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Economic Analysis of the Comparative Advantage of Retrofitting a Gas Assist Flare to an Air-Assist Flare for Smokeless Flare

[1]Omoluwabi-O. Okeoghene Faith, [2]Okologume, Wilfred Chinedu

[1,2]*Department of Petroleum Engineering, Federal University of Petroleum Resources, Effurun, Nigeria*

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ABSTRACT

This research delves into exploring alternatives which have comparative economic advantage to un-automated gas-assist flare systems, whilst eliminating or mitigating the adverse consequence of the use of high-pressure gas for enhancing smokeless flaring and to optimize flare systems. According to the Ringelmann theory, unabated smoky flares based on stipulated timeliness should be recorded as flare incidents. It is this undesirability of Oil/Gas facilities to generate smoky flares that has endeared them to providing the most available flare assist systems in their facility. A gas processing facility in Sub-Sahara Africa was considered and the data obtained shows that the facility supports its flare towards smokeless flaring with useful hydrocarbon gas of about 10,120 tons per year. This accounts for about 10% of the total amount of gas flared for this region. This amount of gas can produce over 2000 Megawatt-hour electricity. With an average power consumption of 1000kwh per household, this can sufficiently power about 2000 households which is about what the Ugbomro community in Uvwie Local Government of Delta State-Nigeria holds. Considering the current era where Oil/Gas organizations are aligning to the global energy transition journey, it has become increasingly necessary to cut down on gas emission. Introducing the option of debottlenecking the gas assist flare with air assist flare would not only stop the facility from flaring an additional 10,120 tons of gas yearly, and make this gas useful for power generation, it will also reduce the carbon footprint of this site by about 10%. While achieving these, it will still be very adaptable to solve the problem of smoky flares with a more improved technical efficiency. The estimated total fixed cost of debottlenecking the existing gas assist flare to air assist flare is about 800,000 USD and an estimated 400,000 USD for operational cost. By this debottlenecking, using the Henry Hub Model for gas pricing, this facility will make cost saving of about 1,380,800 USD per year and this value will increase YoY as the facility expands in gas processing towards their nameplate capacity. This indicates a payback period of 1-2 years. Coupled with a reduced gas emission leading to an enhanced Net Zero Emission journey, every Oil/Gas business running the gas assist flare should do this retrofitting and endeavor to unlock this value.

Keywords: smokeless flaring, air assist flaring, gas emission, power generation, retrofitting

I. INTRODUCTION

Gas flaring is an intentional act of safely burning process gas for which no immediate use is available (Orji, 2014). Flaring has significant economic impacts and contributes to air pollution and greenhouse gas emissions, impacting both climate change and air quality (Gobo, Richard, & Ubong, 2009). For instance, smoke, a very significant and visible effect of flaring, has health implications.

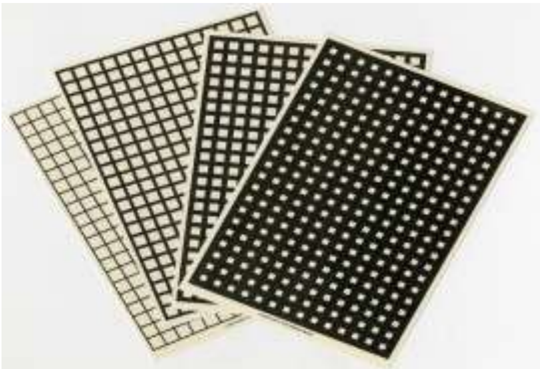

Figure 1: Ringelmann Chart

The Ringlemann scale is used to assess the degree of smokiness of flares by measuring the apparent density or opacity of smoke (Ringleman Smoke Chart, n.d.). With 5 levels of density represented by a grid of black lines on a white surface, one can evaluate with the Ringleman shade the smoke density, ranging from Shade 1 to Shade 5. According to the Centre for Disease Control, United States (Ringleman Smoke Chart, n.d.), the Ringelmann Smoke Chart fulfils an important need in smoke abatement work and in certain problems in the combustion of fuels. The Ringelmann Smoke Chart, which gives shades of grey by which the density of columns of smoke rising from stacks may be compared, was developed by Professor Maximilian Ringelmann in Paris.

To prevent flare incidents occasioned by long duration smokiness, some Hydrocarbon Processing and Production sites use hydrocarbon gas to support the burning of the flared gas This Hydrocarbon gas, called assist gas, adds significantly to the amount of hydrocarbon flared. Hitherto, many gas-rich sites do not see this as a concern. It has become increasingly important to cut down on gas flaring owing to the global call for Net Zero Emission. Hence, this study did not just delve into proposing an alternative to this, but also did a dive into the economic evaluation of retrofitting existing gas assist flare to the alternative, air assist flare system.

II. METHODOLGY

This research set out to assess the economic feasibility of using an air-assisted flare system to reduce air pollutant emissions, specifically smoke, from industrial operations by retrofitting a gas-assisted flare to an air-assisted flare. Economic analysis is the adopted methodology. It involves data gathering and analysis and subjecting the data to detailed evaluation using the various economic indicators for deciding the feasibility of projects or investment in an Oil/Gas facility.

2.1 Data Collection and Analysis.

Data for this study was gathered from a gas facility operating in the sub-sahara region of Africa. The site has been instrumental in gas commercialization in the region, and it has contributed enormously to reduction in gas flaring in this region since the late 90’s when it started operation.

Table 2.1 Amount of assist gas (tons) flared by the site from January 2020 to August 2024.

Date	Assist gas (tons)	Date	Assist gas (tons)	Date	Assist gas(tons)	Date	Assist gas(tons)	Date - 2020	Assist gas(tons)
Jan-24	1,150	Jan-23	1,050	Jan-22	1036	Jan-21	1,012	January	821
Feb-24	432	Feb-23	679	Feb-22	642	Feb-21	853	February	538
Mar-24	957	Mar-23	522	Mar-22	300	Mar-21	1004	March	697
Apr-24	725	Apr-23	479	Apr-22	706	Apr-21	885	April	649
May-24	990	May-23	403	May-22	372	May-21	582	May	859
Jun-24	567	Jun-23	352	Jun-22	227	Jun-21	967	June	1,129
Jul-24	835	Jul-23	1,408	Jul-22	643	Jul-21	856	July	520
Aug-24	2,670	Aug-23	2,063	Aug-22	3,803	Aug-21	848	August	682
		Sep-23	787	Sep-22	1,200	Sep-21	791	September	856
		Oct-23	557	Oct-22	872	Oct-21	1,271	October	1,724
		Nov-23	694	Nov-22	586	Nov-21	1,244	November	1,070
		Dec-23	506	Dec-22	813	Dec-21	809	December	906
	8326	CUM.	9500	CUM.	11,200	CUM.	11,122	CUM.	10,451

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A basic analysis of the data derived from the site revealed that for about 5 years (2020 to 2024 YTD), the percentage contribution of assist gas to the total flared gas has averaged 9.94%. This is equal to about 50,600 tons of assist gas flared between January 2020 and August 2024.

Table 2.2 Percentage contribution of assist gas to the total flared gas from 2020 to 2024 YTD (August 2024).

YEAR	Total Flare (tons)	Assist Gas (tons)	% Contribution of assist gas to total flared gas
2020	111,191	10452	9.4
2021	124,966	11122	8.9
2022	97,391	11200	10.1
2023	82,608	9500	11.5
2024 YTD (AUG 2024)	84,959	8,326	9.8
TOTAL	539,105	50,600	AVG: 9.94%

If we use the Henry Hub Model for Gas Pricing, 1MMBTU is currently priced at 2.58 USD. For about 5 years, 50,600 tons of natural gas was flared due to it being used as assist gas. This gives 2,681,800 MMBTU of gas. This amounts to 6,919,044USD. The naira value of this at an exchange rate of 1600 naira per USD, is #11.1 billion naira. This cost due to the avoidable use of assist gas is the value lost.

Table 2.3 A typical week collation of contribution of the different sources to total flared gas for this site.

SOURCES	% CONTRIBUTION	AMOUNT (TONS)
Assist Gas	28.2	5.15
Start-up	0	0
Flash Gas	0	0
Process plant	7.45	1.3
Boil Off Gas	0	0
Others (Fugitive)	64.3	11.5

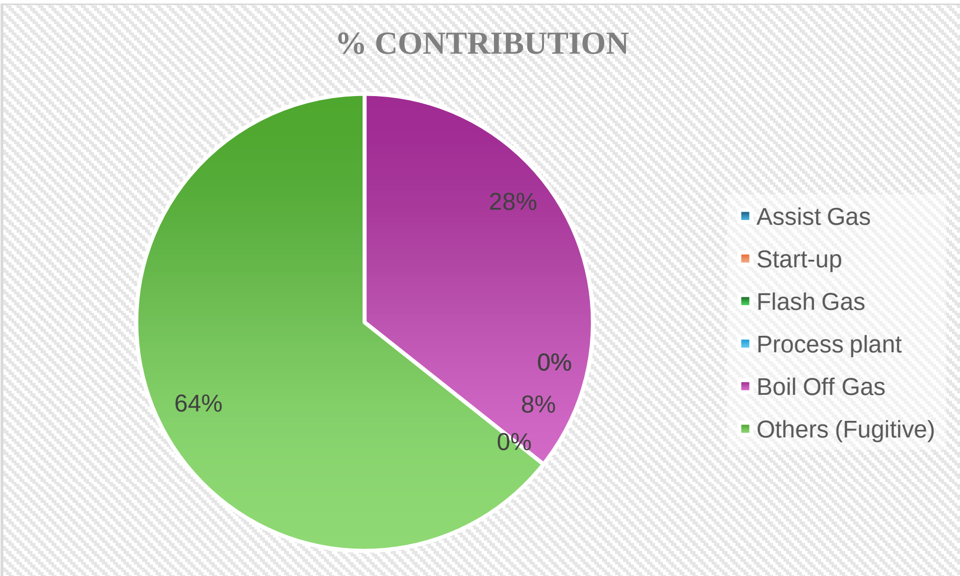

Figure 2.1 Total amount of Gas flared

The above fundamental data analysis reveal that assist gas contributes very significantly to the total amount of gas flared for this site. It is second to the normally operational source of flare. For this week under consideration, it contributes over one quarter of the total flare.

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2.2 COST OF THE RETROFITTING PROJECT

2.2.1 Fixed Cost

Table 2.4 The overall capital cost breakdown of the project.

S/N	Items	Cost ($)
1.	Air-assisted flare tip	300,000
2.	High-pressure air supply system and its auxiliaries	295,000
3.	Site Preparation and Labor	25,000
4.	Engineering and Design	100,000
6.	Miscellaneous	85,000
	Total	800,000

The overall initial investment cost for the flare system retrofit is estimated at $800,000.

2.2.2 Operational Costs for the first year.

Table 2.5 Operational cost

S/N	Items	Cost ($)
1.	Maintenance	150,000
2.	Energy	75,000
3	Labour	175,,000
	Total	400,000

The operational cost for the flare system retrofit is estimated at $400,000. Total Cost = 1.2M USD

2.3 Economic Evaluation

After gathering and analysing the data, it was subjected to sufficient economic evaluation using the following tools;

i. Net Preset Value (NPV)
ii. Internal Rate of Returns (IRR)
iii. Payback Period (PP)
iv. Discounted Payback Period (DPP)
v. Profitability Index (PI)
vi. Savings to Investment Ratio (SIR)
vii. Return On Investment (ROI)

III. RESULTS AND DISCUSSIONS

3.1 The Assist Gas Flaring Volume of the Gas Facility

The records show that this site flared assist gas of about 50,600 tons of gas for 5 years. This gives an average of 10,120 tons of gas per year. If we use the Henry Hub Model for Gas Pricing, 1MMBTU is currently priced at 2.58 USD. 10,120 tons of gas will give 536,360 MMBTU of gas. This amounts to 1,383,808 USD worth of assist gas flared per annum.The naira value of this at an exchange rate of 1600 naira per USD, is #2.2 billion naira. Therefore, cashflow at time t= savings from using the hydrocarbon gas for other energy case = $2.58 × 536,360 mmbtu = $1.38 million.

3.2 Economic Evaluations

3.2.1. Net Present Value (NPV)

Table 3.1 Net present value for ten years period.

Year	NPV ($)	Cumulative NPV ($)
1	855,485	855,485
2	743,900	1,599,385
3	646,869	2,246,255
4	562,495	2,809.750
5	489,126	3,297,877
6	425,327	3,723,204
7	369,849	4,093,054
8	321,608	4,414,662
9	279,659	4,694,322
10	243,182	4,937,504

The NPV is approximately$4,937,504 indicating that investment is expected to generate $4,937,504 in value above the cost of the initial investment over the 10-year period, assuming there is no ongoing cost. This is for a rate of 15%.

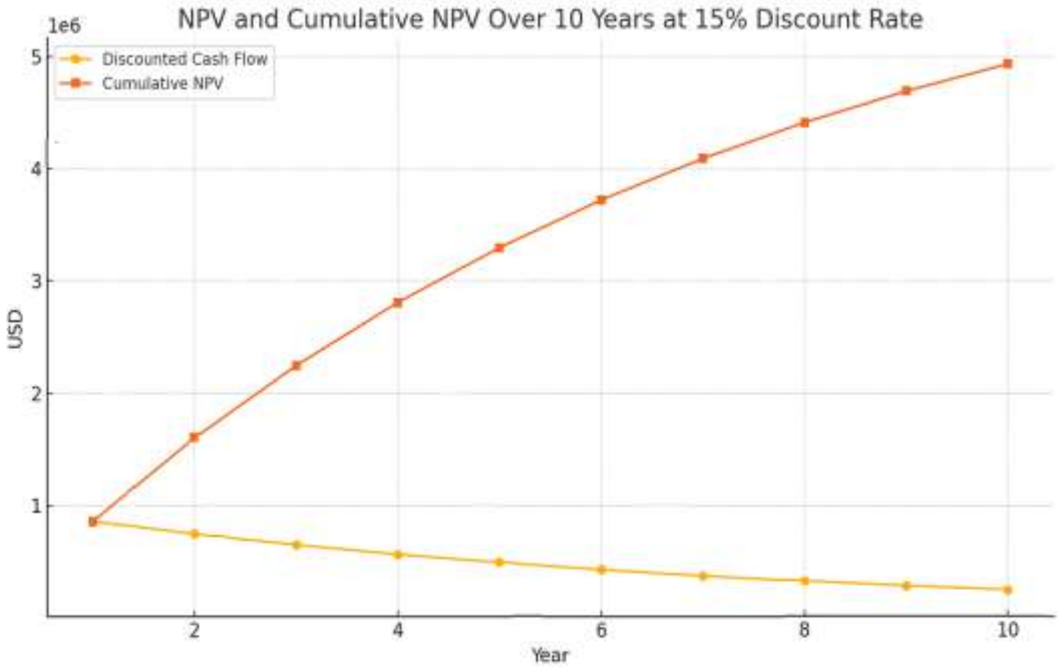

Figure 3.1 NPV and Cumulative NPV over 10 years at 15 % discount rate

i. Using Rate of 5% for 10 years, the NPV is 6.4M USD
ii. Using Rate of 10% for 10 years, the NPV is 4.8M USD
iii. Using Rate of 20% for 10 years, the NPV is 2.9M USD
iv. Using Rate of 25% for 10years, the NPV is 2.3M USD
v. Using Rate of 30% for 10years, the NPV is 1.8M USD

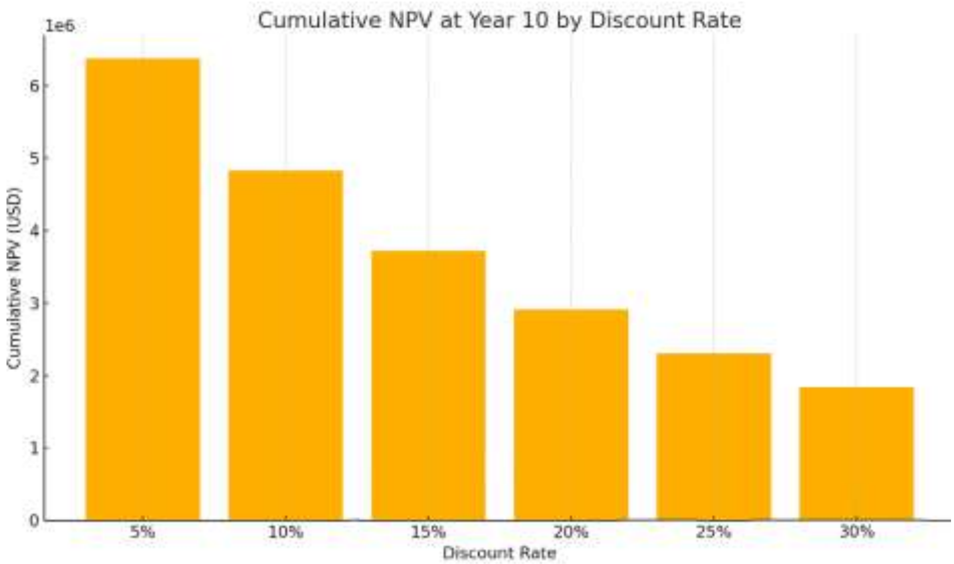

Figure 3.2 Cumulative NPV over 10 years by discount rate

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Figure 3.3 NPV vsDiscount Rate

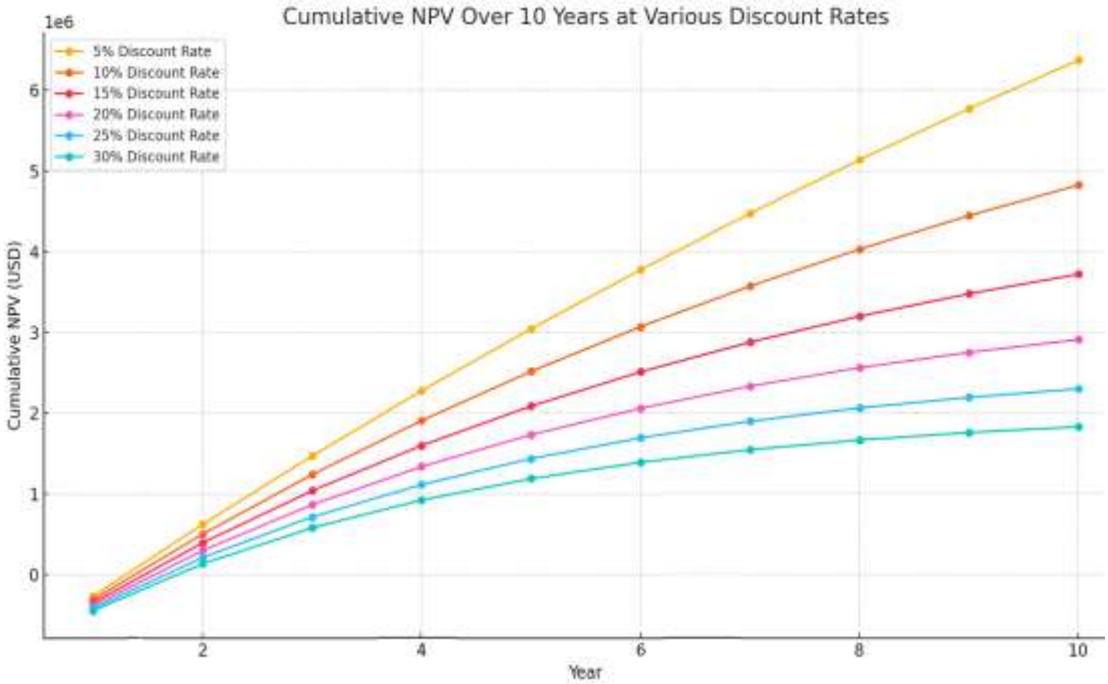

Figure 3.4Cumulative NPV over 10 years at various discount rate

3.2.2. Payback Period

Mathematical Model:= $\frac{\text{Initial Investment}}{\text{Annual Net Cash Flow}}$

Payback Period = $\frac{1200000}{980,808}$ =1.2years.

The payback period is about 1 year and 3 months.

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3.2.3 Internal Rate of Return

Table 3.3Cash flow vs IRR

Year	Cash Flow(M USD) -1200000	IRR
1	980,800	
2	980,800	IRR = 40.08%
3	980,800	
4	980,800	
5	980,800	
6	980,800	
7	980,800	
8	980,800	
9	980,800	
10	980,800	
		IRR at 10years is 81.5%

Running the iteration on excel shows that the NPV will cumulate at zero between the 1st year and the 2nd year and at the end of the 2nd year, the IRR is 40%.

3.2.3 Discounted Payback Period (DPP)

$$\sum_{t=}^{t} 1 \frac{R_t}{(1+r)^t}$$

Where R_t= $1,200,00, r = 15% or 0.15, t = 5 years
Calculating the discounted cash flows for each year and accumulates them until they equal or exceed the initial investment.

Table 3.2 Discounted payback period

Year	$
1	852,869
2	1,594,495
3	2,239,387
4	2,800,162
5	3,287,793

The total discounted cash flow in year is $1,594,495, exceeding the sum of the initial investment and operating cost. This indicates a very quick recovery, even after accounting for the time value of money using a 15% discount rate.

3.2.4 Profitability Index (PI)

$$PI = \frac{\text{Present Value of Future Cash Flows}}{\text{Initial Investment}}$$

$$PI = \frac{4,937,504}{1,200,00}$$

PI = $4.11

The Profitability Index is approximately **$4.11**, indicating that the present value of future cash flows is more than the initial investment since the PI is above 1, making the project **highly profitable** under these assumptions.

3.2.4 Savings to Investment Ratio (SIR)

SIR is calculated using the following formula:

$$SIR = \frac{\text{Present Value of Savings}}{\text{Initial Investment}}$$

$$SIR = \frac{4,937,504}{1,200,00} = 4.11$$

SIR is approximately **4.11**. This indicates that the savings (or benefits) generated by the project exceeds the initial investment, suggesting that the project **financially viable** under the given assumption.

3.2.5 Return on Investment (ROI)

The ROI is calculated by comparing the net benefits to the total cost using the formula

$$\text{ROI Formula} = \frac{\text{Net Profit}}{\text{Total Costs}} \times 100$$

Therefore, Net Profit = Present Value of Future Cash Flows- Initial Investment

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Net Profit = 4,937,504– 1,200,000 = 4,478,120

$$ROI=\frac{4.478,120}{1,200,000}\times 100$$

ROI = 311%

The Return on Investment (ROI) is approximately 311%. This imply that the project is expected to result in a profit of about 311% of the initial investment over 10 years, making it very financially **attractive** under the given assumptions.

3.3 SUMMARY

The chapter outlines the economic analysis of retrofitting a gas-assist flare to an air-assist flare system to eliminate the use of hydrocarbon gas in flaring. The analysis applies economic indicators like Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period, and Profitability Index (PI) to assess the viability of the project. Whereof the following key findings were made:

1. Using flared hydrocarbon gas for other energy purposes would result in significant savings. For example, 10,120 tonnes of gas saved annually translates to $1,383,808 in cash flow at current market prices.
2. With a 15% discount rate over 10 years, the NPV is calculated to be approximately $3.18 million, indicating substantial financial benefit over the project's lifespan.
3. The project is expected to generate a high IRR of 81.7%, suggesting excellent returns compared to the capital investment.
4. The payback period is approximately 1.2 years (about 1 year and 3months), indicating a very quick recovery of the initial investment.
5. A PI of 4.11 indicates that the present value of future cash flows significantly exceeds the initial investment, making the project highly profitable.
6. The ROI is calculated at 311%, demonstrating exceptional financial returns over the 10-year period.

In conclusion, the retrofitting project is financially viable with high profitability and quick payback, driven by savings from utilising hydrocarbon gas for energy and reducing gas flaring.

IV. CONCLUSION

This study has shown that air assisted flare can improve combustion and contribute significantly to reducing GHG, economic analysis retrofitting an existing gas-assist flare system to an air-assist flare system shows that it is a highly viable and profitable investment with a short-discounted payback period. The significant NPV, IRR, and payback period highlight the financial attractiveness of the project, while the environmental benefits align with Africa's long-term sustainability goals. By implementing recommendations such as investing in renewable energy and engaging in policy advocacy, the project's impact can be further optimized. This initiative serves as a benchmark for future gas flaring reduction projects in Africa and other gas-producing regions globally.

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