangan yang mengandung gas dan kondensat, sehingga membuka peluang untuk mengoptimalkan sumber daya energi internal dan mengurangi ketergantungan terhadap pembangkit berbasis diesel. Penelitian menggunakan metode kualitatif dengan pendekatan studi kasus melalui wawancara semi-terstruktur, observasi non-partisipatif, dan dokumentasi. Enam informan dipilih secara *purposive* dari bidang *engineering*, *offshore installation management*, *department head*, *procurement*, *health-safety-environment*, dan akademisi strategi. Data dianalisis melalui *coding*, reduksi data, penyajian data, penarikan kesimpulan, serta triangulasi sumber dengan pendekatan *Resource-Based View* dan kerangka VRIO. Hasil penelitian menunjukkan bahwa GTG memiliki nilai strategis melalui penurunan ketergantungan logistik diesel, peningkatan keandalan operasional, emisi yang lebih rendah, dan efisiensi pemeliharaan. Kelangkaan muncul dari kombinasi GTG, ketersediaan gas-kondensat, dan kondisi operasi MOPU. Kesulitan imitasi dipengaruhi keterbatasan platform, modifikasi teknis, persyaratan keselamatan, serta pengalaman operasional. Dukungan organisasi tercermin dalam koordinasi lintas fungsi, kompetensi operator, adaptasi SOP, monitoring, perencanaan pemeliharaan, dan tata kelola risiko. Secara keseluruhan, GTG berpotensi menjadi sumber keunggulan kompetitif berkelanjutan yang mendukung operasi *offshore* adaptif dan strategi bisnis berorientasi keberlanjutan.

1. Introduction

Offshore oil and gas production requires a reliable power generation system because separation, compression, pumping, safety, utility, and supporting operations depend on a continuous electricity supply. Offshore energy decisions are closely related to energy transition, efficiency, and operational security [1]. Facility selection also affects investment, operating cost, risk exposure, and long-term business continuity [2].

A Mobile Offshore Production Unit (MOPU) offers flexibility in offshore field development because the facility can be redeployed based on reservoir characteristics and field economics. At the Maleo Field, Supraco Lines operates MOPU assets in the Madura Strait and must maintain reliable power generation for offshore production. The thesis context also notes the planned development of a new field with gas containing condensate, which provides a practical reason to evaluate the use of GTG dual-fuel compared with the continued use of the Diesel Generator (DG).

Diesel generators have historically been used because they are mature, relatively simple, and flexible for remote operations. The choice of power generation method affects energy efficiency on offshore platforms [3]. Diesel generator systems remain useful due to their operational flexibility [4]. The use of diesel generators is also common in remote energy systems [5]. However, in offshore operations, DG is constrained by diesel procurement, marine transport, storage, fuel price volatility, exposure to emissions, and higher maintenance intensity.

The Gas Turbine Generator offers an alternative because it can use gas from the production well and be configured for gas-condensate dual-fuel operation. Gas-based generation offers higher efficiency and better emissions performance than diesel-based generation [6]. Gas turbine systems are also suitable for continuous industrial energy applications [7]. Therefore, the GTG in MOPU Maleo is not only a replacement machine but also a potential strategic resource that can influence cost efficiency, operational resilience, and competitive positioning.

Previous studies on strategic resources provide the theoretical foundation for this research. Competitive advantage depends on the quality and management of internal resources [8]. Dynamic capabilities also play an important role in reconfiguring resources for strategic change [9]. Resource-based theory is closely linked to operations management [10]. Resource orchestration can convert resources into a competitive advantage [11]. Managerial capability is also important in shaping strategic change [12]. However, limited research links GTG, a critical technical asset, to RBV and VRIO analyses in the specific context of offshore MOPU operations. Therefore, this study aims to identify and analyze GTG as a strategic resource that can create a competitive advantage and support business strategy in MOPU Maleo operations.

2. Research Method

This research uses a qualitative case study approach. The case study approach was selected because the research examines a specific operational phenomenon, namely the potential shift from diesel-based power generation to GTG dual-fuel utilization in MOPU Maleo operations. Case study research is appropriate when the researcher needs to understand a contemporary phenomenon within its real-life context [13]. The object of research is the Mobile Offshore Production Unit in the Maleo block of the Madura Strait, East Java, operated by Supraco Lines.

Data was collected through semi-structured in-depth interviews, non-participant observation, and documentation. Qualitative research is useful for exploring meaning, processes, and participant experience [14]. Case study research also enables researchers to understand a bounded case using multiple sources of evidence [15]. The coding process followed the logic of qualitative theme development, and structured qualitative coding can link first-order and second-order concepts and aggregate dimensions [16].

Six informants were selected purposively because they were considered relevant to GTG operations and strategic decision-making. The informants included a Lead Engineer, an academic strategy expert, an HSE Manager, an Offshore Installation Manager, a Procurement Manager, and a Department Head. The data analysis followed qualitative stages, including coding, data reduction, data display, conclusion drawing, and verification. Source triangulation was applied by comparing findings across informants. The main analytical framework was the Resource-Based View, with VRIO dimensions: Value, Rarity, Imitability, and Organization.

Table 1. Research Informants

No	Informant	Position	Code
1	YA	Lead Engineer	ENG130426
2	TA	Academic Strategy Expert	MA160525
3	SA	HSE Manager	HSE140426
4	KA	Offshore Installation Manager	OIM130426
5	IA	Procurement Manager	PRC130426
6	HH	Department Head	DPH150426

Based on the informant profile in Table 1, the data sources cover the main operational and strategic functions needed to evaluate GTG implementation. This composition strengthens source triangulation because the findings are not based on a single perspective, but on engineering, offshore operation, procurement, HSE, management, and academic strategy perspectives.

3. Result and Discussion

3.1. Diesel Generator and Gas Turbine Generator in MOPU Maleo.

The findings show that DG remains functional as a power-generation system, but its strategic weaknesses become more evident in offshore operations. DG depends on diesel fuel supplied from outside the platform. Consequently, power generation continuity is influenced not only by machine condition but also by fuel delivery, weather, marine transportation, storage capacity, and procurement planning. In the MOPU context, this dependence increases logistics risk and can affect production continuity when fuel supply is delayed. GTG provides a stronger strategic fit because the system can utilize gas from the production well and may support condensate as an additional fuel in a dual-fuel configuration. By using internal resources, GTG reduces diesel procurement, minimizes logistics exposure, and increases energy independence. This advantage is important because power generation is directly linked to production, utilities, instrumentation, safety systems, and the overall reliability of offshore operations.

From a fuel perspective, GTG creates a more efficient operating logic. Diesel fuel must be purchased, transported, stored, and controlled as an external input, whereas gas and condensates are available from field production. From an emissions perspective, GTG is considered cleaner because gas combustion produces less black smoke and reduces the risks associated with diesel transfer and storage. National emission factor data show that natural gas has a lower CO2 emission factor than diesel and solar fuels [17]. Lower-emission energy choices are also relevant to climate change mitigation [18]. From a maintenance perspective, GTG offers operational advantages, as maintenance can be planned through engine exchange, reliability monitoring, and preventive maintenance. Reliability and maintenance optimization influence the continuity of offshore power systems [19]. Asset management and lifecycle optimization are important for long-term performance [20]. Reliability engineering is essential when system failure has critical consequences [21]. Gas turbine reliability analysis also supports maintenance planning. In contrast, diesel generator performance degradation requires a careful maintenance strategy.

Based on the comparison in Table 2, the GTG provides a more strategic operating logic than the DG because it reduces external diesel dependence and uses internal energy resources from the field. The comparison also indicates that GTG benefits are not limited to fuel substitution, but also include emission reduction, reliability improvement, cost efficiency, and stronger relevance to long-term competitive advantage.

Table 2. Strategic Comparison between Diesel Generator and Gas Turbine Generator

Aspect	Diesel Generator	Gas Turbine Generator	Strategic Meaning
Fuel	Depends on diesel supply from outside the platform.	Uses gas from the well and may use condensate as dual fuel.	Reduces external fuel dependence and logistics risk.
Emission	Higher smoke, diesel combustion emissions, and spill risk during fuel transfer.	Cleaner combustion and lower diesel logistics exposure.	Supports sustainability and environmental risk reduction.
Reliability	Reliability depends on the machine's condition and the stability of the diesel supply.	Potentially higher availability due to internal fuel and maintenance planning.	Strengthens continuity of offshore operations.
Cost	High fuel purchase, transport, storage, and maintenance intensity.	Lower diesel purchase, reduced logistics, and efficient maintenance.	Provides long-term financial and operational benefit.
Strategy	Operationally functional but limited by logistics and cost.	Strategic resource based on internal energy utilization.	More relevant as a source of competitive advantage.

3.2. VRIO Analysis of Gas Turbine Generator

The Value dimension is met because GTG delivers clear economic, operational, and environmental benefits. GTG reduces reliance on shore-based diesel supply, optimizes gas and condensate resources, supports stable power generation, lowers logistics exposure, and improves the efficiency of maintenance planning. Explains that RBV helps firms identify resources that strengthen strategic capacity. These benefits enable the company to capitalize on field opportunities while mitigating threats related to cost escalation, downtime, fuel distribution, and environmental pressures [22].

The Rarity dimension is met because the strategic advantage does not stem solely from owning GTG equipment. GTG technology may be available in the market. Still, the combination of GTG with gas-condensate availability, offshore MOPU constraints, platform characteristics, and Supraco Lines' operational experience is not shared by all competitors. Organizational uniqueness arises from the internal configuration of resources and capabilities [23]. Therefore, rarity is embedded in the specific resource configuration and operational context of the Maleo and future Kakatua field development.

The Imitability dimension indicates that the advantage is not easily copied. Competitors may purchase similar equipment, but they cannot easily replicate the field resource base, platform configuration, safety adaptations, technical modifications, and accumulated offshore operational knowledge. This condition creates path dependency and causal ambiguity because the advantage arises from the interaction among technology, field resources, and organizational routines. The Organization dimension is supported by the company's ability to coordinate engineering, operations, HSE, procurement, and management functions. VRIO can classify resources based on their ability to create competitive advantage [24].

Nevertheless, the thesis findings emphasize that organizational readiness must continue to be strengthened through operator competence development, SOP renewal, monitoring procedures, maintenance planning, and risk governance. Offshore oil and gas operations require risk-based maintenance and safety assessment [25]. Without these organizational mechanisms, GTG's technical potential cannot be fully converted into a sustainable competitive advantage.

Based on Figure 1, the coding relationship shows how interview findings from different informants are connected to the four VRIO dimensions. This figure helps clarify that the analysis was developed from field evidence and categorized systematically into value, rarity, imitability, and organization themes. Based on Figure 2, the competitive advantage structure shows that GTG becomes strategic when technical benefits are supported by rare field conditions, difficult-to-imitate operational capabilities, and organizational readiness. Therefore, the figure reinforces the argument that GTG should be managed as an integrated capability rather than as a stand-alone power-generation asset.

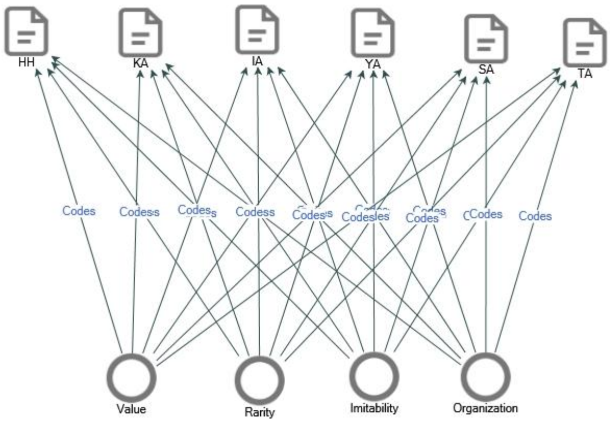

Figure 1. Coding Relationship between Informants and VRIO Dimensions

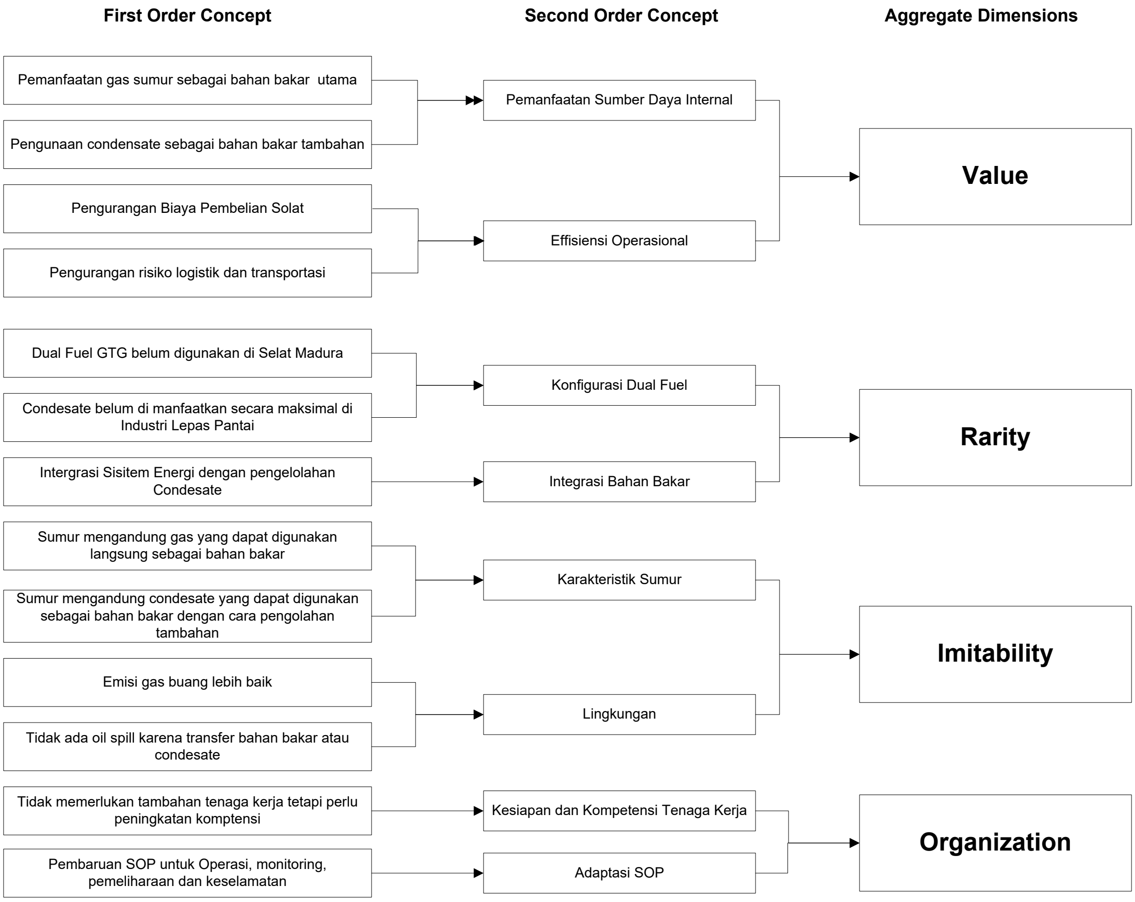

Figure 2. Structure of GTG Competitive Advantage Based on VRIO

Based on the VRIO matrix in Table 3, GTG can be interpreted as a strategic resource because it fulfils the criteria of value, rarity, imitability, and organization. The value of GTG is reflected in its ability to reduce diesel dependence, minimize logistics risk, improve reliability, support lower-emission operations, and increase maintenance efficiency. Its rarity does not only come from the equipment itself, but from the specific combination of GTG technology, gas-condensate availability, and the offshore MOPU operating context.

Table 3. VRIO Matrix of GTG in MOPU Maleo

Dimension	Finding	Evidence from the Case	Result
Value	Cost, reliability, emission, and maintenance benefits.	Lower diesel logistics, internal gas use, and efficient maintenance planning.	Competitive value
Rarity	Unique combination of technology, resources, and offshore context.	Gas and condensate availability with MOPU field characteristics.	Differentiation
Imitability	Difficult to copy as an integrated capability.	Technical modification, platform constraints, HSE requirements, and operational know-how.	Sustained potential
Organization	Cross-functional readiness exists and needs continuous strengthening.	SOP update, competence, monitoring, maintenance, HSE, procurement, and management coordination.	Sustainable competitive advantage

Furthermore, the advantage is difficult to imitate because competitors cannot simply duplicate the same field resources, platform constraints, technical adaptations, HSE requirements, and accumulated operational knowledge. Therefore, the strongest implication is that competitive advantage is created through the integration of technology, internal energy resources, offshore experience, SOP readiness, and cross-functional coordination. With proper organizational support, GTG can be managed not only as a power-generation asset but also as a sustainable competitive capability for MOPU Maleo operations.

3.3. Investment Analysis of GTG Dual Fuel

After the VRIO analysis, the revised thesis adds investment analysis to evaluate whether GTG implementation is financially relevant. The investment data are not shown in vendor names or nominal item prices. They are presented as percentages of total investment to protect commercial information while still explaining the proportional investment structure.

The investment structure consists of two main groups: equipment and material, and service. Equipment and material account for 68.07% of total investment, while service accounts for 31.93%. The largest component is the main Gas Turbine Generator dual-fuel unit, representing 64.40% of total investment. This indicates that GTG is the core asset of the project, while service components represent fabrication, offshore installation, commissioning, logistics, and foundation work.

Table 4. Investment Composition of Gas Turbine Generator

No	Investment Description	Percentage of Total Investment (%)
A	*Equipment & Material*	68.07
1	*Gas Turbine Generator (Dual Fuel)*	64.40
2	24 VDC Battery Bank & Charger	1.37
3	Exhaust Silencer for GTG	1.88
4	E-money for ORSA	0.01
5	Cable Gland	0.37
6	Sampling Port and Rainwater Arrester Port	0.05
B	Service	31.93
7	Pipe Spool Fabrication	9.81
8	Offshore Installation	5.27
9	Installation of Easygen GTG and DEG Maleo Project	0.43
10	Installation and Commissioning	4.69
11	Marine Cargo GTG Delivery	0.07
12	Charter Crane Barge	9.13

Based on Table 4, the largest investment allocation is concentrated on the GTG dual-fuel unit, confirming that the main equipment is the core project driver. The service components show that offshore implementation still requires fabrication, installation, commissioning, logistics, and lifting support to adapt the asset to MOPU conditions.

The revised thesis uses payback period and return on investment to interpret the financial implication. With the assumption of USD 1 equal to Rp18,000 and diesel consumption cost of Rp135,000,000 per day, diesel saving becomes the basis of investment recovery. The calculation shows that daily diesel saving equals 0.19% of total investment, monthly saving equals 5.70%, and annual saving equals 69.40%. Therefore, the first year can cover a substantial part of the investment, but not the entire investment.

The payback period is calculated by comparing total investment with daily diesel savings. The result is 525.92 days or 17.53 months. This means the investment does not fully return in the first year, but it can be categorized as a medium-term investment with strong operational and strategic benefits. The ROI gross for one year is 69.40%, while the net first-year ROI remains -30.60% because the investment has not been fully recovered.

Based on the recovery indicators in Table 5, diesel savings can return 69.40% of total investment within one year, while the full payback period is estimated at 17.53 months. This result indicates that GTG implementation is not an immediate short-term return project, but it has strong medium-term financial feasibility when combined with operational reliability, reduced logistics exposure, and sustainability benefits.

Table 5. Diesel Saving and Investment Recovery Indicators

Calculation Component	Value / Percentage
Diesel savings per day	0.19% of total investment
Diesel saving per month	5.70% of total investment
Diesel saving per year	69.40% of total investment
Remaining investment not recovered in year one	30.60%
Payback period	525.92 days / 17.53 months
Gross annual ROI	69.40%
Net ROI in first year	-30.60%

3.4. Sustainable Development Goals

The Sustainable Development Goals are used in this study as a supporting perspective rather than as the main analytical framework. The main framework remains RBV and VRIO because the study focuses on whether GTG can be evaluated as a strategic resource. The 2030 Agenda serves as a global framework for sustainable development [26]. SDGs also provide a practical framework for linking organizational activities with sustainability outcomes [27]. Therefore, the SDGs strengthen the argument that the competitive advantage generated by GTG is not limited to business efficiency but also extends to broader sustainability issues. In the MOPU Maleo context, GTG dual fuel is associated with energy efficiency, reduced dependence on diesel, the use of condensate as an internal energy source, and reduced environmental risk from fuel distribution. The most relevant goals are SDG 9: Industry, Innovation and Infrastructure, SDG 12: Responsible Consumption and Production, and SDG 13: Climate Action. These goals align with the thesis findings because GTG relates directly to energy use, offshore infrastructure innovation, responsible internal resource utilization, and lower environmental impact than diesel-based generation. SDG 9 is reflected in the adaptation of offshore power generation technology to MOPU characteristics. SDG 12 is reflected in the more responsible use of internal resources, as gas and condensate are not only production outputs but also support operations. SDG 13 is reflected in the potential to reduce the environmental impact of power generation by lowering diesel use and reducing exposure to fuel logistics.

Based on Figure 3, the SDG perspective positions GTG implementation within a broader sustainability agenda. Although SDG is not the main analytical framework of this study, the figure helps connect the operational benefits of GTG with global goals related to infrastructure innovation, responsible production, and climate action. The findings on Table 6 show that GTG implementation is most closely related to SDG 9, SDG 12, and SDG 13 because it supports offshore energy innovation, responsible internal resource utilization, and lower environmental impact.

Based on the sustainability mapping in Table 6, GTG implementation is most relevant to SDG 9, SDG 12, and SDG 13. This means that GTG supports offshore infrastructure innovation, more responsible use of internal gas and condensate resources, and potential climate-related benefits through reduced diesel use and lower environmental risk from fuel logistics.

Figure 3. SDG World Program

Table 6. Sustainability Relevance of GTG Implementation

SDG	Focus	Relevance to GTG Implementation
SDG 9	Industry, innovation, infrastructure	GTG reflects offshore power-generation innovation adapted to MOPU characteristics.
SDG 12	Responsible consumption and production	Internal gas and condensate utilization reduces external fuel logistics and supports efficient resource use.
SDG 13	Climate action	GTG has better emissions performance than diesel operation and reduces environmental risks associated with diesel logistics.

3.5. Adaptive Operational Strategy

Offshore operations, especially on MOPUs, are highly complex because the work environment is dynamic, resource-constrained, and exposed to significant operational risk. The system must maintain production continuity, equipment reliability, cost efficiency, environmental compliance, and organizational readiness. In this condition, the company requires an adaptive operational strategy capable of responding to operational constraints and system limitations. The thesis identifies several operational constraints that affect the effectiveness of power generation: new project development, downtime risk, dependence on fuel distribution, offshore logistics challenges, efficiency pressures, and emission-reduction requirements. DG is vulnerable because diesel distribution requires marine transportation, storage, and scheduling. On the other hand, system limitations include technology compatibility, platform limitations, data integration, workforce competence, government rules, compliance, infrastructure capacity, performance, and safety requirements. The adaptive operational strategy in MOPU Maleo is implemented through GTG based on gas and condensate. The strategy is not merely equipment replacement; it is an organizational response to operational pressure. Using gas directly from the wellstream reduces fuel logistics, while the potential use of condensates aligns with the characteristics of future wells. This approach allows the company to improve efficiency while maintaining the reliability of the power generation system. From a maintenance perspective, GTG requires adjustments to engine exchange, reliability monitoring, preventive maintenance, spare-part readiness, and scheduling. From a human resources perspective, GTG implementation requires training, knowledge transfer, and updated SOPs so that operators and engineers can operate the system safely and effectively. Therefore, the adaptive strategy integrates technology, internal resources, human competence, SOP, HSE, procurement, and management coordination into an integrated operational capability.

Based on Figure 4, the adaptive operational strategy shows that GTG implementation requires the alignment of technology, internal resources, workforce capability, SOP, HSE, procurement, and management coordination. This figure confirms that successful GTG implementation depends on organizational adaptation, not only on technical installation.

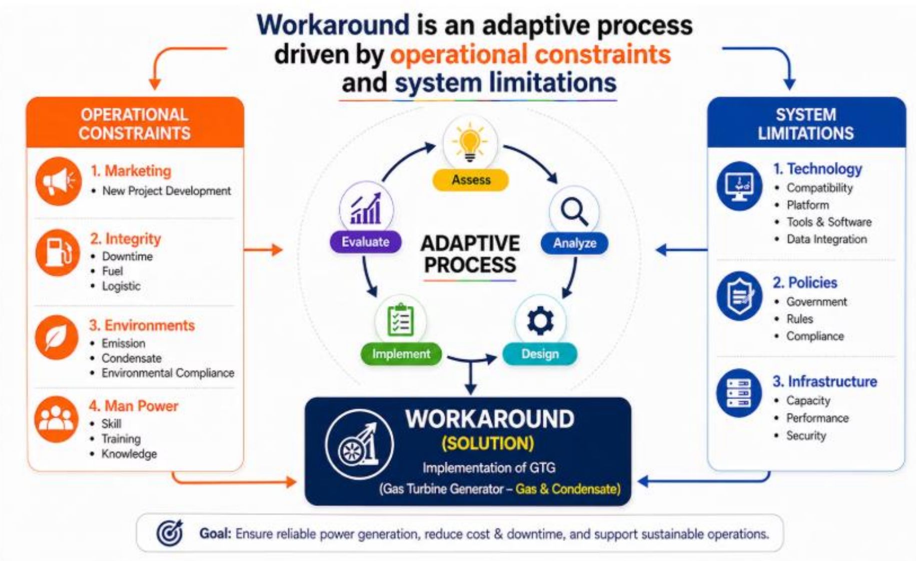

Figure 4. Adaptive Operational Strategy

4. Conclusion

This study concludes that the Gas Turbine Generator (GTG) in MOPU Maleo can be classified as a strategic resource that has the potential to create a sustainable competitive advantage. Based on the VRIO analysis, GTG fulfils the value criterion because it supports fuel cost efficiency, reduces dependence on diesel logistics, improves operational reliability, enables lower-emission operations, and enhances maintenance efficiency. GTG also fulfils the rarity criterion because its advantage is formed by the specific combination of gas-condensate availability, offshore MOPU characteristics, and the company's operational experience. In terms of imitability, the advantage is difficult to replicate because competitors cannot easily copy the same field resources, platform constraints, technical adaptations, HSE requirements, and accumulated organizational know-how. The organization criterion is reflected in the company's cross-functional readiness involving engineering, operations, procurement, HSE, maintenance, and management coordination, although continuous strengthening of SOPs, operator competence, monitoring systems, maintenance planning, and risk governance remains necessary. The investment analysis further shows that GTG dual-fuel implementation offers a financially relevant opportunity, with diesel savings supporting investment recovery within a medium-term payback period. In addition, the SDG perspective indicates that GTG implementation contributes to cleaner and more efficient energy use, offshore infrastructure innovation, responsible internal resource utilization, and reduced environmental impact. Therefore, GTG should not be viewed merely as a power-generation asset, but as an integrated strategic capability that supports adaptive offshore operations, sustainability-oriented business strategy, and long-term competitiveness for Supraco Lines in managing MOPU Maleo operations.

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