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Optimization of the Utilization of Idle Gas Turbine Generator Assets Using the AHP Method To Reduce Co_2 Emissions and Improve Operational Efficiency at the CPPG Power Plant of PT ABC

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gas turbine generator;
CO_2e emission reduction

ABSTRACT

Gas turbine generator (GTG) assets in upstream oil and gas facilities play an important role in ensuring a continuous power supply for production processes. However, aging equipment, declining reliability, increasing maintenance costs, and limited spare parts availability have become major challenges in maintaining operational efficiency. Meanwhile, the utilization of idle assets provides an opportunity to optimize existing resources, reduce the need for new investments, and support emission reduction targets. This study aims to determine the most suitable alternative for utilizing idle GTG assets at the CPPG Power Plant of PT ABC by integrating technical, economic, operational, policy, and environmental considerations. The research employed a case study approach using the Analytical Hierarchy Process (AHP) method. Data were collected through field observations, technical interviews, focus group discussions, operational documents, maintenance records, cost assessments, fuel consumption data, and expert judgments from ten subject matter experts. The results showed that technical criteria had the highest priority weight of 0.317, followed by economic criteria (0.259), operability criteria (0.189), environmental criteria (0.138), and policy criteria (0.096). The AHP synthesis identified AL3, which involved the relocation of two GTGs from Field T and one GTG from Field L, as the optimal alternative with a priority value of 0.391. This alternative provides an 11 MW output capacity, the lowest estimated maintenance and operational cost of USD 48.04 million, and the highest potential reduction in fuel consumption by 1.05 MMSCFD and CO_2e emissions by approximately 22,574 tons/year. In conclusion, the AHP-based decision model effectively supports strategic idle asset utilization decisions by balancing operational reliability, economic efficiency, and environmental sustainability.

cINTRODUCTION

Gas processing facilities require a reliable internal power supply because disruptions to the electrical system can directly affect separation, sweetening, dehydration, utilities, and custody metering processes (Ding et al., 2025; Noorzeha, 2023). In upstream oil and gas facilities, internal power plants based on gas turbine generators (GTGs) are commonly used due to their high power density, fast start-up capability, and strong response to load variations. However, gas turbine performance decreases as operating life increases due to degradation in the air inlet system, compressor, combustion chamber, hot gas path, fuel system, control system, and other auxiliary systems (Arnold & Stewart, 1999; Dev et al., 2024; Hyne, 2012).

CPPG PT ABC is a gas processing facility that utilizes an internal power plant to support process and utility operations. Figure 1 illustrates the CPPG process flow, beginning with gas reception from production wells, followed by impurity separation, and ending with the distribution of sales gas to consumers. This process requires a continuous electricity supply because power interruptions may increase the risk of production losses and reduce operational reliability (Alvarez-Alvarado et al., 2022; Islam et al., 2024; Medina et al., 2022). The normal load demand at CPPG is approximately 5 MW, while peak load demand can reach around 6 MW during equipment start-up or the relocation of major operational equipment (PT ABC, 2024b).

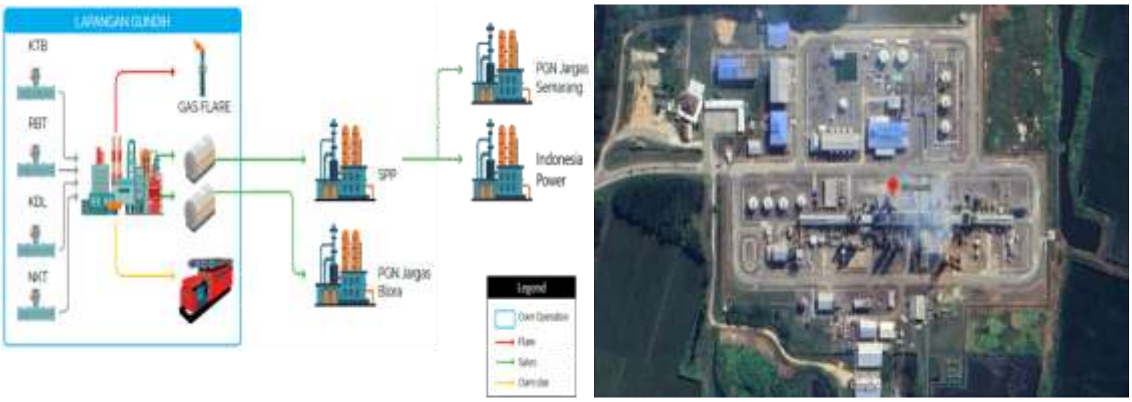
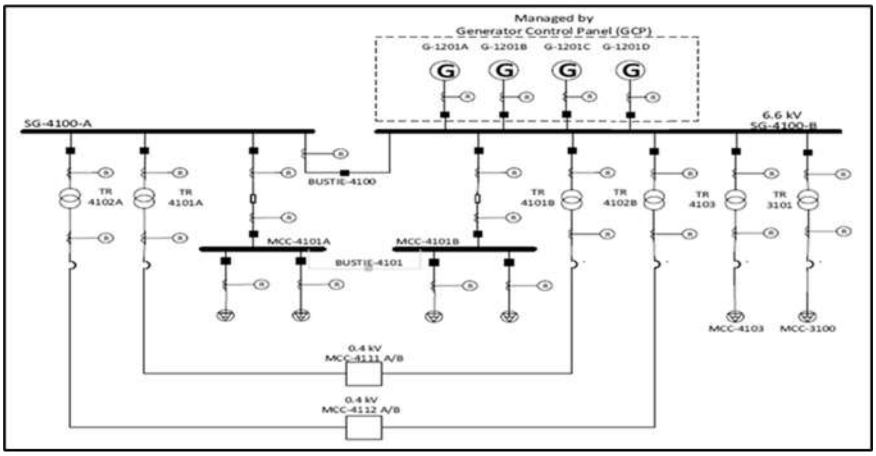


Figure 1. Simple process scheme and operation layout of CPPG PT ABC.

The CPPG power plant is currently supported by four existing GTG units manufactured by Brand K, operating under a three-running-unit and one-standby-unit configuration. Figure 2 presents a single-line diagram of the CPPG plant connected to the facility's medium-voltage electrical system. The existing units have been in operation for more than a decade and have begun to experience technical limitations, including reduced reliability, increased maintenance costs, and increasingly limited availability of spare parts and technical support. These conditions highlight the need to evaluate more sustainable operational alternatives, considering not only initial investment costs but also reliability, maintainability, operability, and emissions performance (PT ABC, 2024b).



Gambar 2. Single line diagram power plant CPPG.

On the other hand, PT ABC has implemented a resource-sharing and idle asset optimization policy to increase asset utilization and avoid unnecessary new procurements. The utilization of idle assets is also aligned with regulations governing the management of upstream oil and gas state-owned assets and production facility projects, which encourage the optimization of design and the utilization of idle assets when technically feasible (Ministry of Finance of the Republic of Indonesia, 2020; SKK Migas, 2023). However, the relocation of idle GTGs cannot be determined solely based on unit availability. The decision-making process must consider technical suitability, relocation and overhaul costs, spare parts availability, operator readiness, policy alignment, and the potential reduction in fuel consumption and emissions.

The Multi-Criteria Decision-Making (MCDM) method is relevant for addressing this problem because idle asset utilization decisions involve multiple competing criteria (Anbari Moghadam & Besiktepe, 2025; Desbalo & Woldesenbet, 2024; Hodosi et al., 2023; Homayounfar & Samimi Namin, 2026; Ozcalici, 2022). Several recent studies have applied MCDM methods for the selection of sustainable generation technologies, maintenance strategies, and power generation asset management (Hernández-Torres et al., 2025; Ohira et al., 2017; Parvaneh & Hammad, 2024; Wang et al., 2025). The Analytic Hierarchy Process (AHP) method was selected in this study because it can transform expert judgments into measurable priority weights, evaluate consistency levels, and provide a transparent decision-making framework that can be easily reviewed by management and technical teams (Saaty, 1980; Tavana et al., 2023).

The contribution of this research is the development of an evaluation model for utilizing idle GTG assets in upstream oil and gas facilities that integrates economic, technical, operability, policy, and environmental aspects within a single AHP framework. Unlike evaluations that focus solely on cost considerations or technical feasibility, this model positions idle asset utilization as a strategic operational decision that supports improved reliability and reduced CO_2e emissions.

METHOD

Research design and data sources

This study employed a case study approach at the CPPG PT ABC Power Plant. The research framework is presented in Figure 3. The research stages included problem identification, literature review, screening of idle GTG candidates, determination of criteria and subcriteria, collection of expert assessments through pairwise comparisons, AHP calculations, validation of results, and development of implementation recommendations. The study used both primary and secondary data. Primary data were obtained through field observations, technical interviews, and focus group discussions. Secondary data included operation and maintenance documents, logsheets, unit inspection reports, GTG inventory data, cost estimates, fuel consumption data, and internal company policy documents (PT ABC, 2024a, 2024b, 2024c).

Idle GTG alternative filtering

Idle GTG candidates are screened from PT ABC's asset database with minimum criteria: assets in the form of GTG, single gas turbine coupled with generator, minimum capacity of 2,000 kW, frequency of 50 Hz, and preferably dual fuel capability. Based on the screening, two potential asset sources were identified, namely Field T and Field L. Field T has two GTG units with a capacity of 4,200 kW with an output voltage of 6.6 kV, while Field L has two GTG units with a capacity of 2,600 kW with an output voltage of 400 V. The combination of these units results in four alternatives that are evaluated, as summarized in Table 1.

Table 1. Alternatives to the use of GTG are evaluated.

Code	Configuration	Main characteristics
AL1	Relocation of 2 GTG Field L + 2 GTG existing	9.6 MW total output; support idle asset utilization, but the Field L unit requires a major overhaul.
AL2	Relocation of 2 GTG Field T + 1 GTG existing	10.6 MW total output; The Field T unit is in good condition, but still depends on the existing GTG.
AL3	Relocation of 2 GTG Field T + 1 GTG Field L	11.0 MW total output; the fullest utilization of idle assets and the highest potential for fuel/CO_2e reduction.
AL4	Overhaul GTG existing CPPG	8.8 MW total output; The implementation is the simplest, but it does not provide fuel reduction or idle asset utilization.

Criteria, subcriteria and structure of the AHP

Evaluation criteria are determined through literature review, operational needs, technical discussion results, and asset utilization policies. The five main criteria used are economic, technical, operability, policy, and environment. Table 2 shows the subcriteria as well as the basis of the measurement used. Economic criteria include capital cost and maintenance and operation cost. Technical criteria include unit condition, rated output, and availability and reliability. Operability criteria include parts support, operator familiarity, and GTG population. Policy criteria represent alignment with the idle asset optimization program, while environmental criteria are assessed from the potential for CO_2e emission reduction based on a reduction in fuel gas consumption (API, 2021; Fachrie & Arviansyah, 2020; Wang et al., 2025).

Table 2. Criteria, subcriteria, and basis for measuring the AHP model.

Criteria	Subkriteria	Measurement basis
Economy	Capital cost	The cost of relocation, dismantling, mobilization, re-installation, shelter, E&I modification, mechanical-piping, commissioning, certification, and overhaul costs.
Economy	Maintenance and operation cost	Preventive/corrective maintenance, overhaul, fuel, lubricant, and preservation costs until the end of the analysis period.
Technical	Unit condition	Inspection results, physical condition of the unit, repair needs, overhaul needs, and operation history.
Technical	Rated output	The generation capacity and margin to the normal load requirement is 5 MW and the peak load is 6 MW.
Technical	Availability and reliability	Historical data and estimated reliability of operation configurations.
Operability	Spare parts and local support	Vendor availability, support contracts, materials, field service, and borrowing parts/units.
Operability	Training and operator familiarity	Operator/technician readiness and training needs for candidate units.
Operability	GTG population	The GTG population is similar in the PT ABC environment as a proxy for operational support.
Policy	Idle asset optimization alignment	Compliance with internal policies, PMK, and PTK SKK Migas.
Environment	Emission reduction potential	Potential fuel gas reduction and CO_2e reduction compared to existing configurations.

The hierarchical structure of the AHP in Figure 4 consists of four levels: objectives, criteria, subcriteria, and alternatives. This figure shows that each alternative is evaluated against all subcriteria so that the final result is not determined by a single parameter, but by a synthesis of all aspects of the evaluation.

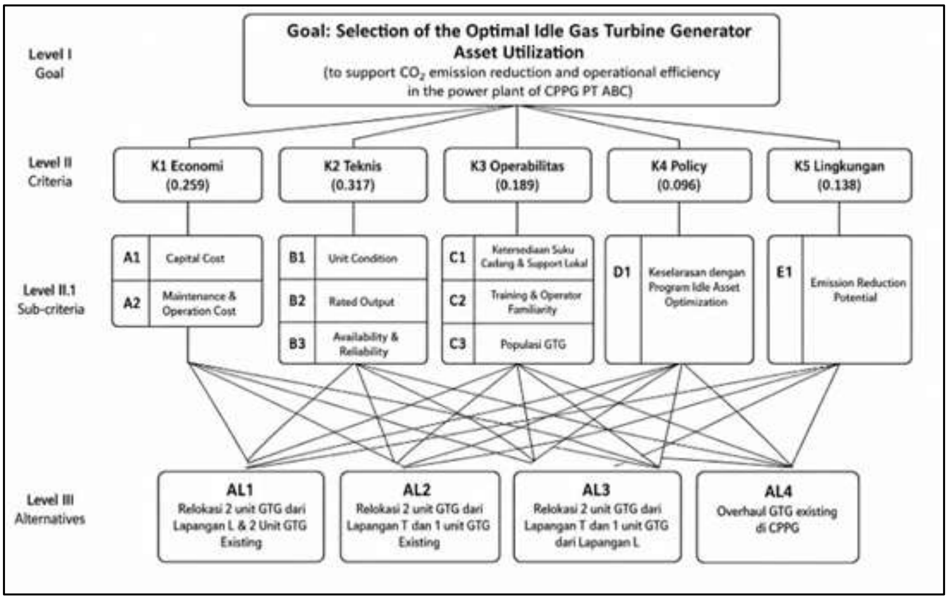


Figure 4. The AHP hierarchical structure of the selection of alternative GTG utilization idle.

AHP calculation and consistency test

The calculation of AHP follows the procedure of Saaty (1980). Each respondent filled out a paired comparison matrix using a scale of 1–9. A value of 1 indicates the same importance, while a value of 9 indicates the extreme dominance of one element over another. If the element i is more important than the element j, then the element j against i is filled with its inverse value. Because the study involved ten SMEs, individual matrices were combined using geometric mean to maintain the reciprocal properties of the matrix (Ishizaka, 2019; Tavana et al., 2023).

For each comparison matrix, the total columns are calculated with the equation $S_j = \Sigma a_{ij}$. Furthermore, each element is normalized with $x_{ij} = a_{ij}/S_j$. The priority weight is obtained from the average of the normalization line, i.e. $w_i = (1/n)\Sigma x_{ij}$. Consistency is calculated through the weighted sum vector, λmax, Consistency Index (CI), and Consistency Ratio (CR), with $CI = (\lambda max - n)/(n - 1)$ and $CR = CI/RI$. The matrix is declared acceptable if the $CR \leq 0.10$. Alternative global priorities are calculated through the synthesis of criterion weights, subcriterion weights, and alternative local priorities for each subcriterion.

Table 3. Random Index (RI) in the AHP consistency test.

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

Respondent and model validation

The AHP assessment was carried out by ten subject matter experts from operations, maintenance, planning, engineering, QA/QC, and field management functions. The composition of respondents in Table 4 was selected to reduce the bias of a single discipline. Operations respondents provided assessments related to power supply continuity and ease of operation, maintenance respondents assessed reliability, support, and overhaul needs, while planning and engineering respondents assessed cost, integration, and implementation readiness. One senior decision-maker is involved separately to validate the alignment of results with managerial preferences.

Table 4. AHP respondent profile and decision validation.

Code	Job Title/Background	Experience	Education	Role
R1	Sr Engineer Surface Facilities	10–15 years	S1/D4	WE ARE
R2	Assistant Manager Field Operation	>15 years old	S2	WE ARE
R3	Assistant Manager Field Operation	10–15 years	S1/D4	WE ARE
R4	Maintenance & Inspection Manager	>15 years old	S2	WE ARE
R5	Assistant Manager Maintenance & Integrity	>15 years old	S2	WE ARE
R6	Maintenance Engineer	10–15 years	S1/D4	WE ARE
R7	Sr Engineer QA/QC	10–15 years	S1/D4	WE ARE
R8	Field Manager	>15 years old	S2	WE ARE
R9	Maintenance & Inspection Manager	>15 years old	S1/D4	WE ARE
R10	Planner	5–10 years	S2	WE ARE
R11	Senior Manager Operation & Surface Facilities	>15 years old	S2	Decision maker

Validation is carried out in three ways. First, mathematical validation using CI and CR values. Second, managerial validation by comparing the ranking of geometric mean results of 10 SMEs to the ranking of decision makers. Third, validation of replication in similar projects in Field S to see if the weighting structure can produce rational decisions in other cases within PT ABC.

RESULT AND DISCUSSION

CPPG power plant conditions and idle GTG utilization opportunities

Figure 5 shows that the availability and reliability of existing GTG units decreased in several units in the 2021–2025 period, especially in GTG-A and GTG-D. This performance decline is a concern because the CPPG operation configuration uses a 3+1 pattern. When two units show a decrease in reliability, operating flexibility decreases and the risk of power supply disruption increases. The bad actors identified include the load-shedding system, fuel system, control cable, and governor. In addition to technical factors, limited access to control systems and parts books from manufacturers also prolongs the troubleshooting process and increases maintenance costs (PT ABC, 2024b).

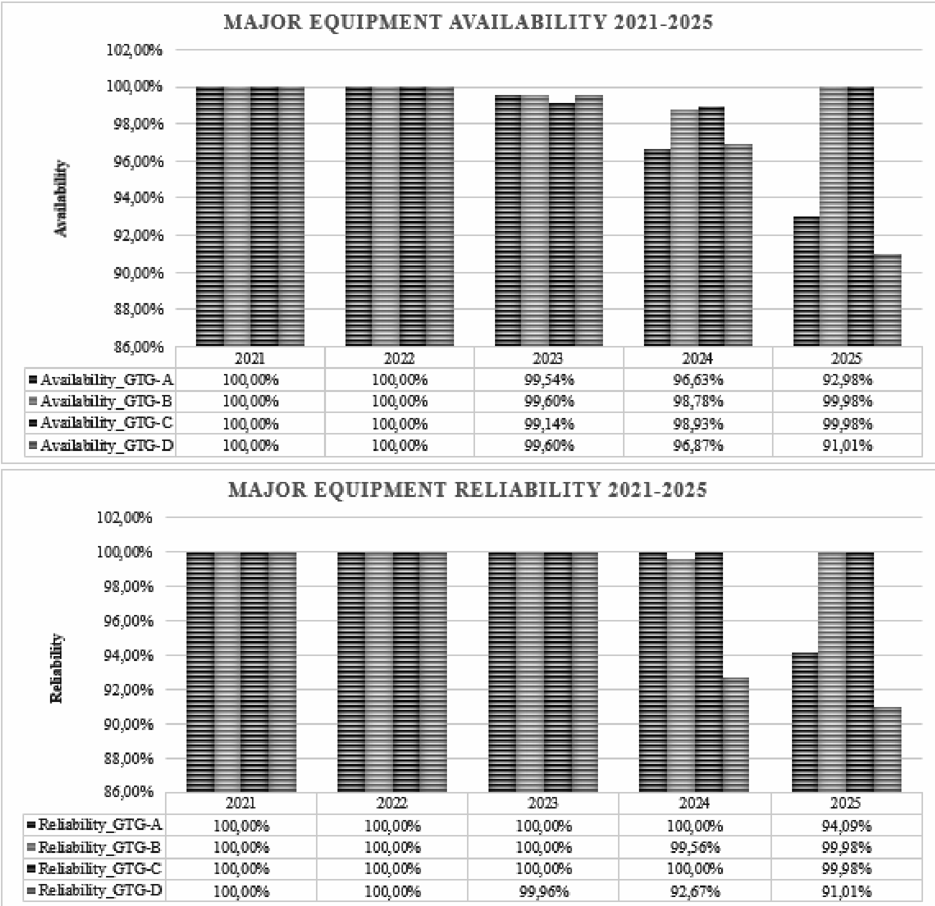


Figure 5. Availability and reliability of GTG existing CPPG for the 2021–2025 period.

Figure 6 shows the GTG population in the PT ABC environment. Brand ST has 20 active units and 7 non-operating units, while Brand O and Brand K each have only 4 active units. This condition is important because the larger fleet population usually supports the availability of parts, maintenance experience, operator familiarity, and the opportunity to borrow parts/units in an emergency. More importantly, the existence of 7 non-operating units of Brand ST opens up opportunities for the utilization of idle assets for CPPG as an alternative to dependence on existing Brand K units or new procurement.

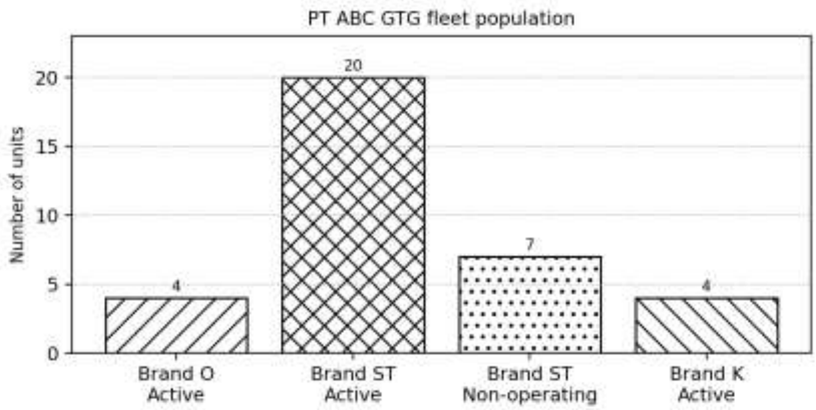


Figure 6. The population of GTG PT ABC is based on brand and operating status.

The inspection results in Table 5 show the difference in characteristics between the GTG candidates of Field T and Field L. Field T units have a capacity of 4,200 kW with a voltage of 6.6 kV so that they are easier to integrate into the CPPG electrical system. His condition is considered ready for operation with minor repairs. In contrast, the Field L unit has a capacity of 2,600 kW and a voltage of 400 V, so it requires voltage adjustment and major overhaul. However, the Field L unit has an enclosure that can be an added value in terms of noise and protection.

Table 5. The results of the inspection of idle GTG candidates in Field T and Field L.

Unit source	Tag number	Model	Output	Voltage	Enclosure	Unit condition
Field T	TG-100 / TG-200	ST T-60	4.200 kW per unit	6.600 V	Open	Ready for operation with minor repair
Field L	GTG-A / GTG-B	ST C-40	2.600 kW per unit	400 V	Enclosure	Requires major overhaul and adjustment of the voltage system

Alternative technical, economic, and environmental profiles

Table 6 summarizes the profile of each alternative from technical, economic, operability, policy, and environmental aspects. There is no superior alternative on all indicators. AL2 has the lowest capital cost because the Field T unit only requires minor repairs. AL3 has a medium capital cost because it combines two units of Field T with one unit of Field L that requires an overhaul. AL1 has the largest capital cost among relocation options because two units of Field L need major restoration. AL4 is relatively simple in terms of implementation, but it does not increase capacity, does not diversify the fleet, and does not provide fuel or emission reductions.

Table 6. Technical, economic, operability, policy, and alternative environment profiles.

Indicator	AL1	AL2	AL3	AL4
Capital cost (USD million)	8,41	5,05	6,61	6,27
Maintenance & operation cost (USD million)	52,79	57,69	48,04	82,43
Unit condition	Poor	Good	Fair	Fair
Rated output (MW)	9,60	10,60	11,00	8,80
Availability / reliability	97,01% / 98,82%	98,06% / 98,82%	99,10% / 99,50%	98,70% / 98,89%
Spare parts & support	Good	Good	Good	Fair
Operator familiarity	Good	Good	Good	Poor
GTG population	Quite common	Quite common	Common	Limited
Idle asset policy	Yes	Yes	Yes	No
Fuel reduction (MMSCFD)	0,90	0,81	1,05	0,00
CO_2e reduction (t/year)	19.349	17.414	22.574	-

The cost comparison in Figure 7 clarifies the trade-off between capital cost and long-term operating costs. AL3 does not have the lowest initial cost, but it results in the lowest maintenance and operation cost. This suggests that the decision to utilize idle GTGs cannot be based solely on capital costs, as operating and maintenance costs during the analysis period have a greater influence on long-term value.

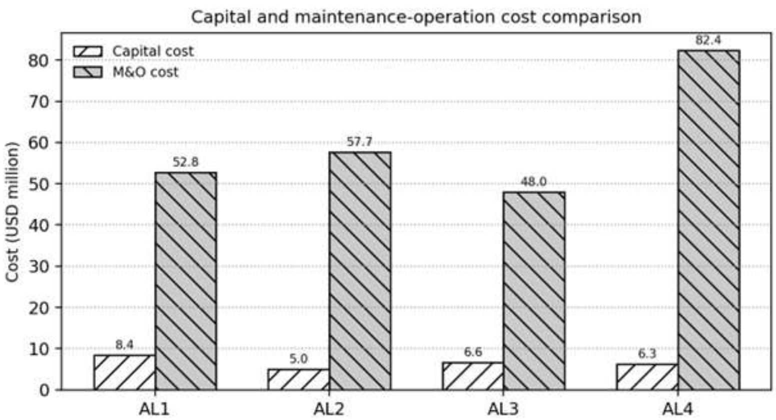


Figure 7. Comparison of capital costs and maintenance-operation costs between alternatives.

Weight of criteria and consistency of AHP calculation

The criteria weighting stage is presented in detail so that the AHP process can be traced from expert assessment inputs to consistency values. Table 7 shows a paired comparison matrix of geometric mean aggregation results for five main criteria. The values in rows and columns indicate the relative importance between the criteria. For example, the K2 to K3 value of 2.390 indicates that the technical aspect is seen as more important than operability in the context of selecting idle GTG for CPPG.

Table 7. Paired comparison matrix of the main criteria of geometric mean results.

Criteria	K1	K2	K3	K4	K5
K1 Economics	1,000	1,000	1,390	2,667	1,552
K2 Technical	1,000	1,000	2,390	3,000	2,158
K3 Operability	0,719	0,418	1,000	2,158	1,732
K4 Policy	0,375	0,333	0,463	1,000	0,719
K5 Environment	0,644	0,463	0,577	1,390	1,000
Number of columns	3,738	3,214	5,820	10,215	7,161

Table 8 presents the results of the matrix normalization. Each value is divided by the number of columns, then the average of each row is used as the priority weight. From the normalization, the technical criteria obtained the highest weight of 0.317, followed by economy 0.259, operability 0.189, environment 0.138, and policy 0.096. The dominance of technical criteria is logical because CPPG power plants are critical utilities that are directly related to gas production continuity.

Table 8. Normalization of the matrix and priority weights of the main criteria.

Criteria	K1	K2	K3	K4	K5	Weight
K1 Economics	0,268	0,311	0,239	0,261	0,217	0,259
K2 Technical	0,268	0,311	0,411	0,294	0,301	0,317
K3 Operability	0,192	0,130	0,172	0,211	0,242	0,189
K4 Policy	0,100	0,104	0,080	0,098	0,100	0,096
K5 Environment	0,172	0,144	0,099	0,136	0,140	0,138

Figure 8 visually shows the weight of the main criteria. The technical criteria are in the first position, indicating that the condition of the unit, power capacity, and reliability are more decisive than the other criteria. Economic criteria remain important as the second rank because the relocation decision must consider capital costs as well as long-term operating costs.

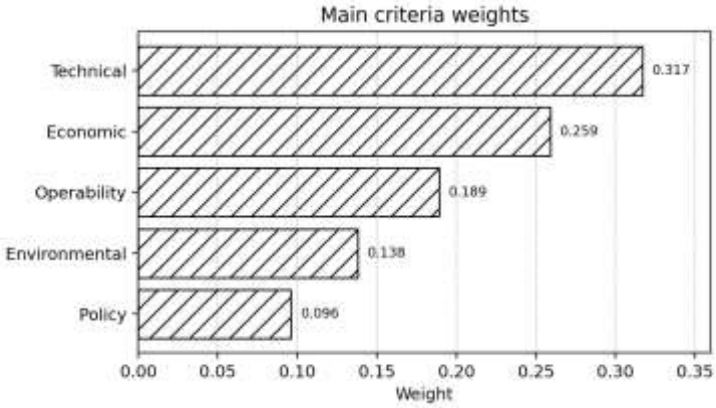


Figure 8. The weight of the main criteria in the AHP model.

The consistency test in Table 9 showed λmax of 5.056, CI of 0.014, and CR of 0.012. Since the CR is less than 0.10, the main criteria matrix is declared consistent and feasible for use in the synthesis process. Thus, the expert judgment does not show significant logical contradictions.

Table 9. Calculation of the consistency of the main criteria matrix.

Parameter	Basics	Value
n	Number of criteria	5
λmax	E-mail λi	5,056
MT	(λmax − n)/(n − 1)	0,014
RI	RI Saaty for n=5	1,120
CR	CI/RI	0,012
Verdict	CR < 0,10	Accepted

The weight of the subcriteria in Table 10 shows that maintenance and operation cost is slightly more dominant than capital cost in economic criteria. In technical criteria, unit condition is the main factor because it affects overhaul needs, integration risk, and operational readiness. In the operability criteria, spare parts and local support have the highest weight because the success of the relocation depends not only on the performance of the unit, but also on technical support after the unit is operational.

Table 10. The weight of the subcriteria used in the synthesis of AHP.

Criteria	Subkriteria	Weight
Economy	Capital cost	0,485
Economy	Maintenance & operation cost	0,515
Teknis	Unit condition	0,485
Teknis	Rated output	0,276
Teknis	Availability-reliability	0,239
Operability	Spare parts and local support	0,393
Operability	Training and operator familiarity	0,353
Operability	GTG population	0,254

Policy	Idle asset optimization alignment	1,000
Environment	Emission reduction potential	1,000

Alternative priorities and final synthesis

Table 11 and figure 9 show the alternative local priorities for each subcriterion. AL2 excels in capital cost and unit condition because the Field T unit is in good condition and only requires minor repairs. AL3 excels in maintenance and operation cost, rated output, operability support, GTG population, and emission reduction. AL4 obtained a relatively low score in policy and environmental aspects because it did not utilize idle assets and did not provide a reduction in fuel. This analysis shows that the final outcome is not determined by a single variable, but rather by a combination of advantages on several subcriteria that have different weights.

Table 11. Alternative local priorities on each subcriterion.

Code	Subkriteria	AL1	AL2	AL3	AL4
A1	Capital cost	0,102	0,383	0,238	0,276
A2	M&O cost	0,164	0,250	0,465	0,121
B1	Unit condition	0,079	0,376	0,318	0,228
B2	Rated output	0,247	0,240	0,378	0,135
B3	Availability-reliability	0,250	0,250	0,250	0,250
C1	Spares and support	0,196	0,196	0,515	0,094
C2	Training-familiarity	0,178	0,178	0,531	0,114
C3	GTG population	0,192	0,192	0,518	0,099
D1	Idle asset policy	0,280	0,280	0,280	0,161
E1	Emission reduction	0,184	0,217	0,523	0,076

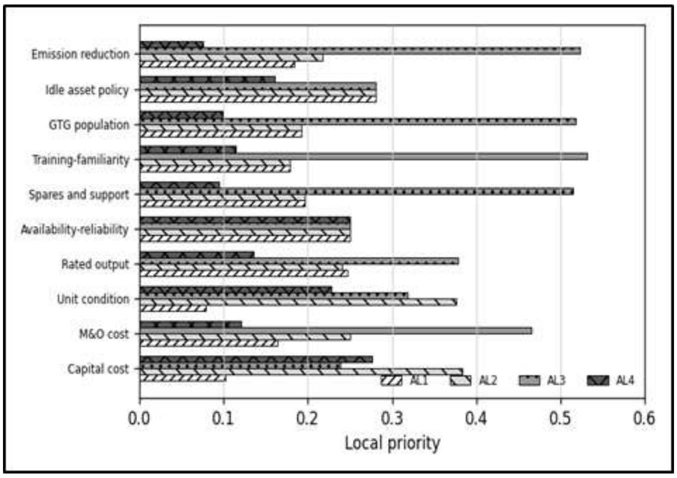


Figure 9. Comparison of alternative priorities per subcriterion

The final synthesis results in Table 12 and Figure 10 show that AL3 obtained the highest priority of 0.391. AL2 was in second place with a value of 0.272, followed by AL1 of 0.175 and AL4 of 0.162. The difference in AL3's priority to AL2's of 0.119 indicates that AL3 has a stronger integrated value, not only because of one superior indicator, but because of the greatest combination of output, lowest operating costs, better fleet support, fuller utilization of idle assets, and highest emission reduction.

Table 12. Final priority and alternative ranking of GTG utilization.

Alternatif	Configuration	Priorities	Ranking
AL1	Relocation of 2 GTG Field L + 2 GTG existing	0,175	3
AL2	Relocation of 2 GTG Field T + 1 GTG existing	0,272	2
AL3	Relocation of 2 GTG Field T + 1 GTG Field L	0,391	1
AL4	Overhaul GTG existing CPPG	0,162	4

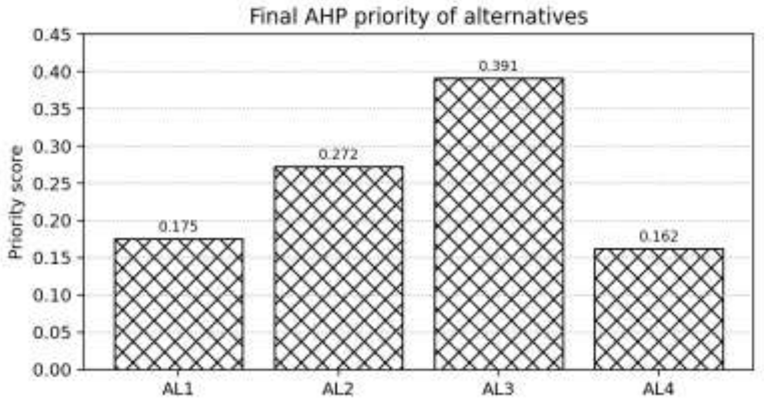


Figure 10. The final priority of alternative utilization of idle GTGs.

Technically, AL3 provides a rated output of 11 MW so that it provides the strongest margin for the normal load and peak load needs of CPPG. Economically, AL3 had the lowest maintenance and operation cost of USD 48.04 million during the analysis period. In terms of operability, the use of the ST brand GTG is more in line with the large population of PT ABC's fleet, thus supporting the availability of spare parts and operator familiarity. In terms of policy, AL3 maximizes the utilization of idle assets from two fields. In terms of the environment, AL3 provides the highest reduction in fuel consumption and emissions.

Environmental impact and contribution to operational efficiency

Figure 10 shows the potential for a reduction in fuel and CO_2e emissions in each alternative. The reduction in fuel consumption is the basis for calculating emissions because GTG uses natural gas as fuel. With the activity data and emission factor approach, the decrease in fuel gas is directly proportional to the decrease in CO_2e (API, 2021). AL3 provides the potential for a fuel reduction of 1.05 MMSCFD and an emission reduction of around 22,574 tCO_2e/year. AL1 lowers fuel by 0.90 MMSCFD with an emission reduction of around 19,349

$tCO_{2}e$/year, while AL2 lowers fuel by 0.81 MMSCFD with an emission reduction of around 17,414 $tCO_{2}e$/year. AL4 does not provide reduction because it retains the existing configuration.

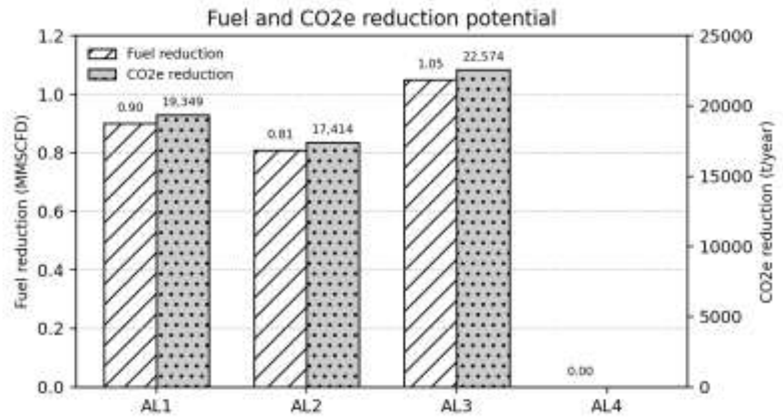


Figure 11. Potential to reduce fuel consumption and reduce $CO_{2}e$ emissions.

The findings show that the utilization of idle assets can be part of a decarbonization strategy if the relocated units have better fuel performance than existing units. In the case of CPPG, AL3 not only increases power margins and lowers operating costs, but also contributes to emission reduction targets. Thus, the decision to relocate idle assets can be positioned as a decision that connects reliability improvement, cost efficiency, asset optimization, and sustainability.

Validation of results and implementation roadmap

Validation with the decision holder in Table 13 shows the same ranking order as the geometric mean results of 10 SMEs, namely AL3 as the first rank, AL2 second, AL1 third, and AL4 fourth. This similarity of sequence suggests that the AHP model is not only mathematically consistent, but also aligned with managerial preferences. The difference in values between AL3 and AL2 on smaller decision-maker assessments indicates that implementation risk and execution readiness are still managerial considerations. However, AL3 is still chosen because it provides greater total benefits.

Table 13. Ranking validation with decision makers

Case	Alternatif	Model/SME	Decision/aktual	Ranking
CPPG	AL1	0,175	0,207	3
CPPG	AL2	0,272	0,302	2
CPPG	AL3	0,391	0,329	1
CPPG	AL4	0,162	0,162	4

Additional validation was carried out on the project to add a minimum 600 kW power plant in Field S. With the same weight structure as SME, the alternative relocation of 1 GTG of the Lim Field obtained the highest priority of 0.342, followed by lease of 0.320 and purchase of 0.316. These results are in line with actual decisions in the field, thus reinforcing that the AHP model can be replicated in the utilization cases of other idle generation assets with alternative data adjustments, this can be seen in table 14.

Table 14. Alternative Priority Value of Field Generation S

	MATRIX MULTIPCATION	RANKING
Relocation of 1 unit of GTG Lim Field	0,342	1
Purchase of 1 unit of GTG	0,316	3
Rent 1 unit of GTG	0,320	2

In order for the AHP results to be implemented effectively, AL3 needs to be followed by an execution roadmap as shown in Table 15. This roadmap is important because GTG's relocation includes not only the physical relocation of the unit, but also technical verification, asset transfer approval, engineering integration, dismantling, transportation, installation, commissioning, and performance monitoring after start-up. Each stage has critical controls that need to be maintained in order for the technical and economic benefits calculated in the model to be truly realized.

Table 15. Implementation roadmap for AL3 alternatives.

Stages	Main activities	Deliverable	Control Criticism
1	Detailed inspection	Confirmation of technical condition and repair scope	It does not continue if the actual condition is materially different from the assumption of AHP.
2	Engineering integration	Electrical, control, mechanical, and civil integration package	Konfirmasi voltage, protection, load shedding, fuel interface, dan safety system.
3	Asset transfer	Asset transfer approvals and handover documents	Make sure ownership status, asset value, logistics, and responsibilities are clear.
4	Dismantling and logistics	GTG package preserved and delivered	Avoid damage, contamination, and loss of accessories.
5	Installation	Mechanical completion dan loop-check record	Ensure readiness interface control and safety requirements.
6	Commissioning	Synchronization, load test, dan performance acceptance	Verifikasi reliability, fuel use, protection response, dan operating envelope.
7	Monitoring	Post-start-up performance report	Compare actual performance with assuming decisions and updates of idle asset databases.

Managerial implications and research contributions

The results of the study provide several implications. First, the AHP model provides a documented basis for decisions to explain why an idle asset is worth relocating or not. This is important because asset transfers involve operations, maintenance, engineering, finance, supply chain, and asset management. Second, the results show that the utilization of idle assets is not always synonymous with the lowest initial cost. AL3 was chosen because it provides the best integrated value, although its capital cost is not the lowest. Third, this model shows that asset optimization can be linked to decarbonization programs through explicit fuel reduction and CO_2e reduction assessments.

From the academic side, this research enriches the application of AHP in the context of the utilization of idle power plant assets in Indonesia's upstream oil and gas industry. From a practical point of view, the same framework can be applied to other idle assets such as diesel generators, compressors, pumps, transformers, or auxiliary equipment. Adjustments are only required on technical subcriteria, while the logic of the decision remains similar: technically feasible, cost rational, operable, governance-compliant, and providing better environmental impact.

CONCLUSION

This study developed an AHP-based decision model to determine the optimal utilization alternative for idle GTG assets at PT ABC's CPPG Power Plant. The model integrated five main criteria, namely economic, technical, operability, policy, and environmental aspects, using data obtained from operation and maintenance documents, unit inspections, cost simulations, fuel consumption calculations, and expert assessments. The consistency test results showed a Consistency Ratio (CR) value of 0.012 for the main criteria matrix, indicating that the assessment met the required consistency level for methodological acceptance.

Technical criteria represented the most important factor, with a weight of 0.317, followed by economic criteria (0.259), operability criteria (0.189), environmental criteria (0.138), and policy criteria (0.096). At the subcriterion level, unit condition was identified as the most dominant technical factor, maintenance and operating costs were considered slightly more important than capital costs, and spare parts availability and local support were the primary operability factors. These findings indicate that the selection of idle GTGs should consider technical readiness and the sustainability of operational support, rather than focusing solely on initial investment costs.

The final AHP synthesis identified AL3, involving the relocation of two GTGs from Field T and one GTG from Field L, as the optimal alternative with a priority value of 0.391. AL3 provides a rated output capacity of 11 MW, the lowest estimated maintenance and operating cost of USD 48.04 million, supports the idle asset optimization program, reduces fuel consumption by 1.05 MMSCFD, and has the potential to reduce emissions by approximately 22,574 tCO_2e/year. Validation with decision-makers and comparisons with similar projects demonstrated consistent rankings, indicating that the proposed model can serve as a basis for rational and measurable decision-making.

Further research is recommended to incorporate sensitivity analysis to evaluate potential ranking changes due to variations in economic, technical, and environmental criteria weights. The model can also be integrated with other Multi-Criteria Decision-Making (MCDM) methods, such as TOPSIS, VIKOR, or PROMETHEE, as well as probabilistic analysis approaches, to assess decision robustness under uncertainties related to fuel prices, overhaul costs, project schedules, and actual reliability performance.

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