

Implementation of Latest Technology in Oil and Gas Industry Business Processes: Case Study of Production Processes in Upstream Oil and Gas with Zero Flaring Technology

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ABSTRACT

Keywords: gas flare, electricity, oil and gas, economic feasibility, FGR technology. This study aims to evaluate and implement the latest technology in reducing flare gas (Flare Gas Recovery) in the upstream oil and gas industry. Flare gases, which are often burned and released into the atmosphere, are a significant source of emissions and a contributor to warming. The results of the SWOT and AHP analysis show that the technology of converting flare gas into electrical energy has advantages compared to other technologies. From an economic perspective, calculations show that this project is very feasible to implement, with an NPV value of IDR 48.82 billion, an IRR of 23.03%, a BCR of 1.14, and a payback period of only 4.27 years. The LCC of IDR 400.37 billion and the CoE of IDR 285.98/kWh indicate that this project can keep energy production costs at a competitive and sustainable level. This study concludes that Flare Gas Recovery to Electricity technology is the optimal solution to support zero flaring initiatives and make a real contribution to reducing flare gas emissions, as well as providing high added value in terms of economy and environment.



Introduction

The upstream oil and gas (oil and gas) industry in Indonesia plays a crucial role in contributing to national energy security (Winarto, 2021). As one of the largest natural resources, this industry not only provides vital energy for the community, but also becomes the main support for economic growth (Khalili-Garakani, Nezhadfar, & Iravaninia, 2022). In this study, attention to the implementation of the latest technology in the upstream oil and gas industry business process, especially in the use of flare gas which is currently still burned in the flaring system, becomes increasingly urgent (Putri & Rahmanida, 2023).

The oil and gas industry faces significant challenges as the world transforms towards a clean energy transition. One of the impacts is the large number of financial sectors that have stopped funding new oil and gas projects (Aripin, Prabowo, Haryanto, & Kumara, 2023). However, oil and gas demand is still growing, especially in developing

regions such as India, Africa, and Asia, where economic growth, urbanization, industrialization, and the number of vehicles are predicted to increase significantly. Therefore, investment in oil and gas projects is still needed to provide energy security and meet the increasing demand for oil and gas, before renewable energy technology becomes more competitive (Soesanto, Angelicleatemia, & Julia, 2024).

The government also targets oil production of 1 million barrels and 12 BSCFD gas by 2030, with a focus on domestic utilization. Indonesia has 68 potential unexplored basins and proven oil reserves of 2.4 billion barrels, as well as proven gas reserves of around 43 TCF (Prasetyo & Windarta, 2022). To encourage upstream oil and gas investment, the government has made policy breakthroughs through contract flexibility, improvement of terms and conditions in oil and gas work area auctions, and fiscal/non-fiscal incentives. The government is also ready to revise the 2001 Oil and Gas Law to improve the investment and economic climate of oil and gas projects in Indonesia. IOG 2022 was held in a hybrid manner with the active participation of the Ministry of Energy and Mineral Resources, which participated in discussions and exhibitions related to the oil and gas industry (Amanda, Putri, Arifan, Hidayat, & Ikaningtyas, 2024).

On May 22 - 24, 2023, the special task force for upstream oil and gas business activities (SKK Migas) held a workshop on technology and gas utilization, which was initiated as a follow-up to the gas expo forum in 2022 (Manalu & Setyadi, 2010). The workshop covered various aspects, ranging from the implementation of gas technology, gas potential estimation, gas market absorption capabilities, to conversion methods from oil to gas. This workshop will also be a reflection of awareness of the importance of continuing to develop more efficient gas management technologies and strategies (Newnan, Eschenbach, & Lavelle, 2004).

Average emissions per facility also varied, with oil refineries having the highest emissions per facility of 1.15 million metric tons of CO₂. Accumulation and enhancement had average emissions per facility of 0.25 million metric tons of CO₂, followed by onshore production of 0.20 million metric tons of CO₂, natural gas processing and overall production of 0.13 million metric tons of CO₂, and offshore production of 0.05 million metric tons of CO₂ (Genc, Genc, & Goksungur, 2017). Of the total emissions, flare and blowdown vent emissions reached 36 million metric tons of CO₂, of which oil refineries and onshore production were the main contributors with 3.2 and 18 million metric tons of CO₂, respectively (Mian, 2011). The largest percentage of emission sources from flares and blowdown vents were found in offshore production (25.4%) and onshore production (19.3%).

The objectives of this research are as follows:

1. Identify the latest technologies that can be applied to improve efficiency and productivity in the upstream oil and gas production process.
2. Analyze the effectiveness of the implementation of the latest technology in minimizing flare gas emissions in the upstream oil and gas industry.
3. Develop a strategy to optimize the use of beacon gas in Indonesia's upstream oil and gas industry to support sustainable development goals.

4. Analyze/identify changes in business processes in the application of zero flaring technology.

Method

This research method will use the SWOT (Strengths, Weaknesses, Opportunities, Threats) and AHP (Analytical Hierarchy Process) approaches to analyze the potential implementation of beacon gas reduction technology in the oil and gas industry. A SWOT analysis will help identify internal and external factors that affect the success of the project, while AHP will give weight and priority to the various criteria involved in decision-making. In addition, economic analysis such as IRR (Internal Rate of Return), BEP (Break-Even Point), NPV (Net Present Value), and ROI (Return on Investment) will be used to evaluate the financial feasibility of this project. The data from this economic analysis will provide an overview of the potential benefits and risks of investment, helping companies determine whether these projects can provide significant added value.

The plan for new products such as electricity generated from the conversion of flare gas will be designed to meet the company's internal energy needs and can also be sold to the national power grid. The risk and economic feasibility assessment will include a comparative analysis between existing regulations and the technical aspects of the implementation of these technologies. This evaluation will consider various factors such as initial investment costs, operational costs, potential revenue, and the impact of applicable environmental regulations. Thus, the results of this method will provide a comprehensive view of the advantages and challenges of implementing flare gas reduction technology, as well as ensure that decisions are based on a holistic and informed analysis.

The data analysis techniques that will be used in this study are:

1. Qualitative analysis, such as thematic analysis and content analysis.
2. Quantitative analysis, such as economic and risk analysis.

Literature Studies

A literature study is needed to gain a thorough understanding of SWOT analysis, AHP, economic analysis, and risk evaluation as well as best practices in the use of the latest zero flaring technology that will be discussed in this study. Literature studies can be derived from academic literature, industry reports, and relevant case studies and analyze the findings of literature reviews to identify key concepts, theories, and methodologies. The purpose of the literature study is to be used as a comprehensive literature review that summarizes the current knowledge of the latest zero flaring technology with SWOT, AHP, economic analysis, and risk evaluation methods.

Data Collection

Quantitative data collection in this study will be carried out through various credible and relevant sources, including:

1. Annual Reports and Industry Statistics: Data from global energy agencies such as the International Energy Agency (IEA), U.S. Energy Information Administration (EIA), and the World Bank will be used to obtain statistics on flare gas volumes, oil production, and CO₂ emissions from different regions and time periods. These reports provide detailed and reliable data on production and emission trends in the oil and gas industry.
2. Public Databases and Archives: Access to national and international databases such as the BP Statistical Review of World Energy, which provides historical and up-to-date data on oil and gas production, as well as flare gas emissions.
3. Company Case Studies: Empirical data from oil and gas companies that have implemented flare gas reduction technology, such as sustainability reports and case studies on the implementation of Flare Gas Recovery (FGR) technology.

Results and Discussion

Based on the results of data processing from 364 gas fields, it was found that the composition of the gas association produced has a fairly good methane (CH₄) content, so that it provides great potential to be used in various flare gas processing projects (Bahadori, 2014). The significant methane content in these fields shows the potential utilization of flare gas into energy, both in the form of electricity and fuel, in accordance with the Flare Gas Recovery (FGR) technology proposed in this study.

Table 1
Gas Content and Gas Calorific Value

| Field | NHV/LHV (dry, real gas) [BTU/SCF] |
|----------------|-----------------------------------|
| Red Field 39 | 1102 |
| Red Field 57 | 1055 |
| Blue Field 5 | 1004 |
| Blue Field 11 | 1437 |
| Blue Field 13 | 1192 |
| Blue Field 41 | 1123 |
| Blue Field 42 | 1115 |
| Green Field 41 | 1473 |
| Black Field 6 | 1158 |
| Black Field 8 | 1305 |
| Black Field 9 | 1253 |
| Black Field 10 | 1213 |
| Black Field 11 | 1184 |
| Black Field 22 | 1007 |
| Black Field 24 | 1011 |

| | |
|-----------------|------|
| Black Field 28 | 1235 |
| Black Field 32 | 1033 |
| Black Field 58 | 2200 |
| Yellow Field 9 | 1281 |
| Yellow Field 23 | 1063 |
| Yellow Field 48 | 1046 |
| Yellow Field 53 | 1089 |
| White Field 15 | 1654 |
| White Field 16 | 1680 |
| White Field 25 | 1013 |
| White Field 33 | 1041 |
| White Field 34 | 1195 |
| White Field 35 | 1106 |

The results of data processing from 364 gas fields in Appendix 1, are presented in Table 1 for several fields that have a calorific value above 1,000 BTU/SCF. In this case, it is interpreted that the higher the calorific value, the higher the potential for electricity capacity produced (Aoun et al., 2024). Therefore, these fields have very good potential to be utilized into electrical energy or fuel. This is also supported by a reference to the gas specifications listed in Table 2.

Table 2
Typical Pipeline Gas Specification (Handbook of Natural Gas Transmission and Processing, 2015)

| Characteristic | Specification |
|--|---------------------------------------|
| Water content | 4-7 lbm H ₂ O/MMscf of gas |
| Hydrogen sulfide content | 0.25-1.0 grain/100 scf |
| Gross heating value | 950-1200 Btu/scf |
| Hydrocarbon dewpoint | 14-40 F at specified pressure |
| Mercaptans content | 0.25-1.0 grain/100 scf |
| Total sulfur content | 0.5-20 grain/100 scf |
| Carbon dioxide content | 2-4 mol% |
| Oxygen content | 0.01 mol% (max) |
| Nitrogen content | 4-5 mol% |
| Total inerts content (N ₂ + CO ₂) | 4-5 mol% |
| Sand, dust, gums, and free liquid | None |
| Typical delivery temperature | Ambient |
| Typical delivery pressure | 400-1200 psig |

However, in addition to the high methane content, some fields also show the presence of impurities in the form of acid gases such as carbon dioxide (CO₂) and

hydrogen sulfide (H₂S). This impurity content requires an additional purification process before the gas can be utilized optimally. This purification process is important to increase the efficiency of *zero flaring* technology to be applied and minimize the environmental impact of toxic gas emissions.

In Table 3, it is found that the composition of the resulting gas association has a high content of impurities and impurities. Among them are H₂S Gas, CO₂, and Moisture. With the content of impurity gases and water, the flare gas that will enter the FGR technology must be processed first to separate H₂S, CO₂, and Moisture gases.

Table 3
Gas Content of H₂S, CO₂, and Moisture

| Field | Carbon Dioxide [% (mole)] | H ₂ S content [ppm] | Moisture Content [Lbs/MMSCF] |
|-----------------|---------------------------|--------------------------------|------------------------------|
| Red Field 4 | 70,69 | 1100 | 15 |
| Red Field 7 | 65,45 | 250 | 15 |
| Red Field 8 | 59,25 | 50 | 15 |
| Red Field 59 | 62,26 | 290 | 15 |
| Red Field 60 | 76,37 | 250 | 15 |
| Blue Field 1 | 52,63 | 1 | 15 |
| Blue Field 2 | 53,79 | 130 | 15 |
| Blue Field 3 | 52,53 | 100 | 15 |
| Blue Field 38 | 71,8 | 25 | 15 |
| Green Field 26 | 55,61 | 25 | 15 |
| Black Field 12 | 79,67 | 14 | 15 |
| Black Field 14 | 61,59 | 100 | 15 |
| Black Field 15 | 73,67 | 100 | 15 |
| Black Field 18 | 67,82 | 50 | 15 |
| Black Field 19 | 58,57 | 50 | 15 |
| Black Field 20 | 66,94 | 2000 | 15 |
| Black Field 21 | 71,57 | 320 | 15 |
| Black Field 26 | 53,99 | 400 | 15 |
| Black Field 27 | 60,53 | 60 | 15 |
| Black Field 29 | 80,91 | 140 | 15 |
| Yellow Field 48 | 64,84 | 100 | 15 |
| Yellow Field 52 | 94,2 | 200 | 15 |
| White Field 14 | 56,34 | 300 | 15 |
| White Field 15 | 58,84 | 100 | 15 |
| White Field 21 | 54,61 | 150 | 15 |
| White Field 30 | 74,55 | 110 | 15 |
| White Field 31 | 65,21 | 600 | 15 |
| White Field 38 | 79,31 | 75 | 15 |
| White Field 39 | 79,07 | 150 | 15 |

| | | | |
|----------------|-------|-----|----|
| White Field 40 | 65,1 | 125 | 15 |
| White Field 41 | 61 | 195 | 15 |
| White Field 42 | 54,08 | 30 | 15 |
| White Field 43 | 63,95 | 520 | 15 |
| White Field 44 | 61,32 | 600 | 15 |
| White Field 52 | 57,51 | 7 | 15 |
| White Field 55 | 62,45 | 100 | 15 |
| White Field 56 | 61,96 | 100 | 15 |

The removal of H₂S from flare gases through the purification process also offers additional benefits, namely producing sulfur as an economically valuable by-product and can be used as a feedstock in the chemical industry (Kohl & Nielsen, 1997). This step not only reduces contaminants that lower the calorific value, but also creates additional revenue potential from by-products. On the other hand, the use of *Carbon Capture, Utilization, and Storage (CCUS)* technology to manage CO₂ separate from the gas stream can support efforts to reduce carbon emissions, while maintaining the purity of methane needed to achieve high generation efficiency.

Thus, the use of purification technology in the processing of flare gas not only allows for increased value, but also strengthens the sustainability aspect from an environmental and economic perspective. The utilization of previously wasted flare gas, through an increase in the calorific value generated from refining, shows that *Flare Gas Recovery technology* can be optimized as an effective step in supporting energy efficiency and emission reduction in the upstream oil and gas industry.

In addition, the calorific value of the gas produced from each field varies, indicating the potential for different energies from one field to another that will merge into multiple gathering *stations*. This difference in calorific value will be an important consideration in determining the most suitable type of project and technology to implement at each collection station.

With the gas association profiles identified, this chapter will continue the discussion related to project and development options that can support the implementation of *zero flaring technology*. This evaluation was carried out to maximize the energy potential of flare gas and reduce emissions, in line with the goal of reducing flaring in the upstream oil and gas industry.

Interview Results

Interviews conducted with 3 (three) expert resource persons provided diverse insights related to the processing operations of gas associations that are currently still burned in flares. Although each resource person has a different approach in technical and strategic views, they all have the same goal, which is to minimize flare gas emissions through the application of zero flaring technology. This diverse approach reflects the

complexity and challenges of selecting the most suitable project alternatives to be implemented in existing gas fields.

One of the speakers emphasized the reliability of the current operation, where the use of flares is considered an efficient solution in the short term to deal with excess gas. However, he also acknowledged that long-term sustainability requires investment in more environmentally friendly and economical technologies. Other speakers highlighted the need to improve infrastructure and develop highly competent human resources to manage new technologies such as Flare Gas Recovery (FGR). Meanwhile, the third speaker focused on the regulatory aspects and policy support needed to encourage the implementation of zero flaring technology, especially in facing economic and technical challenges.

Although each speaker provided a different point of view, they agreed that each planned alternative project has its own strengths and weaknesses. The reliability of current operations must be carefully considered in determining the right solution, both in terms of the technology to be used and in planning for the future of flare gas management. The results of this interview provide an overview that the selection of project alternatives must consider not only technical reliability, but also alignment with the long-term vision in supporting emission reduction through zero flaring.

Alternative Analysis of Zero Flaring Technology Selection

In this evaluation, an alternative approach and selection are used that are generally carried out in each oil and gas project at the pre-FEED (*Preliminary Front End Engineering Design*) stage. This approach aims to identify and select the most suitable technology based on technical, economic, and environmental criteria. The pre-FEED stage is an important step in determining the overall feasibility of the project before proceeding to further studies and the detailed design and implementation stages.

Table 4
Alternatives and Selection of Zero Flaring Technology

| Criterion | FGR to Electricity | FGR to Fuel (LNG/CNG) | FGR Reinjection | FGR to LPG |
|--------------------------------|--|--|---|--|
| Operational Reliability | High, stable for internal energy requirements | Medium, requires distribution infrastructure | Moderate, maintaining reservoir pressure | Moderate, requires additional purification |
| Cost | High, large initial investment but potentially quick payback | High, transportation and storage costs | Medium, the initial investment is high, and the operational | Meanwhile, the processing process is |

| | | | | |
|-------------------------------------|---|--|--|---|
| | | | costs are also high | more expensive |
| Regulatory Aspects | Support, in accordance with zero flaring policy | Supports, but requires distribution permission | Supporting, part of energy conservation programs | Support, depending on the LPG market |
| Complexity of Technology | Medium, requires turbine and generator technology, but implementation is quite common in the industry | High, requires gas liquefaction facilities | Medium, existing gas injection technology | Meanwhile, the gas separation process is more complicated |
| Potential Emission Reduction | Very high, eliminates gas flares completely | High, reducing emissions from gas combustion | Meanwhile, gas remains stored in the reservoir | High, gas converted to LPG |
| Implementation Time | Medium, requires the construction of new facilities, but can be integrated with existing operations | Long, requires the development of LNG/CNG infrastructure | Medium, small additional infrastructure | Medium, requires additional facilities |
| Economic Benefits | High, energy can be sold or used | High, large fuel market potential | Maintaining oil and gas production | High, LPG has economic value |

Based on the evaluation carried out, the technology for utilizing flare gas into electrical energy was chosen as the best alternative to be applied in gas processing in the fields studied. The use of gas into electrical energy was chosen because this technology was considered the most suitable for the gas association conditions produced from the 364 fields analyzed. In addition, this technology offers advantages in terms of operational reliability, potential energy savings, as well as a significant contribution to the reduction of flare gas emissions, in line with the goal of zero flaring.

AHP Analysis

In the AHP (Analytical Hierarchy Process) method, each alternative is assessed based on several key criteria, such as operational reliability, cost, regulation, complexity, potential emission reduction, and economic benefits. Each criterion is weighted based on its level of importance, then a pairwise comparison assessment is carried out to determine technology priorities. Here are the weights and results of the AHP analysis:

Table 5
AHP Zero Flaring Technology

| Criterion | Weight | FGR to Electricity | FGR to Fuel (LNG/CNG) | FGR to Reinjection | FGR to LPG |
|------------------------------|--------|--------------------|-----------------------|--------------------|------------|
| Operational Reliability | 0.30 | 0.90 | 0.75 | 0.80 | 0.70 |
| Cost | 0.25 | 0.70 | 0.60 | 0.65 | 0.60 |
| Regulation | 0.20 | 0.85 | 0.80 | 0.70 | 0.75 |
| Complexity of Technology | 0.10 | 0.75 | 0.65 | 0.70 | 0.60 |
| Potential Emission Reduction | 0.10 | 0.95 | 0.85 | 0.65 | 0.80 |
| Economic Benefits | 0.05 | 0.90 | 0.80 | 0.70 | 0.85 |
| Relative Weight | | 0.835 | 0.735 | 0.715 | 0.720 |

FGR to Electricity (0.835) has the highest relative weight because it scores higher in critical aspects such as operational reliability, potential emission reductions, and economic benefits, although the initial cost and complexity are quite high. FGR to Fuel (LNG/CNG) (0.735) is in second place, because its economic potential is high, but the cost and complexity are greater. FGR to LPG (0.720) scored third with an advantage in the LPG market and emission reduction, but its complexity and processing costs were factors in the relative weight reduction. FGR Reinjection (0.715) is ranked last because

although it maintains reservoir pressure, this technology has limitations in emission reduction and economic benefits compared to other options.

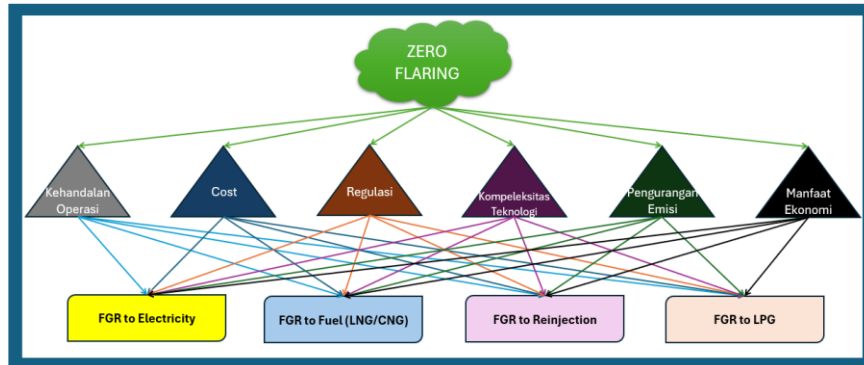


Figure 1
AHP Analysis Hierarchy Diagram

In Figure 1, the AHP Analysis hierarchy diagram shows the structure, criteria, and alternative selection of technologies for beacon gas treatment. This diagram presents three levels: the main objectives, the main criteria, and the technological alternatives, which provide an overview of the relationships between the elements used in the decision-making process.

Based on the results of AHP analysis, *FGR to Electricity* has the highest relative weight, which makes it the best alternative to implement. This technology not only supports *zero flaring* policies, but also has the most significant economic benefits and emission reduction potential.

Financial Analysis

In this section, a financial analysis is carried out to evaluate the feasibility of the project of utilizing flare gas into electrical energy through the calculation of three main parameters: Net Present Value (NPV), Internal Rate of Return (IRR), Benefit-Cost Ratio (BCR), payback period (PBP), Life cycle cost analysis (LCC), and Cost of Energy. These six parameters are used to assess whether the investment in the project can provide a decent return, as well as to determine the level of profitability of the project in the long term.

Net Present Value (NPV)

The NPV calculation is done to find out whether the project provides positive added value after taking into account the cash flow generated over the life of the project and subtracting it from the initial investment.

In this analysis, it is assumed that the value of the initial investment project is Rp 350 billion with a power generation capacity of 10 megawatts. This project is planned to operate for 20 years with an electricity price of Rp 1,300 per kWh. The discount rate used

is 20%, while operational and maintenance (*O&M*) costs are estimated at 10% of the total annual revenue generated from electricity sales.

$$NPV = C_0 + \sum_{t=1}^n \frac{C_t}{(1+r)^t}$$

Where:

C_0 : initial investment (Rp. 100 billion)

C_t : annual operating expenses (Rp. 81.9 billion)

R : Discount rate (20% or 0.2)

N : Project lifespan (20 years)

Assumptions (base)

Project Value (Initial Investment): IDR 100 Billion

Electricity Generated Capacity: 10 Megawatts (MW)

Electricity Price: Rp 1,300 per kWh

Discount Rate: 20%

Project Lifespan: 20 years

Number of Operating Hours per Year: 7,000 hours (operational assumptions per year)

Operating and Maintenance (O&M) Expenses: 10% of revenue per year

Annual Revenue:

Annual Electricity Production: 10 MW \times 7,000 hours = 70,000 MWh

Revenue per Year: 70,000 MWh \times Rp 1,300/kWh = Rp 91 Billion per year

Operating Expenses (O&M): 10% \times Rp 91 Billion = Rp 9.1 Billion per annum

Annual Net Cash Flow: Revenue – O&M Expenses = IDR 91 Billion – IDR 9.1 Billion = IDR 81.9 Billion

The NPV calculation shows a positive value, which indicates that the cash flow of this project can cover the entire investment cost and generate added value for the company in the long run. In addition, the IRR rate obtained is higher than the discount rate used, indicating that the project will provide an attractive rate of return for stakeholders. A BCR

greater than 1 also shows that the financial benefits of the project outweigh the costs. A PBP of 4.27 years indicates a very short payback time. The PBP indicates that the initial investment will return in about one year and three months, which indicates the low financial risk of the project and the rapid acquisition of positive cash flow. The LCC of Rp 400.37 billion shows that this project is not only profitable but also has controlled costs in the long term. The CoE of Rp 285.98 per kWh shows that the energy production cost of this project is very low, far below the average electricity market price. This low CoE signifies that the project is able to generate electricity at a very competitive cost, which can provide large operational cost savings or even generate additional revenue if electricity is sold to the grid.

With the results of this positive economic analysis, gas conversion technology into electrical energy is considered to be able to be implemented efficiently in the gas fields that have been studied. This project not only helps to minimize flare gas emissions through the implementation of zero flaring, but also provides economic benefits that can improve overall operational efficiency. Therefore, from a technical and financial perspective, this technology is considered feasible to be adopted in supporting the sustainability of the upstream oil and gas industry.

Conclusion

The application of Flare Gas Recovery (FGR) to electricity technology is an effective solution to support zero flaring in the upstream oil and gas industry, by converting flare gas into electrical energy that can be used for the company's operational needs. This technology not only significantly reduces carbon emissions, but also creates economic added value through by-products, such as sulfur from H₂S purification that can be utilized in the chemical industry, and carbon sequestration potential through Carbon Capture, Utilization, and Storage (CCUS) technology for CO₂. In addition, FGR to electricity supports operational efficiency by utilizing exhaust gas that was previously wasted. While it requires large initial investments and adjustments to infrastructure and workforce competencies, the technology offers long-term benefits, including energy savings, reduced greenhouse gas emissions, and improved environmental sustainability. Overall, this technology not only supports the company's sustainability initiatives, but also has a positive economic and environmental impact.

Bibliography

- Amanda, Riska, Putri, Safira Arindia, Arifan, Yesi Nabela Mia, Hidayat, Rusdi, & Ikaningtyas, Maharani. (2024). Optimalisasi Proses Operasional dengan Menggabungkan Teknologi IoT dan Big Data: Studi Kasus pada PT Pertamina dalam Industri Minyak dan Gas Operational Process Optimization by Combining IoT and Big Data Technology: A Case Study on PT Pertamina in the Oil. *Economics And Business Management Journal (EBMJ)*, 3(01), 93–102.
- Aoun, Ala Eddine, Pu, Hui, Rasouli, Vamegh, Tomomewo, Olusegun, Khetib, Youcef, & Ameer, Mohamed Cherif Ben. (2024). Enhanced oil recovery through alternating gas Re-injection to reduce gas flaring in the Bakken. *Energy*, 290, 130103.
- Aripin, Aa Iksan, Prabowo, Frans Setya, Haryanto, Ahyo, & Kumara, Shandi Dani. (2023). Kerangka Penilaian Kesiapan Mobile Cloud Computing di Hulu Migas Menggunakan RAMI 4.0. *Teknologi: Jurnal Ilmiah Sistem Informasi*, 13(2), 30–41.
- Bahadori, Alireza. (2014). *Natural gas processing: technology and engineering design*. Gulf Professional Publishing.
- Genc, Mahmut, Genc, Seda, & Goksungur, Yekta. (2017). Exergy analysis of wine production: Red wine production process as a case study. *Applied Thermal Engineering*, 117, 511–521.
- Khalili-Garakani, Amirhossein, Nezhadfar, Mahya, & Iravaninia, Mona. (2022). Enviro-economic investigation of various flare gas recovery and utilization technologies in upstream and downstream of oil and gas industries. *Journal of Cleaner Production*, 346, 131218.
- Manalu, Nerva Juniari, & Setyadi, Muhammad Andri. (2010). Analisa Nilai Guna Teknologi Informasi Dalam Perbaikan Proses Penyediaan Barang Pada PT Xyz. *Seminar Nasional Aplikasi Teknologi Informasi (SNATI)*.
- Mian, Mohammed A. (2011). *Project economics and decision analysis: deterministic models* (Vol. 1). PennWell Books.
- Newnan, Donald G., Eschenbach, Ted G., & Lavelle, Jerome P. (2004). *Engineering economic analysis* (Vol. 1). Oxford University Press.
- Prasetyo, Ahmad Wisnu, & Windarta, Jaka. (2022). Pemanfaatan Teknologi Carbon Capture Storage (CCS) dalam Upaya Mendukung Produksi Energi yang Berkelanjutan. *Jurnal Energi Baru Dan Terbarukan*, 3(3), 231–238.
- Putri, Nabilla Amelia, & Rahmanida, Sri Firial. (2023). Analisis Implementasi Sistem Informasi Akuntansi Sebagai Transformasi Bisnis Pt Pertamina. *Neraca: Jurnal Ekonomi, Manajemen Dan Akuntansi*, 1(5), 142–150.

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Soesanto, Edy, Angelicleatemia, Angelicleatemia, & Julia, Nona. (2024). Implementasi Berbasis Undang–Undang 1945 Sebagai Transformasi Teknologi dalam Meningkatkan Strategi Perdagangan dan Pemasaran Industri Migas Yang Bersifat Dinamis. *Jurnal Bisnis Inovatif Dan Digital*, 1(3), 1–15.

Winarto, Wahid Wachyu Adi. (2021). Analisis Review Penggunaan Sistem Informasi pada PT Pertamina. *BIOS: Jurnal Teknologi Informasi Dan Rekayasa Komputer*, 2(2), 51–59.