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Evaluation of Gas Flare Recovery System Selection Using the Ahp Method to Increase Gas Sales Potential at PT Xyz's Oil and Gas Fields

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Abstract

Flare gas utilization has become an important issue in the oil and gas industry due to its economic potential and contribution to greenhouse gas emissions. Continuous gas flaring not only results in energy losses but also limits opportunities to increase gas sales potential. Therefore, selecting an appropriate Flare Gas Recovery (FGR) technology is essential to support operational efficiency and emission reduction targets, including the Zero Routine Flaring by 2030 initiative. This study aims to evaluate and determine the most suitable FGR technology alternative for PT XYZ's oil and gas field by applying a systematic multi-criteria decision-making approach. The research employed the Analytic Hierarchy Process (AHP) method to evaluate three FGR alternatives: LPG extraction, High-Pressure (HP) fuel gas recovery, and recycle compression. The evaluation criteria included cost, implementation time, operability, recovered condensate potential, and manpower requirements. Data were collected through expert interviews, technical document analysis, operational data review, and process simulation evaluation. The results showed that recycle compression (T3) achieved the highest priority based on the AHP calculation, with a final priority value of 0.4070, followed by LPG recovery (T1) with a value of 0.3315 and HP fuel gas recovery (T2) with a value of 0.2615. Sensitivity analysis confirmed that T3 provided the most stable decision under various changes in evaluation criteria. This study concludes that the AHP-based evaluation model can support objective technology selection and provide a practical framework for improving gas utilization, reducing flaring emissions, and enhancing operational efficiency in upstream oil and gas facilities.

INTRODUCTION

The oil and gas industry involves a complex business process consisting of exploration, production (upstream), processing (midstream), and distribution and sales (downstream) activities (Favour, 2024; Hussain et al., 2022; Ojuekaiye, 2024; Olaizola et al., 2022; Oyekan, 2024; Patidar et al., 2023). During the production process, naturally occurring gas produced alongside hydrocarbons cannot always be fully utilized; therefore, a portion of the gas is combusted through a flare system to maintain process safety, pressure control, and system stability. This combustion process generates flare gas, which is commonly found in Central Processing Plant (CPP) and Gas Processing Plant (GPP) facilities within the oil and gas industry (Zadakbar et al., 2008; Ndunagu et al., 2022).

According to World Bank data (2025), Indonesia's CO_2 emissions reached 674.5 million tons of CO_2e in 2023, representing a substantial increase compared with emission levels in the

1970s. This growth was primarily driven by the energy sector, including emissions generated from gas flaring activities at oil and gas facilities. To address this issue, the Government of Indonesia, through the Ministry of Energy and Mineral Resources (MEMR), launched the Zero Routine Flaring by 2030 (ZRF 2030) initiative as a commitment to reduce routine gas flaring in oil and gas operations. This initiative is part of the Global Gas Flaring Reduction Partnership (GGFR) established by the World Bank and supports Indonesia's transition toward Net Zero Emissions (NZE) by 2060 in accordance with the Paris Agreement (COP21). Under this commitment, Indonesia aims to reduce greenhouse gas emissions by 31.89% independently and by 43.20% with international support (World Bank, 2023).

Achieving reductions in flaring activities requires significant contributions from the upstream oil and gas sector (Babalola & Olawuyi, 2022; Ogundipe et al., 2025; Wood, 2022). One of the objects examined in this study is PT XYZ, a Cooperation Contract Contractor (Kontraktor Kontrak Kerja Sama / KKKS) engaged in the exploration and exploitation of oil and natural gas. PT XYZ operates the ABC Field, which is equipped with a Central Processing Plant (CPP) as its primary processing facility. The CPP consists of two gas processing trains supported by several major systems, including Gas-Liquid Separation, Acid Gas Removal, Acid Gas Conversion Unit, Dew Point Control System, Condensate Stabilization System, and Produced Water Treatment System.

One of the operational challenges at the CPP is the continuous combustion of excess gas through the flare system (Al Mamari, 2023; Ghazali & Ahmad S, 2023; Parekh et al., 2025; Sriana & Yulianto, 2025). This condition results in lost opportunities for increasing gas sales potential and contributes to carbon dioxide (CO_2) and black carbon emissions. The excess gas combustion occurs due to an imbalance between Low-Pressure (LP) fuel gas production and actual fuel system consumption. Consequently, excess gas is directed to the flare system. However, flare gas still contains C_1–C_4 hydrocarbon components with significant calorific value and potential for recovery through the implementation of Flare Gas Recovery (FGR) technology (Asadi et al., 2021).

Incomplete combustion of hydrocarbon gases can generate black carbon (BC), which consists of fine carbonaceous particles that negatively affect air quality, human health, and climate conditions (Chen et al., 2022). Therefore, reducing flaring activities is important not only from an energy efficiency perspective but also for emission control and improvement of corporate environmental performance. In continuously operating oil and gas facilities, effective flare gas management has become increasingly important because the combusted gas still contains hydrocarbon components with economic value.

From technical, economic, and environmental perspectives, flare gas management requires a comprehensive evaluation approach. One of the technologies used for flare gas utilization is Flare Gas Recovery (FGR), which captures gas from the flare header before combustion and compresses it for reuse in fuel gas networks or gas processing systems (Sarkari et al., 2022). Technically, FGR systems require consideration of recovery efficiency, power requirements, integration with existing facilities, and operational reliability (Asadi et al., 2021).

From an economic perspective, commonly applied parameters for evaluating FGR feasibility include Capital Expenditure (CAPEX), Operational Expenditure (OPEX), Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period. Previous studies have demonstrated that FGR implementation can reduce energy losses, minimize flaring activities, and increase the utilization of recovered gas as fuel gas or process feedstock (Zadakbar et al., 2008; Asadi et al., 2021; Sarkari et al., 2022). Furthermore, from an environmental perspective, this technology supports improvements in corporate environmental performance in accordance with Environmental, Social, and Governance (ESG) principles.

In the case of ABC Field, continuous flaring occurs due to an imbalance between LP fuel gas production and consumption capacity, resulting in the loss of economically valuable gas and the generation of significant greenhouse gas emissions. This condition requires a comprehensive technical evaluation of FGR implementation as a strategic solution to minimize energy losses and support low-carbon operational targets. The urgency of this research is further strengthened by the availability of three potential FGR technology alternatives: LPG Extraction, which recovers heavier hydrocarbon fractions into LPG and condensate; HP Fuel Gas Recovery, which utilizes flare gas as an energy source for high-pressure fuel gas systems; and Recycle Compression, which returns excess LP gas to the process system. A systematic evaluation of these alternatives is required to determine the most feasible technology based on technical, economic, and operational considerations while increasing gas sales potential and improving processing facility efficiency.

However, for decision-makers in oil and gas companies, FGR technology selection is not determined solely by technical feasibility. The decision-making process must also consider multiple criteria, including energy efficiency, investment cost, implementation duration, operational flexibility, recovered product potential, and manpower requirements. This complexity arises because each FGR alternative provides different advantages and limitations across various evaluation criteria.

Previous studies have examined flare gas utilization through technical, economic, environmental, and process optimization approaches. However, a research gap remains regarding the availability of systematic and measurable selection methods for evaluating alternative FGR technologies at the CPP facility scale, particularly under the operational conditions of ABC Field. In addition, PT XYZ does not yet have a standardized, structured, and multi-criteria framework for objectively comparing FGR technology alternatives. This limitation may result in decision-making processes that do not fully balance cost, implementation time, operability, recovery potential of economically valuable products, and manpower requirements.

In other words, previous studies have generally emphasized technical or economic aspects separately, whereas oil and gas industry decision-making requires a multi-criteria approach capable of simultaneously incorporating technical, economic, operational, and strategic considerations. Therefore, this study aimed to develop a systematic, measurable, and applicable FGR technology selection evaluation model that could be implemented under PT XYZ's operational conditions to support more objective, transparent, and accountable decision-making.

Based on these conditions, this study focused on evaluating alternative flare gas utilization technologies using the Analytic Hierarchy Process (AHP) method. The objective of this research was to develop a multi-criteria decision-making model applicable to Indonesia's upstream oil and gas industry, particularly gas processing facilities with significant flare gas potential, such as ABC Field. The proposed model was expected to assist in determining the optimal FGR technology alternative by considering cost, implementation time, operability, recovered condensate potential, and manpower requirements, while supporting the achievement of Zero Routine Flaring by 2030 and broader emission reduction targets.

RESEARCH METHODS

This study employed a Multi-Criteria Decision-Making (MCDM) approach using the Analytic Hierarchy Process (AHP) method to determine the most suitable Flare Gas Recovery (FGR) technology. The evaluated alternatives included T1 LPG Recovery, T2 HP Fuel Gas Recovery, and T3 Recycle Compression. The evaluation criteria consisted of cost, implementation time, operability, recovered condensate potential, and manpower requirements. Respondent C1 represented the decision-maker perspective, while respondents C2–C8 represented operational and technical personnel involved in facility evaluation.

The assessments from respondents C2–C8 were aggregated using the geometric mean method to obtain group pairwise comparison values. The validity of the AHP results was evaluated through the Consistency Ratio (CR), with an acceptable threshold of CR < 0.1. In addition to calculations performed using Microsoft Excel, the final model results were validated using Super Decisions software to ensure consistency in the hierarchical structure, criterion weights, and alternative priorities.

Table 1. Data Collection Methods

Identification Method	Activity Description
Identification through Technical Interviews (Expert Interviews).	Identify operational constraints of *the flare* system. Obtain an initial assessment of the feasibility of each FGR alternative.
Field Observation	Observing process parameters
Direct evaluation of the Simulation model	Reviewing simulation inputs: composition, boundary conditions. Analyze the potential for LPG/condensate recovery.
Engineering Documents (FEED, P&ID, Philosophy)	Studying *flare capacity*, pipelines, and existing equipment. Analyze control and protection systems.
Analyze the simulation of the processes that are already available. Process Simulation Report.	Reviewing material balance. Calculates the potential of gas and condensate that can be recovered.
Historical Operational Data	Collecting *gas flare trends*. Examine pressure, temperature, downtime & trip flare system.
Economic Data, Internal Cost & Price Report Study.	Take the price of *fuel gas*, LPG, condensate. Identify OPEX/CAPEX related to FGR.
Regulation & Policy	Examining the ZR *Flare* 2030 regulations, SKK Migas, KLHK.
FGR Scientific Literature & Benchmark	Analyze global FGR technology: LRC, ejector, compression, LPG extraction.

At this stage, an analysis of the results of data processing that has been obtained from the weighting and assessment process using the AHP method is carried out. The analysis is focused on the weight of the criteria as well as the alternative scores of FGR technology generated through calculations using Microsoft Excel or other supporting software. These values are then further reviewed to ensure consistency levels through *Consistency Index (CI)* and *Consistency Ratio (CR) tests*. This evaluation is important to assess whether the paired comparison matrix has met the limits of methodological consistency and reflects the actual technical and operational conditions *of the flare* system in Field ABC.

In addition, this study also discusses the potential replication of the AHP model used for similar problems in other upstream oil and gas facilities. The potential for replication arises because the characteristics *of the flare* system, CPP operating pattern, and challenges related to *flaring* reduction generally have similarities in various oil and gas fields in Indonesia. Thus, the assessment model and alternative evaluation framework of FGR developed in this study have the potential to be reused as a reference in technical decision-making in other fields that face the need for the implementation of *Flare Gas Recovery*.

RESULTS AND DISCUSSION

Results of Calculation of Alternative Priority Values of C1 Respondents

After weighting the main criteria and subcriteria using the Analytic Hierarchy Process (AHP) method, the next stage is to calculate the global weight for each alternative Flare Gas Recovery (FGR) technology.

Table 2. Results of the Alternative Ranking of FGR Technology Selection

Global Weight	Priority Values	Ranking	Alternatives
T1	0,809	3	T1. Lpg Extraction
T2	0,930	2	T2. Hp Fuel Gas Recovery
T3	1,260	1	T3. Recycle Compression

The final results of the AHP calculation showed that the T3 (Recycle Compression) alternative obtained the highest value of 1.260 so that it became the most optimal alternative to Flare Gas Recovery (FGR) technology, followed by T2 (HP Fuel Gas Recovery) with a value of 0.930, and T1 (LPG Extraction) with a value of 0.809. T3's advantages are supported by the best performance in economic aspects, especially CAPEX, OPEX, and payback periods, as well as operability, gas recovery capabilities, and ease of integration with existing systems. Thus, T3 provides the best balance between cost, implementation time, operational efficiency, and human resource needs. Meanwhile, T2 showed a fairly good performance in terms of operability and maintenance needs, but still lost to T3 in terms of economy. T1 is ranked last because it requires higher investment, equipment, and process complexity despite having advantages in the recovered condensate aspect.

Results of Calculation of Alternative Priority Values for Respondents C2-C8

The calculation of alternative priority values was also carried out for C2-C8 respondents. Based on the calculation results, the T1 LPG Extraction alternative obtained the highest priority value of 1.07785933 so that it ranked first. Furthermore, the T3 Recycle Compression alternative obtained a score of 1.045227937 and was ranked second, while the T2 HP Fuel Gas Recovery alternative obtained a value of 0.876912733 and was ranked third.

Table 3. Results of the Alternative Ranking of FGR Technology Selection

Global Weight	Priority Values	Ranking	Alternatives
T1	1,07785933	1	T1. Lpg Extraction
T2	0,876912733	3	T2. Hp Fuel Gas Recovery
T3	1,045227937	2	T3. Recycle Compression

The results of the Analytic Hierarchy Process (AHP) calculation in the C2-C8 respondent group show that the T1 alternative LPG extraction is the highest priority. This suggests that the working level group tends to place greater emphasis on the potential recovery of products of economic value and certain aspects of implementation. However, the difference in values between T1 and T3 is relatively not too far, so these results need to be read together with the results of the C1 respondents, Super Decisions validation, and sensitivity analysis so that the final recommendations still reflect the technical, economic, operational, and strategic balance.

Analysis of the Difference in Priority Values of Respondents C1 and C2-C8

The difference in the results of the alternative ranking of Flare Gas Recovery (FGR) technology in the two calculation results shows that the AHP synthesis process is greatly influenced by the alternative weight value in each subcriterion according to the respondent's perception. Although the method used is the same, namely the Analytic Hierarchy Process (AHP), changes in the value of pairwise comparison at the alternative level can result in a significant change in the final ranking. This condition shows that the AHP method has high sensitivity to changes in respondents' assessment priorities, especially on criteria that have dominant weight.

In the results of the calculation of the C1 respondents, different results were obtained, where the alternative T3 Recycle Compression obtained the highest value of 1.2606, followed by T2 HP Fuel Gas Recovery of 0.9303, and T1 LPG Extraction of 0.8093. Meanwhile, in the calculation results of C2-C8 respondents, the alternative of T1 LPG Extraction was ranked first with a value of 1.0779, followed by T3 Recycle Compression of 1.0452, and T2 HP Fuel Gas Recovery of 0.8769. This difference shows that there is a variation of views between decision-makers and working levels in assessing FGR technology priorities.

The most significant differences were seen in the Cost subcriterion group, particularly in the CAPEX subcriterion (A1). The alternative weight distribution has changed significantly, especially in the aspect of investment costs. This shows that the perception of initial investment needs is one of the factors that most influence the change in alternative ratings between C1 and C2-C8 respondents.

In the results with C2-C8 respondents, the alternative of T1 LPG Extraction obtained the highest weight at CAPEX of 0.6068, while T3 Recycle Compression only obtained a value of 0.1361. This condition caused T1 to make a very large contribution from the initial investment aspect, especially since *Cost* is the main criterion with the highest weight in the AHP structure, which is 0.4016. T1's dominance in CAPEX greatly affects the final result because the initial investment is the most sensitive factor in the evaluation of FGR technology. In the implementation of oil and gas projects, technologies with lower initial investment requirements will generally be more readily accepted because the financial risk of the project becomes smaller. Therefore, when T1 gains the highest weight in CAPEX, the total contribution of T1's global weight increases significantly. In addition to excelling in CAPEX, T1 also obtained high scores on several other subcriteria such as *Total Schedule* (0.6297), Lead *Time* Equipment (0.6677), Reuse/Recovered Gas (0.6867), Condensate Economic Value (0.7116), Number of Operators (0.6573), Maintenance Intensity (0.6455), Training Operators (0.6602). The dominance of these subcriteria shows that LPG extraction technology is seen as superior in terms of project implementation, monetization of recovery results, and efficiency of human resource needs. This causes T1 to accumulate a fairly high value in the final synthesis result.

Table 4. Comparison of FGR Alternative Election Results

Evaluation Aspects	**C1 Responders**	**Group C2-C8**
Tier 1 Alternatives	T3 Recycle Compression	T1 LPG Extraction
T1 Value	0,809	1,077
T2 Value	0,930	0,876
T3 Value	1,2606	1,045
Cost Dominance	T3 excels in CAPEX, OPEX, and Payback Period	T1 excels at CAPEX
Domination of Time	T3 excels in Duration of shutdown	T1 excels in Total Schedule and Lead Time
Dominance of Operability	T2 remains dominant	T2 excels in Ease of Operation and Reliability
Dominance of Recovered Condensate	T3 excels in gas recovery	T1 excels in Condensate Economic Value
Manpower Dominance	Doesn't affect the final ranking too much	T1 dominant

Overall, the difference in alternative ratings in Table 4 shows that the selection of *Flare Gas Recovery* (FGR) technology is strongly influenced by the evaluation priorities used in the weighting process. If the company prioritizes investment efficiency, project implementation, product monetization, and *manpower* efficiency, then the T1 *LPG Extraction* alternative is the most optimal choice. On the other hand, if the main priority is directed at operational efficiency, minimization *of shutdowns*, ease of integration with existing systems, and long-term operational cost efficiency, then the T3 *Recycle Compression* alternative is a superior choice. These results show that there is no single FGR technology that is completely superior in all aspects of evaluation, so the selection must be adjusted to operational needs, the company's business strategy, the condition of existing facilities, and *the flaring* reduction target. This finding is in line with the research of Enayati et al. (2025) which shows that LPG extraction technology has high excision efficiency and product economic value, so it is more suitable if the company is oriented towards increasing the added value of *recovery* results. In addition, the research of Khalili-Garakani et al. (2022) also states that each FGR configuration has different technical, economic, and economic characteristics so that no one technology is always the best choice for all operating conditions. Therefore, the selection of technology must consider the goals and priorities of each facility.

Model Validation and Alternative Final Priorities

After the results of the C1 respondents and the C2-C8 group were analyzed, the decision model was validated to obtain the final priority of the FGR technology alternatives. Validation is carried out by ensuring that the Consistency Ratio (CR) value is below 0.1 and comparing the results of Excel's calculations with the Super Decisions software. The validation results showed the final priority order of T3 Recycle Compression as the best alternative, followed by T1 LPG Recovery and T2 HP Fuel Gas Recovery.

Table 5. Results of FGR Alternative Final Priority Validation

Alternatives	Normalization Values	Ranking
T3 - Recycle Compression	0,4070	1
T1 - LPG Recovery	0,3315	2
T2 - HP Fuel Gas Recovery	0,2615	3

These results confirm that Recycle Compression is the most balanced alternative because it is able to accommodate the needs of integration with existing facilities, maintain operational reliability, and still provide the benefits of reusing gas flares without too high process complexity.

From the perspective of corporate decision-makers, the T3 Recycle Compression alternative is seen as most in line with the characteristics of Non-Business Development (NBD) investments, namely investments that emphasize operational sustainability, flaring reduction, implementation risk reduction, and optimization of existing facilities. On the other hand, the working level group tends to consider T1 LPG Extraction more attractive because it has the potential to recover products with economic value. This difference shows that the FGR's decision-making process needs to accommodate strategic and technical aspects at the same time.

Sensitivity Analysis to Weight Changes Criteria

Sensitivity analysis was conducted to evaluate the stability of AHP's decision results to changes in criterion weights. This analysis is important because the results of the selection of alternative *Flare Gas Gas Recovery* technology are determined not only by the alternative performance value, but also by the priority of the weighting of the criteria given by the respondents. Therefore, tests were carried out to find out how much the main decision could change from the initial alternative, namely T3 (*Recycle Compression),* to another alternative.

In this study, sensitivity analysis was focused on three criteria, namely Cost, Time, and Recovered Condensate. The three criteria were chosen because they represent three main aspects in FGR technology decision-making, namely cost feasibility, implementation speed, and potential added value from product recovery results. The Cost criteria represent the aspects of investment, OPEX, and payback period. The Time criterion represents the duration of implementation, equipment procurement time, and shutdown needs. Meanwhile, the Recovered Condensate criteria represent the potential for hydrocarbon recovery and increased economic value from the use of flare gas.

The sensitivity analysis method was carried out by changing the weight of one of the criteria, while the weight of the other criteria was re-normalized proportionally so that the total weight of all criteria remained 1.0000. This approach is carried out on a *one-at-a-time* basis, where only one criterion is changed in each scenario, so that the influence of each criterion on the change in decision can be observed separately. Based on the results of AHP on basic conditions, the T3 (*Recycle Compression)* alternative obtained the highest priority value, making it the main recommended alternative. Therefore, sensitivity analysis is directed to find out the limits of weight changes that can cause the decision to change from T3 to another alternative.

The Cost *criteria* are analyzed with a weight loss scenario. Cost weight reduction is used to describe a condition when the cost aspect is no longer the dominant consideration in decision-making. This condition can occur if the company emphasizes the potential for product improvement, long-term benefits, or added value from the use of *flare gas* rather than the initial cost efficiency. The results of the analysis show that the T3 (*Recycle Compression*) alternative remains a priority as long as the *Cost* weight does not fall too much. The new decision change occurred when *the Cost weight* fell by about 50.24% from the initial weight. In these conditions, the T1 alternative (*LPG extraction*) begins to have a higher priority value than T3. These results show that the decision on T3 is quite stable against the change in *the weight of Cost*, because it takes a relatively large reduction in *the weight of Cost*, which is around 50.24%, to change the decision to T1. In other words, as long as the cost aspect still has a fairly dominant role in evaluation, T3 remains the most powerful alternative.

The *Time* criterion is analyzed with the weight gain scenario. The increased *weight of Time* is used to describe a condition when a company prioritizes the speed of project implementation, the duration of equipment procurement, and the minimization of *shutdown time*. This is relevant because the FGR project is a project to modify existing facilities, so the implementation schedule and the risk of operational disruption are important aspects in the selection of technology. The results of the analysis showed that the initial decision on T3 remained stable at *a moderate change in Time* weight . The new decision changes from T3 to T1 when the *Time weight* increases by about 102.44% from the initial weight. This means that *the weight of Time* must be more than doubled for T1 to be a priority alternative.

The Recovered Condensate criteria were analyzed with weight increase scenarios. The increase in the weight of this criterion is used to describe conditions when decisions emphasize more on the potential for hydrocarbon recovery, the increase in economic value products, and the potential for additional income from the use of flare gases. This scenario is important because alternatives such as LPG extraction have the potential to produce value-added products, although they require more complex process configurations. The results of the analysis showed that the T3 decision remained stable against the increase in the weight of the Recovered Condensate within the normal change range. The new decision changes to T1 if the weight of Recovered Condensate increases by about 359.58% from the initial weight. In other words, the weight of this criterion must be more than quadrupled compared to the basic conditions for T1 to be a priority alternative. A summary of the results of the sensitivity analysis to the three main criteria is shown in Table 6.

Table 6. Resume sensitivity of change in criterion weights to alternative changes

Criteria Tested	Direction of Weight Change	Weight changes when decisions change	Early Alternatives	Alternatives After Change
Cost	Get Down	-50,24%	T3 – *Recycle Compression*	T1 – LPG Extraction
Time	Rise	102,44%	T3 – *Recycle Compression*	T1 – LPG Extraction
Recovered Condensate	Rise	359,58%	T3 – *Recycle Compression*	T1 – LPG Extraction

The results of the sensitivity analysis showed that the Recycle Compression (T3) alternative had a high level of stability (robustness) against changes in the weight criteria. The new decision changes to LPG Recovery (T1) if the Cost weight is reduced by around 50.24%, the Time weight is increased by around 102.44%, or the Recovered Condensate weight is increased by around 359.58% from the initial condition. These findings are in line with the research of Hajizadeh et al. (2018) which shows that gas flare utilization technology can provide technical and economic benefits if the system configuration is chosen according to the characteristics of the facility. This result is also supported by Zadakbar et al. (2008) who stated that gas flares that are compressed and returned to the fuel gas header can reduce fuel gas consumption, operating costs, emissions, and improve process stability. Furthermore, Sarkari et al. (2022) reported that the integration of exhaust gases into compression networks can significantly reduce flaring rates and reduce CO_2 and CH_4 emissions, while Tahouni et al. (2016) prove that the integration of flare gas with fuel gas networks can save natural gas consumption while reducing greenhouse gas emissions. Thus, the results of this study not only confirm the advantages of Recycle Compression from various aspects, but also show that it is a stable alternative to changing decision-makers' preferences.

CONCLUSION

Based on the results of the study, three Flare Gas Recovery (FGR) technology alternatives suitable for application in gas processing facilities within Indonesia’s upstream oil and gas industry were identified: LPG Recovery (T1), HP Fuel Gas Recovery (T2), and Recycle Compression (T3). These alternatives have different characteristics, in which T1 excels in producing economically valuable products, T2 provides a simpler system for internal fuel utilization, while T3 offers advantages in operational flexibility, ease of integration with existing facilities, minimal shutdown requirements, and lower implementation risks. Based on the weighting process using the Analytic Hierarchy Process (AHP) method across five main criteria—Cost, Time, Operability, Recovered Condensate, and Manpower—the Recycle Compression (T3) alternative achieved the highest priority value. Therefore, T3 was identified as the most suitable technology for the research object because it provided the optimal balance among economic considerations, project implementation, operational performance, and flaring reduction objectives.

The developed decision-making model was validated through the AHP consistency test, comparison of calculation results using Super Decisions software, and sensitivity analysis. The validation results showed that all pairwise comparison assessments were acceptable, as the Consistency Ratio (CR) values were below 0.1. Validation using Super Decisions produced the final priority ranking of Recycle Compression (T3) at 0.4070, LPG Recovery (T1) at 0.3315, and HP Fuel Gas Recovery (T2) at 0.2615. Therefore, the AHP-based model applied in this study can serve as a systematic and measurable framework for selecting FGR technologies in upstream oil and gas facilities with similar operational conditions.

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