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Decarbonizing Nigeria's Oil and Gas Sector

Leveraging Flare Gas Reduction for Climate Action

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Impressum

As a federally owned enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development.

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

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Design/layout, etc.:
flmh – Labor für Politik und Kommunikation GmbH

Publication Date
28 July 2026, Abuja, Nigeria

This study is published by H2-diplo - Decarbonization Diplomacy a programme implemented by Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH on behalf of the Auswartiges Amt (Federal Foreign Office) Germany and is financed by the International Climate Initiative (IKI).
The opinions and recommendations expressed do not necessarily reflect the positions of the commissioning institutions or the implementing agency.

Content

List of Abbreviations

BoD	**Board of Directors**
bopd	**barrels of oil per day**
Bscf	**Billion standard cubic feet**
BTU	**British Thermal Unit**
CAPEX	**Capital Expenditure**
CNG	**Compressed Natural Gas**
CPI	**Consumer Price Index**
DPR	**Department of Petroleum Resources (Pre-PIA Regulator)**
EBITDA	**Earnings Before Interest, Taxes, Depreciation, and Amortization**
E&P	**Exploration and Production**
EPC	**Engineering, Procurement, and Construction**
FGN	**Federal Government of Nigeria**
FID	**Final Investment Decision**
FIRS	**Federal Inland Revenue Service**
FLNG	**Floating Liquefied Natural Gas**
FX	**Foreign Exchange**
GDP	**Gross Domestic Product**
GSA	**Gas Sales Agreement**
GtP	**Gas-to-Power**
HSE	**Health, Safety, and Environment**
HostCom	**Host Communities (Development Trust)**
IFRS	**International Financial Reporting Standards**
IMGP	**Integrated Modular Gas Project**
IOC	**International Oil Company**
IRR	**Internal Rate of Return**
JV	**Joint Venture**
LNG	**Liquefied Natural Gas**
LPG	**Liquefied Petroleum Gas**
MMbo	**Million barrels of oil**
MMscf	**Million standard cubic feet**
MMscfd	**Million standard cubic feet per day**
MoU	**Memorandum of Understanding**
MT	**Metric Tonnes (or Metric Tons)**
NCDMB	**Nigerian Content Development and Monitoring Board**
NDDC	**Niger Delta Development Commission**
NEITI	**Nigeria Extractive Industries Transparency Initiative**
NGFCP	**Nigerian Gas Flare Commercialisation Programme**
NMDPRA	**Nigerian Midstream and Downstream Petroleum Regulatory Authority**

NNPCL	**Nigerian National Petroleum Company Limited**
NPV	**Net Present Value**
NUPRC	**Nigerian Upstream Petroleum Regulatory Commission**
OPEX	**Operating Expenditure**
PAFW	**Payment Assurance Framework**
PIA	**Petroleum Industry Act**
PPA	**Power Purchase Agreement**
PSC	**Production Sharing Contract**
s-LNG	**Small-Scale Liquefied Natural Gas**
Tcf	**Trillion cubic feet**
TIGA	**Third-Party Infrastructure Gas Access**
WACC	**Weighted Average Cost of Capital**

Executive Summary

Nigeria retains Africa's largest proven natural gas reserves of 215.19 TCF as of 1st January 2026 (NUPRC) , yet in 2024 it flared approximately 5.3 billion cubic metres (BCM) (approximately equal to 187.17 BSCF of associated gas), an increase of 12% over the previous year. This volume positioned the country seventh globally in the World Bank's Global Gas Flaring Tracker and represented an annual direct economic loss of about US$1.5 billion, enough gas to generate roughly 3,000 MW of new electricity (equivalent to 25 % of current grid capacity) and enough greenhouse-gas emissions (16 million tonnes of CO_2-equivalent) to consume nearly one-third of Nigeria's unconditional 2030 Nationally Determined Contribution target.

The Petroleum Industry Act of 2021, the relaunched Nigeria Gas Flare Commercialisation Programme (NGFCP), and the Climate Change Act of 2021 have together created the strongest legal, regulatory, and commercial framework Nigeria has ever possessed to end routine flaring. Despite these advances, progress remains constrained by enforcement gaps, midstream bottlenecks, and domestic market distortions. This final report, refreshed with the latest data from the Nigerian Upstream Petroleum Regulatory Commission and the World Bank, delivers a finance-ready and execution-oriented roadmap to convert a multi-billion-dollar liability into one of the highest-return investment opportunities on the continent.

Technical feasibility is no longer the binding constraint. Modular compression, cryogenic natural-gas-liquids recovery, mini-LNG and compressed-natural-gas virtual pipelines, and reciprocating-engine power islands are field-proven technologies that can be deployed in twelve to eighteen months, even on sites producing as little as two to five million standard cubic feet per day.

The study identifies three core de-risking pillars for bankable flare-to-value projects: robust Measurement, Reporting and Verification (MRV), secure and bankable payment structures, and Foreign Exchange (FX)-indexed revenue mechanisms to mitigate currency risk. These pillars are further strengthened by complementary commercial enablers, including carbon credits, Natural Gas Liquids (NGLs), and other value-added gas products, which enhance project returns, resilience, and overall investor confidence.

The updated execution roadmap is structured in three phases. From 2026 to 2028, the priority is foundation and continuous enforcement of certified flow metering on every flare stack, delivery of the first fifteen quick-win NGFCP clusters, and establishment of a National Carbon Registry, targeting a 40 % reduction in flaring intensity by 2028. From 2029 to 2032, the focus shifts to scale: completion of the Ajaokuta–Kaduna–Kano and OB3 pipeline extensions, deployment of more than one hundred modular and virtual-pipeline projects, and introduction of a sectoral carbon budget for oil and gas, capturing over 90 % of current flare volumes. Beyond 2033, the agenda is targeted towards deep decarbonisation: hydrogen-ready pipelines, carbon-capture-and-storage pilots on large reinjection sites, and full Article 6 carbon-market linkage, achieving zero routine flaring and net-zero upstream operations by 2060.

For the immediate 2026 actions, It is recommended that the Nigerian Upstream and Midstream Petroleum Regulatory Authorities validate that all flare site have flare meters installed and where gaps are noticed, mandate certified meters on such flare stacks by the second quarter of 2026 and link them to a live public dashboard. The Ministry of Finance and the Central Bank of Nigeria should extend 100% foreign-exchange retention to carbon-credit and natural-gas-liquids export revenues from flare projects. The Nigerian Content Development and Monitoring Board should fast-track local-content waivers for proven modular packages to reach 50% Nigerian fabrication by 2028, cutting capital expenditure by 15–20%. The NGFCP Secretariat must publish binding delivery milestones for the forty-nine awarded sites and enforce forfeiture for non-performance after twenty-four months.

01 Section One

Rationale and Background

Context Nigeria's Gas and Energy Paradox.

Nigeria is an oil & gas giant, yet it faces very significant energy and power deficits. This is the country's gas paradox. Sitting on Africa's largest proven gas reserves, Nigeria burns off billions of dollars' worth of natural gas as an unwanted byproduct of oil production every year; a practice known as gas flaring.[9] For over six decades, this associated gas was treated as a nuisance (waste) to be disposed of rather than a valuable product. However, with Nigeria's new Energy Transition Plan and policies, this practice is no longer tenable. Transforming this supposed "nuisance" into a catalyst for economic growth and energy security is one of Nigeria's most pressing and promising opportunities.

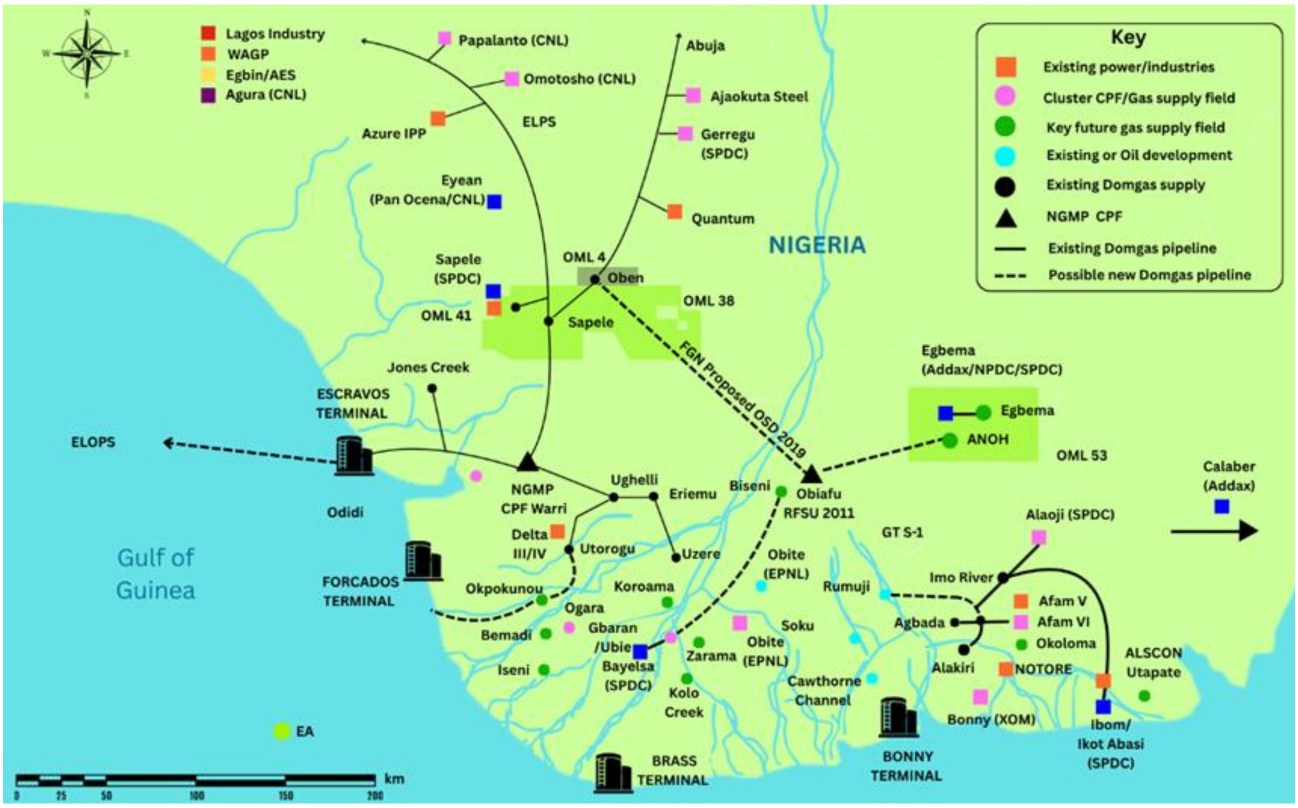

Figure 1. Nigeria's oil & gas infrastructure.

1.2 The Scale of Gas Flaring: Losing on three critical fronts

The sheer scale and frequency of gas flaring inflict triple losses on Nigeria: 1. economic, 2. environmental, and 3. social. Globally, satellite monitoring data from organizations such as the World Bank's Global Gas Flaring Reduction Partnership (GGFR)[8] consistently rank Nigeria among the top gas-flaring nations worldwide. Satellite observations reveal that despite localized reductions, persistent flaring remains a prominent environmental and energy security challenge in the region, placing Nigeria's upstream sector under intense international scrutiny for its carbon intensity.
, the country flared enough gas to represent:

- **A Massive Economic Loss:** An estimated $1.5 billion USD in lost annual revenue, which is more than Nigeria's budgeted amounts for agriculture and rural development and power combined.

- **Wasted Energy Potential:** Enough fuel to generate over 3,000 MW of electricity, which is approximately 25% of Nigeria's typical power generation capacity.

- **Severe Climate Impact:** The release of nearly 16 million tonnes of CO_2 equivalent into the atmosphere directly undermines Nigeria's climate commitments and contributes to global warming.

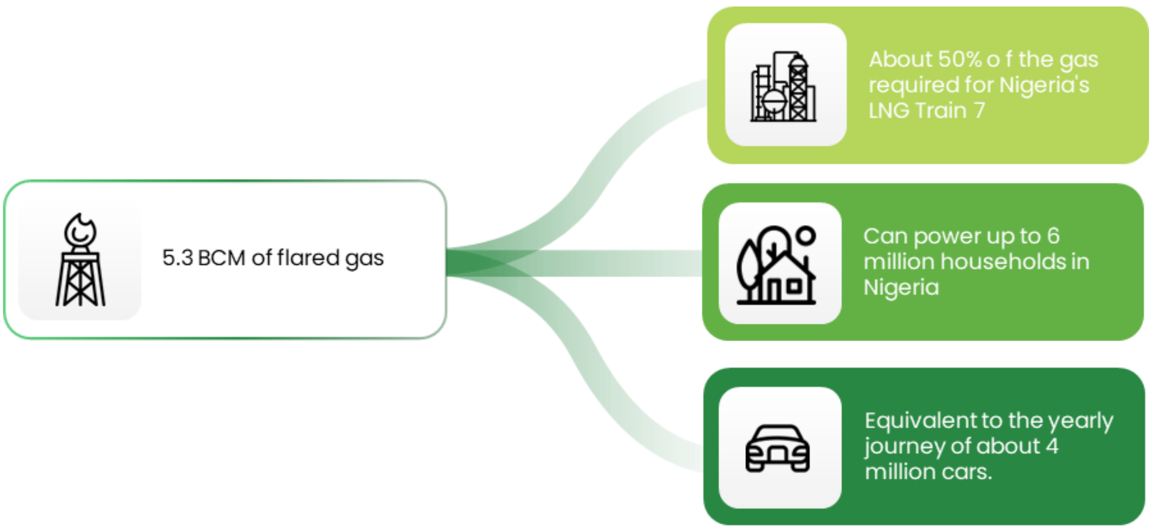

Figure 2. Showing the equivalents of Nigeria's flared gas volumes

At the national level, official metered and regulatory data anchored by assessments from the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and recent empirical sector analyses quantify the severe domestic losses associated with this practice. Current estimates indicate that routine flaring wastes approximately 16 million tonnes of CO_2-equivalent (CO_2e) annually, while squandering billions of cubic feet of gas that could otherwise generate gigawatts of captive power for industrial growth and bridge domestic energy deficits[3]

1.3 Building the Right Policy & Legal Frameworks

Fortunately, Nigeria's policy landscape is catching up to the urgency to decarbonise. To illustrate this, a clear legal and strategic framework now exists to turn this long-standing environmental and economic challenge into a national opportunity.[1] The momentum for change is anchored by three key pillars:

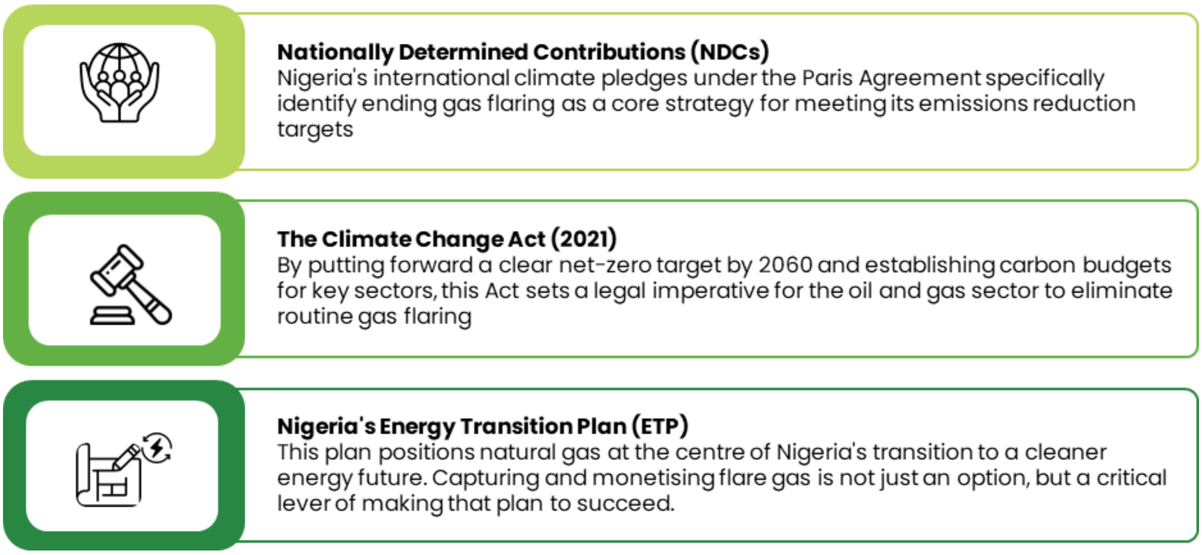

Figure 3. Climate Policy & Legal Frameworks.

1.4 Why Nigeria Must Act Now (The Golden Opportunity)

The case for commercialising flare gas is clear, compelling and self-explanatory. It represents a rare opportunity where economic growth, social advancement, and environmental (climate) action are not competing priorities, but aligned outcomes of a single, decisive strategy. This very unique outcome creates a powerful "win-win-win" imperative that Nigeria has to act on immediately:

1. **Economic Growth:** Unlock billions of dollars in additional revenue streams, thereby driving industrialisation through lowcost and more reliable power, and create thousands of high-value jobs.
2. **Social Advancement:** Drastically improve health outcomes in the Niger Delta by reducing toxic air pollutants and providing millions of households with access to cleaner cooking fuel (LPG).
3. **Environmental (Climate) Action:** Take a giant leap toward achieving Nigeria’s climate goals, cement its role as a leader in Africa's energy transition, and attract international climate finance.

02. Section Two

Objectives of the Study

This study report goes beyond simply diagnosing the problem of gas flaring to putting forward a clear and actionable pathway. It provides a strategic blueprint for government, industry, and investors to transform flared gas from a liability into an asset for Nigeria's economic and climate recovery.

To achieve this, the study will pursue four primary objectives:

Figure 4. Core Objectives of the study.

03 Section Three

Setting the Scene: Nigeria's Oil and Gas Sector and Flare Gas Context

3.1 Breakdown of the Oil and Gas Sector

Nigeria's oil and gas industry is currently seeing a drastic and systemic change, primarily driven by the Petroleum Industry Act (PIA) 2021.[1] The industry, which was historically dominated by Joint Ventures (JVs) between the Nigerian National Petroleum Company Limited (NNPCL) and International Oil Companies (IOCs), is now functionally segmented into Upstream, Midstream, and Downstream operations, each regulated by dedicated agencies; the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA)[1].

Data from the NUPRC shows that the majority of routine associated gas flaring stems from legacy onshore and shallow water JV assets, where gas gathering infrastructure was historically deemed non-commercial from a CapEx standpoint or due to uncertainty in gas pricing regimes.
On the flip side, deep offshore assets, governed by Production Sharing Contracts (PSCs), often have gas reinjection or utilisation as part of the initial Field Development Plan (FDP), leading to comparatively lower flaring intensity. Making this distinction is vital, as it dictates the technical feasibility, regulatory compliance, and economic models applicable to flare gas monetisation projects.

3.2 Natural Gas Reserves and Production Outlook

Nigeria holds one of Africa's largest proven natural gas reserves reported at 215.19 TCF as of 1st January 2026 (NUPRC[4]). This colossal endowment positions gas not merely as a "transition fuel" but as the cornerstone of Nigeria's industrial future. This strategic shift, which has now been concretised in the "Decade of Gas" initiative, aims to rapidly increase proven reserves and rapidly scale up gas commercialisation and utilisation.
[5]

At present, Nigeria's production is hampered by infrastructure deficits, capacity bottlenecks, and the historically fragmented nature of the domestic gas market. That said, the future production outlook is highly dependent on the successful completion of major midstream projects (e.g., the Ajaokuta-Kaduna-Kano (AKK) gas pipeline, OB3 pipeline, etc) and the effectiveness of the new regulatory environment in incentivising deep exploration and non-associated gas (NAG) developments.[16]

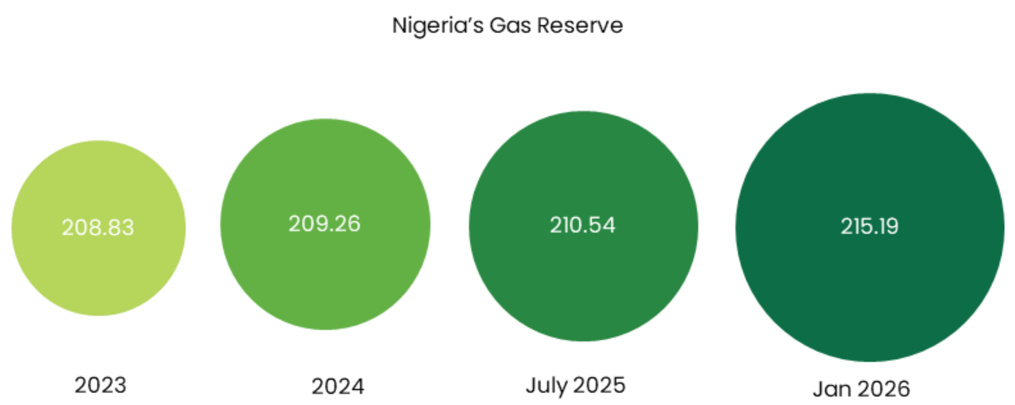

Figure 5. Nigeria's Gas Reserve.

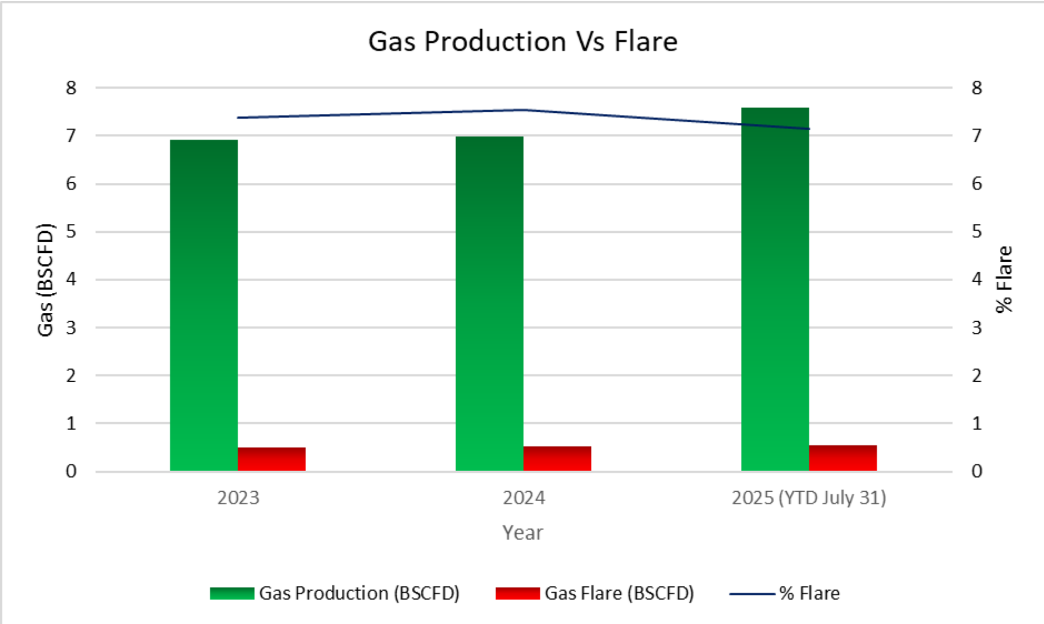

Figure 6. Nigeria's Gas Production vs Flare %.

3.3 Flare Sites: Volumes, Distribution and Historical Trends

Accurate, consistent and real-time measurement at source is always the first step toward effective flaring mitigation. Data from the NUPRC shows that even though flare gas volumes have decreased over the last decade, they remain high compared to other nations, placing Nigeria in the top quartile of high-flaring countries.

3.3.1 Onshore vs. Offshore Distribution

In the Niger Delta, gas flaring is disproportionately concentrated in the older onshore and shallow water assets, where past developments prioritised oil product monetisation with very little obligation for a gas monetisation strategy in the field development plans. This unfortunately means that communities in these areas bear a huge brunt of the environmental and social impacts of these effects. Often, these flare sites exhibit low-pressure and very dispersed flare points requiring smaller, modular recovery solutions. Deep Offshore flares, while fewer, can often involve larger volumes and require more complex technological solutions, such as reinjection or Floating Liquefied Natural Gas (FLNG) concepts.

3.3.2 Historical Trends and Measurement

Looking back over the last few years, the historical trends show a somewhat volatile, but generally downward, trajectory in flaring intensity,[4] largely due to major gas export projects (LNG) absorbing significant associated gas volumes. However, recent data highlights the persistence of smaller, technically challenging flare sites which are remote, scattered across the Niger Delta are not easily abated.

That said, consideration of satellite monitoring to complement the mandatory on-site (source) metering, as required under the Petroleum Industry Act (PIA), is critical for reconciling operator-reported data with independent assessments, thereby improving transparency and enforcement.

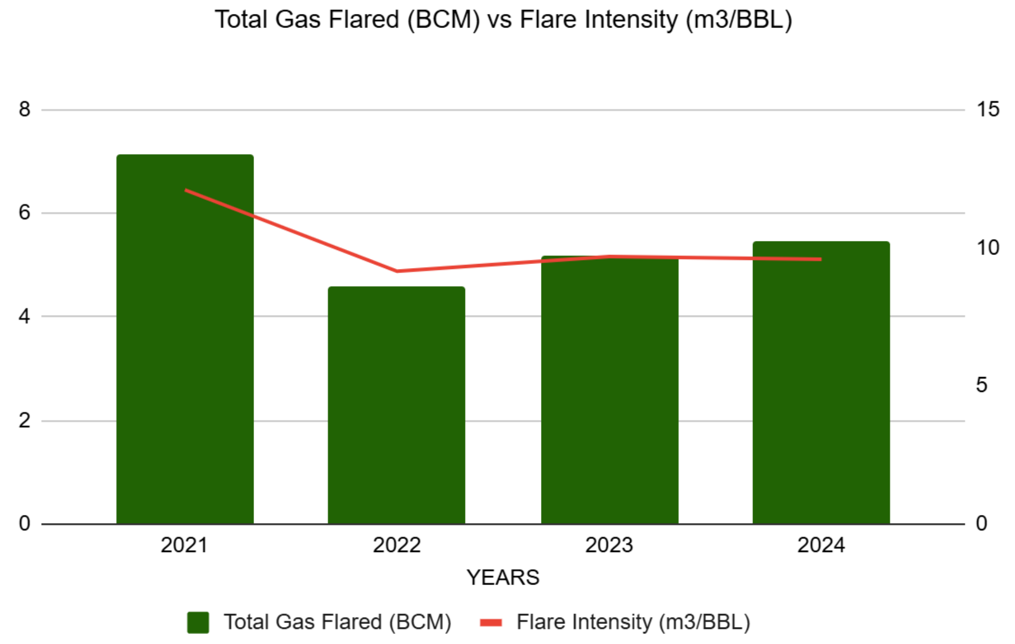

Figure 7. Nigeria's Gas Flared Volume vs Flare Intensity.

3.4 Energy Demand and Role of Gas in Nigeria's Energy Mix

Without a doubt, the primary driver for gas monetisation in Nigeria is the acute power deficit. With a huge amount of installed grid capacity underutilised, and industrial users struggling with high energy costs, flare gas offers a low-cost, domestically sourced feedstock. Gas-to-power remains the fastest pathway to monetisation and is central to improving grid stability and supply reliability.[5] Beyond electricity and power generation, gas is essential for industrial feedstock (fertiliser, petrochemicals) and expanding the availability of Liquefied Petroleum Gas (LPG) to displace biomass and kerosene in domestic and household cooking.

3.5 Ongoing Projects and Initiatives

3.5.1 The Nigerian Gas Flare Commercialisation Programme (NGFCP)

The Nigerian Gas Flare Commercialisation Programme is a core implementation instrument for monetising previously flared gas. First launched in 2016 and relaunched in 2022 under the Petroleum Industry Act framework, with the Nigerian Upstream Petroleum Regulatory Commission as the implementing agency, the programme aims to eliminate routine flaring, convert flare gas into commercially valuable products, reduce emissions, and attract private investment.

Under the programme, the Federal Government grants third-party investors permit to access flare gas through competitive bidding processes. Permit holders develop utilisation projects for power generation, LPG production, industrial gas use and other market applications. The program is designed to ensure bankable projects, where tariffs, gas pricing, technical requirements, and investor protections are structured to support financing and execution.

As of December 2025, 42 companies had been awarded flare sites, with 28 issued Flare Gas Permits and several projects at various development stages. The programme is expected to capture 250–300 MMSCF/D of gas, attract approximately US$2 billion in investment, and generate significant employment.
The NGFCP is Nigeria’s flagship initiative intended to auction flare gas sites to third-party investors for utilisation and monetisation. The program is a significant move to decouple flare gas recovery from the oil production operators themselves, treating the gas as a stand-alone resource.[3]

It is anchored in the Flare Gas (Prevention of Waste and Pollution) Regulations, 2018, which raised penalties and established permits, data and metering obligations for producers, creating an economic and legal basis for offtake projects. Relaunched in October 2022, the NGFCP ran a bid round that closed in March 2023; on October 4, 2023, the regulator announced 46 successful bidders were awarded rights to 49 flare sites (40 standalone sites and 9 in clusters), with reserve bidders named.

The programme is positioned as a pillar of Nigeria’s “Decade of Gas” strategy to deepen domestic gas supply, power generation and industrial use while cutting emissions. Its success is a key metric for Nigeria's commitment to the World Bank’s Zero Routine Flaring by 2030 initiative.[3]

3.5.2 The Presidential Initiative on CNG (PiCNG)

The PiCNG (launched in October 2023)[36] serves as the primary demand-side catalyst for the domestic gas market. Launched by President Bola Ahmed Tinubu as part of the palliative measures following the removal of the Premium Motor Spirit (PMS) subsidy, it seeks to diversify Nigeria's energy mix by transitioning the transportation sector to gas[36].

- Virtual Pipeline Integration: The initiative incentivizes the deployment of CNG compression stations and "mother-daughter" distribution models. This directly supports the monetization of flare gas at sites where pipeline connectivity is absent, creating a "virtual pipeline" for road-based gas logistics.

- National Fleet Conversion: By targeting the conversion of over 1 million vehicles by 2027, the PiCNG creates a guaranteed, high-volume market for processed flare gas, providing project developers with a stable off-take anchor.

- Economic Impact: By substituting expensive, imported PMS and AGO with locally processed flare gas, the PiCNG enhances the project IRR of flare capture units while providing significant foreign exchange (FX) savings for the Federation.

3.5.3 The Midstream and Downstream Gas Infrastructure Fund (MDGIF)

Established under the statutory framework of the PIA 2021, the MDGIF[37] is a strategic investment vehicle designed to de-risk gas infrastructure projects through equity participation and blended finance.

- **Targeted Investment:** The fund focuses on midstream infrastructure—gas processing plants, gas gathering networks, and modular LNG facilities—that are essential for "wet" gas conditioning from flare sites. It is funded primarily by a 0.5% levy on the wholesale price of petroleum products and natural gas sold in Nigeria.

- **Risk Mitigation:** For NFGCP winners, the MDGIF provides a source of low-cost capital and government "skin in the game," which significantly improves the bankability of projects for commercial lenders. It acts as a bridge for infrastructure that would otherwise be considered too capital-intensive for pure private equity.

- **Regulatory Alignment:** Unlike a commercial bank, the MDGIF's mandate is aligned with the **Decade of Gas** policy, prioritizing projects that increase domestic gas utilization rather than purely focusing on export-led returns.

3.5.2 Infrastructure Expansion

Key midstream infrastructure projects, notably the AKK and OB3 pipelines, aim to create robust national gas grid backbones, which are critical for aggregating flare gas from various points and transporting it to markets and demand centres across the country. Other critical initiatives include modular refining, mini-LNG, and virtual pipeline projects promoted by agencies like the Gas Aggregation Company of Nigeria (GACN) and NMDPRA.

These efforts are being complemented by private-sector investments in gas processing and compression facilities that convert stranded and flared gas into CNG, LPG, and feedstock for industries. The expansion of the domestic gas distribution network also underpins Nigeria's ambition to become a regional gas hub, supplying neighbouring West African markets through interconnection projects. Additionally, digital gas metering and flare-tracking technologies are being introduced to improve data accuracy, enforce accountability, and support carbon credit generation under emerging methane-reduction frameworks. Collectively, these initiatives position gas infrastructure as a linchpin of Nigeria's energy transition and economic diversification strategy.[3]

04. Section Four

Establishing a Baseline for Emissions and Environmental Impact

4.1 Scope 1 Emissions from Flaring and Methane Leakage

A substantial part of the Nigerian oil and gas sector's Scope 1 emissions, i.e., those directly from owned or controlled sources, is dominated by gas flaring, which releases substantial volumes of carbon dioxide (CO_2) and methane (CH_4) emissions.[12] This is so because of the routine nature of gas flaring in the onshore and shallow water areas (as discussed previously).

4.1.1 The Methane Challenge

While the visible plumes of a flare primarily generates CO_2, the true climate impact often lies in the "methane slip." Flaring efficiency of most state-of-the-art flares is rarely 100%; incomplete combustion,[11] especially under poor operational conditions (e.g., low-pressure or high wind), results in the release of un-combusted methane. Methane is a short-lived climate pollutant but has a Global Warming Potential (GWP) approximately 28 to 84 times greater than CO_2 over a 100-year and 20-year horizon, respectively. And because of this, reducing methane slip is an immediate and important high-leverage decarbonisation opportunity.[26]

Additionally, fugitive emissions, i.e., unintentional leaks from pipelines, valves, and processing equipment, also contribute significantly to Nigeria's oil & gas sector's methane footprint. To mitigate both effects, a comprehensive Leak Detection and Repair (LDAR) program is critical to capture these emissions, which are often invisible but very environmentally damaging. Addressing this slip is a cornerstone of the NDC 3.0 Mitigation Strategy, which prioritizes short-lived climate pollutants (SLCPs).

4.2 Quantitative Analysis of GHG Emissions Trends

Analysis of Nigeria's historical emission data (2000–2024) and recent findings in the NDC 3.0 (2025) reveal a volatile but structurally significant trend in Greenhouse Gas (GHG) emissions from the oil and gas sector. While satellite data shows a gross decline, recent research (e.g., *Springer, 2025*) indicates that the "intensity" of methane release remains a critical barrier to national climate goals.

4.2.1 Emission Components and Sectoral Trends

Based on the longitudinal data for Nigeria's upstream emissions (Figure 4.1) and aligned with NDC 3.0 baseline assessments, we observe the following:

Total GHG Emissions (CO_2e): Peaked significantly in 2004 at approximately 5.7 million Tonnes/Yr. As of 2024, operator-reported emissions have stabilized at approximately 1.4 million Tonnes/Yr. However, NDC 3.0 notes that total national emissions across all sectors are approximately 494 MtCO2e, with the Energy sector (including fugitive emissions from flaring) contributing the largest share (60\%).

Carbon Dioxide (CO_2): Represented by the red trace, CO_2 tracks the total GHG curve almost identically. This confirms that the combustion of associated gas is the primary source of the sector's visible carbon footprint.

Methane (CH_4): Represented by the yellow trace. While the volume peaked at nearly 700,000 Tonnes/Yr in 2004, current scientific analysis[18] suggests that actual methane emissions are often underestimated due to "venting" (unlit flares) and incomplete combustion. Methane's 20-year Global Warming Potential (GWP) is over 80 times that of CO_2, meaning even the lower volumes shown in the chart represent a massive climate forcing impact.

Nitrous Oxide (N_2O): Remains a negligible part of the flaring profile but is monitored under the NDC 3.0 enhanced transparency framework.

4.3 Alignment with Nigeria's NDC 3.0 (2025)

Nigeria's Third Nationally Determined Contribution (NDC 3.0)[35], elevates the ambition for the oil and gas sector, explicitly linking flare elimination to the 2060 Net Zero Pathway.

4.3.1 Quantifying the Impact on National Targets

The "one-third" equation presented in the Executive Summary is a vital metric for understanding the scale of this opportunity within the context of NDC 3.0:

- The 16 Million Tonne Metric: Current routine gas flaring and associated fugitive leaks contribute approximately 16 million tonnes of CO_2-equivalent (CO_2e) annually.

- NDC 3.0 Unconditional Commitment: Nigeria's unconditional target seeks to limit emissions to approximately 350-360 MtCO_2e by 2030[35]. The mitigation required to meet the "unconditional" gap (the difference between the BAU and the target) is approximately 45-50 MtCO_2e.

This makes flare monetization not just a sector priority, but the single most impactful strategy for Nigeria to remain "On-Track" for its 2025–2030 climate milestones without relying exclusively on international conditional funding.

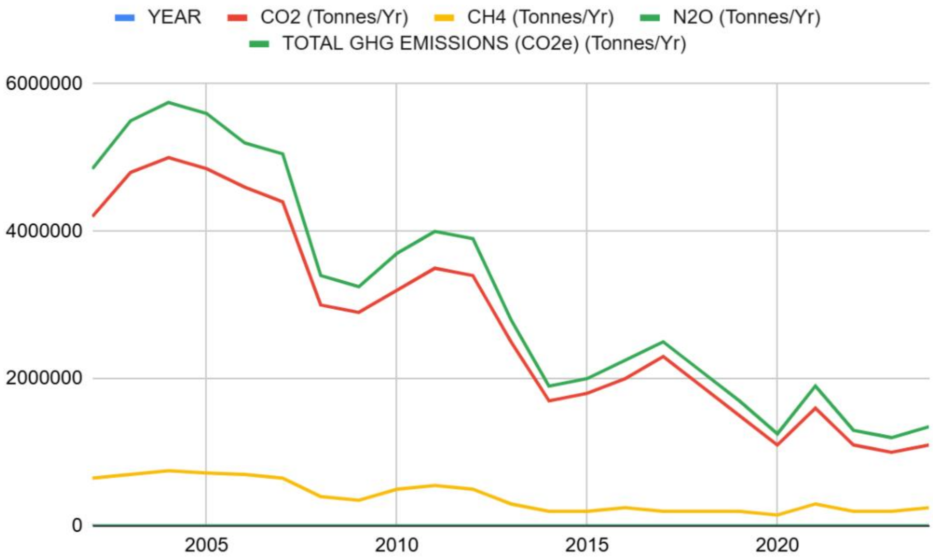

Figure 8. Nigeria's Greenhouse Gas Emissions

Generally, any reduction in flaring intensity translates directly into a lower national emissions profile, providing credibility for international climate finance access.

4.4 Health and Environmental Impacts and Consequences

The most obvious and discussed environmental impact of flaring is climate change; however, in the host communities of the Niger Delta, flaring leads to highly localised, severe pollution that directly affects public health and livelihoods[11]. Agriculture becomes a big casualty because of the immense radiation and poor air quality, etc.

4.4.1 Air Quality and Public Health

The combustion of flare gases releases numerous harmful polluting substances, including nitrogen oxides (NO_x), sulphur oxides (SO_x), carbon monoxide (CO), and most notably, Black Carbon (BC), a fine particulate matter (soot) known to be a carcinogen. It is a known fact that exposure to these contaminants leads to elevated rates of respiratory illnesses, asthma, cancer, and chronic obstructive pulmonary disease among residents[12]. Additionally, the constant light pollution from the flares also disrupts local ecosystems and human sleep patterns.

4.44.2 Damage to Ecosystems and Habitats

Further to the above, toxic fallout, particularly acid rain caused by SO_x and NO_x contaminates local soil and water bodies, drastically reducing agricultural productivity and fish stocks. These direct correlations between flaring activity and decreased crop yields and dying ecosystems represent a massive environmental injustice and a key driver of social unrest in poor communities in the Niger Delta.

4.5 Economic Valuation of Flared Gas

The estimated $1.5 billion USD in annual economic losses cited in Section 1 is the bearest minimum, i.e., the mere revenue loss from the gas commodity itself. To get the full economic value of the loss, the analysis must capture the lost opportunity cost and external costs (externalities).

4.5.1 The Opportunity Cost (Cost of the lost opportunity)

We assess this to include the forgone value chain benefits:

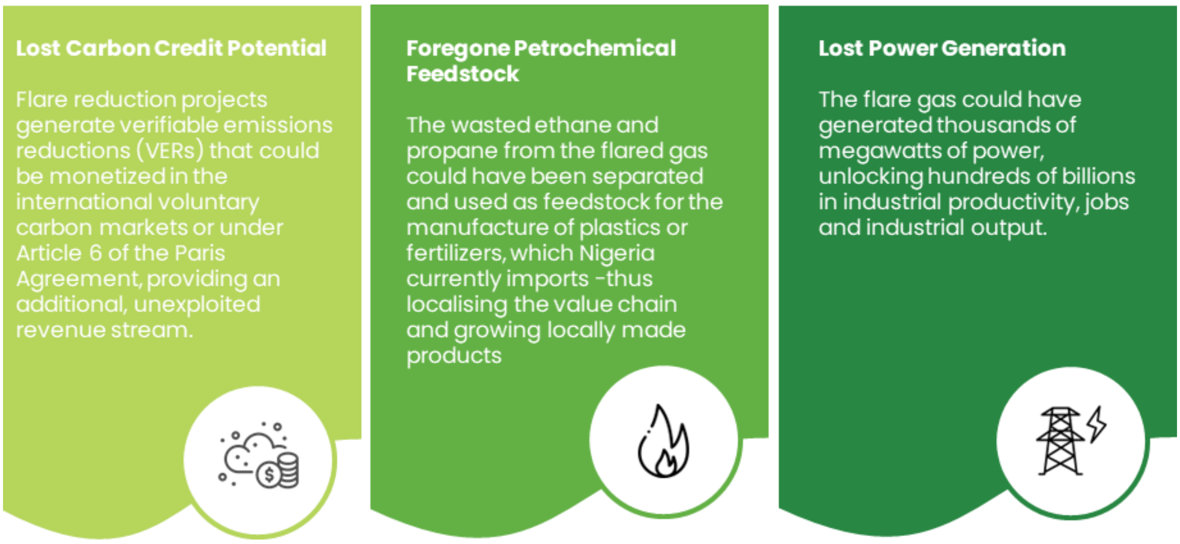

Figure 9. The Opportunity Cost.

4.5.2 Externality Costs

Quantifying the cost of health damage, lost productivity, and ecosystem repair adds a significant premium to the economic valuation. When fully accounted for, the true economic cost of flaring far outweighs the capital expenditure required to install recovery and utilisation infrastructure. And as such, gas flaring is an active drain on national finances and human capital.

4.6 Benchmarking Nigeria vs. Global Flaring Intensity

To fully contextualise the scale of the flaring challenge, Nigeria must be benchmarked against global peers using the metric of Flaring Intensity (i.e., volume of gas flared per barrel of oil produced). While total flared volumes may increase or decrease based on production cuts, price or contract situations, flaring intensity provides a good measure of operational efficiency and commitment to environmental stewardship.

A significant portion of the country's current flaring intensity stems from legacy facilities commissioned during an era when engineering philosophy prioritized crude oil processing and evacuation. During the initial development of many oil fields in the Niger Delta, associated gas (AG) was viewed as an operational nuisance—a high-pressure byproduct that presented safety risks but lacked a viable commercial market or gathering infrastructure.

As a result, many legacy flow stations were designed with integrated flare systems as the primary means of gas disposal to ensure continuous oil production. In these scenarios, flaring was seen as an inevitable operational necessity. Modern efforts to eliminate flaring at these sites essentially require retrofitting decentralized midstream technology onto assets that were never architecturally intended for gas recovery.

Historically, Nigeria's flaring intensity has been significantly higher than that of leading producers and peers committed to the World Bank's Zero Routine Flaring by 2030 initiative (e.g., Saudi Arabia, Norway, and even the United States, which has seen dramatic decreases in intensity in new basins)[8]. The high intensity suggests systemic issues, lack of midstream capacity, fragmented gas markets, and regulatory non-compliance. Flare-gas recovery is not just a climate measure; it is a fundamental correction of operational inefficiency within the upstream sector.

05. Section Five

Flare Gas Capture and Utilisation Pathways

Without a doubt, the elimination of routine gas flaring hinges on the deployment of commercially viable technologies that convert a waste stream into a valuable product. The choice of such an optimal recovery and utilisation pathway is not that simplistic; it depends on the volume, pressure, gas composition, and, critically, the proximity of the flare site to a viable market.

5.1 Options for Flare Gas Recovery

In the context of the Nigerian situation, the recovery of Associated Gas (AG) at the wellhead or flow station is the foundational technical step. Flared gas (at the flow station) is typically low-pressure, making primary recovery technologies focused on boosting and cleaning the gas stream essential.

5.1.1 Gas Compression and Conditioning

This process is fundamentally necessary when recovering low-pressure associated gas (AG) from ageing oil reservoirs, which is often the source of flaring. Since pipeline specifications typically require pressure levels between 750 and 1,200psig and downstream conversion processes (like LNG or CNG) require even higher pressures, the recovered gas must be significantly boosted.[13]

- **Compression:** This is achieved using specialised machinery. Reciprocating compressors (piston-driven) are robust and highly effective for achieving very high pressures, making them suitable for reinjection or long-distance pipeline transport. Screw compressors are often favoured for lower pressure ratios and mid-range flow applications, particularly in modular, skid-mounted units.

German Companies like Neuman & Esser specialise in high-reliability reciprocating compressor systems, crucial for both large-scale gas movement and high-pressure reinjection. The modular solutions from the 2G consortium utilise compact compressors for their virtual CNG pipeline model.

- **Conditioning (Cleaning):** Before any downstream process, the gas must be "conditioned." This involves two critical steps:
-
    - **Acid Gas Removal:** The removal of corrosive contaminants, primarily hydrogen sulphide (H_2S) and carbon dioxide (CO_2), is often achieved using amine treating units. High H_2S levels can corrode pipelines and poison catalysts in conversion plants.
    - **Dehydration**: The removal of water vapour (moisture) to prevent the formation of hydrates (ice-like structures) in pipelines or compressors at low temperatures, which

can cause severe blockages, and to prevent corrosion. This is typically done using molecular sieves or glycol dehydration systems.

Failure to properly condition the gas stream leads to operational failure, pipeline integrity risks, and non-compliance with commercial specifications.

5.1.2 Gas Processing and Separation

This technique focuses on maximising the value of the recovered gas stream by treating it not just as methane, but as a source of valuable Natural Gas Liquids (NGLs). This is particularly relevant for "wet" gas flares common in the Niger Delta. [13]

- **Wet Gas vs. Dry Gas**: "Wet" gas is hydrocarbon gas that contains significant concentrations of heavier hydrocarbons like propane (C_3H_8), butane (C_4H_{10}), and pentane (C_5H_{12}). "Dry" gas is primarily methane (CH_4).
-
- **Cryogenic Separation**: This is the most common and efficient technology for high-volume NGL recovery. The gas is subjected to rapid cooling (to temperatures as low as -150°C) and pressure changes, causing the heavier NGL components to condense into a liquid state while the lighter methane remains gaseous.
-
- **Absorption Separation (Lean Oil Absorption):** This older method uses a cold, low-molecular-weight oil (lean oil) to absorb the NGLs from the gas stream. The NGLs are then separated from the lean oil via heating and distillation.
-
- **Economic Viability:** Monetising the NGLs (which are sold as LPG, chemical feedstocks, or gasoline blend stock) drastically improves the overall Net Present Value (NPV) and Internal Rate of Return (IRR) of a flare monetisation project. The value of the NGL component can often exceed the value of the corresponding dry methane.

5.1.3 Gas Reinjection

This is a key upstream reservoir management practice that serves dual purposes: Enhanced Oil Recovery (EOR) and temporary carbon mitigation. While it addresses flaring, its primary driver is operational efficiency, not immediate commercial monetisation.[13]

- **Mechanism**: Associated gas is captured, compressed to extremely high pressures (often exceeding 5,000psig), and then injected via dedicated wells into the oil-bearing reservoir.

- **Enhanced Oil Recovery (EOR):** The injected gas maintains or restores reservoir pressure, which naturally depletes as oil is produced. This pressure boost pushes oil towards the production wells, significantly improving the recovery factor of the field. In some cases, the gas dissolves into the oil, lowering its viscosity and improving its flow characteristics (miscible or immiscible injection)[27].

- **Climate Mitigation (Temporary):** By placing the gas back into the geological formation, CO_2 emissions from flaring are avoided, effectively storing the gas underground. This is an operational substitute for Carbon Capture and Storage (CCS), but it differs in that the primary purpose is oil recovery, and the gas may be retrieved later.

- **Capital Intensity**: Reinjection projects require high capital expenditure (CapEX) for specialised, high-pressure, high-capacity reciprocating compressors and deep, dedicated injection wells, making it less viable for small, non-EOR critical flares.

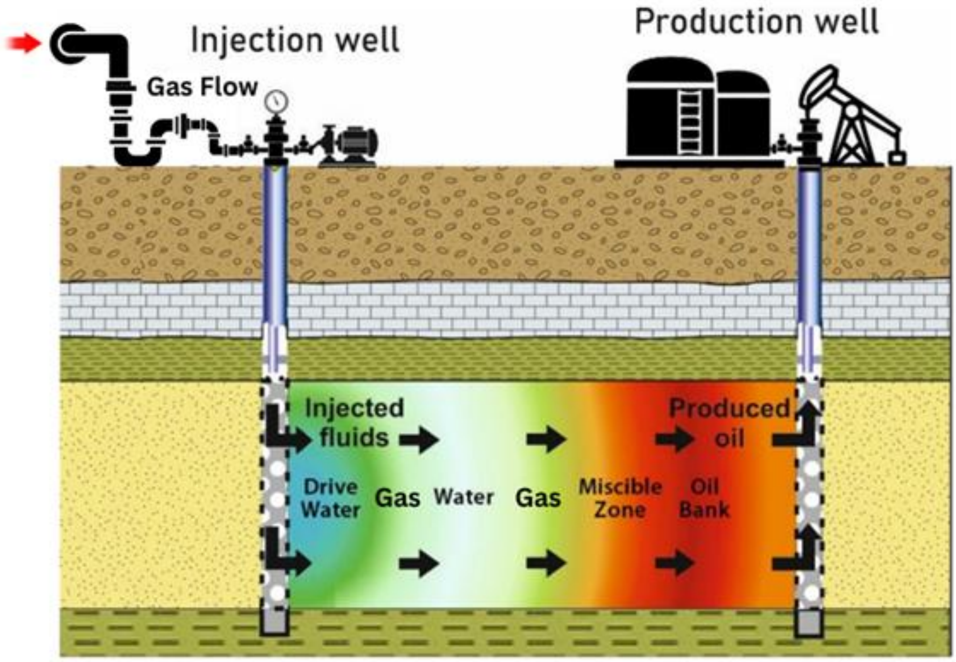

Figure 10. Gas Reinjection Mechanism and Oil Recovery.

5.2.1 Power Generation (On-Grid, Off-Grid, and Captive)

Gas-to-Power (GtP) represents the fastest and highest-impact route for flare gas monetisation, directly addressing Nigeria's persistent power deficit. This pathway utilises the gas's inherent energy value (measured in BTUs) to drive mechanical power.[13]

Prime Movers: The core conversion technology relies on two types of thermal machines:

- **Gas Turbines:** Best suited for continuous, large-scale (utility-grade) power generation. They operate on the Brayton cycle, achieving high efficiency, especially when configured in a Combined Cycle Gas Turbine (CCGT) mode.

- **Reciprocating Engines (Gas Engines):** Ideal for smaller, modular, and off-grid/captive power applications. They offer high efficiency in part-load operation and better heat rate at smaller scales, making them perfect for stranded gas sites.

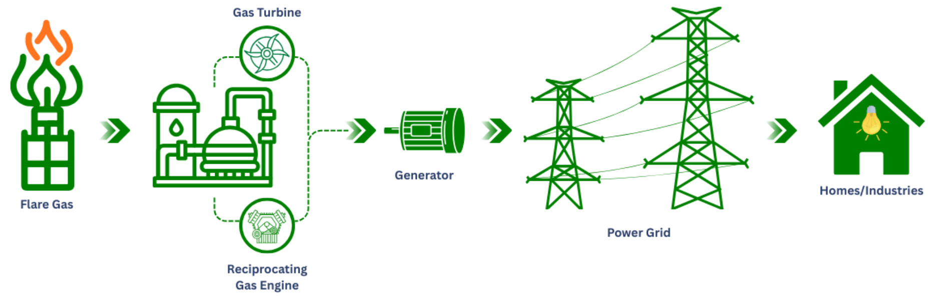

Figure 11. Flare to Value Schematic for Power Generation (GtP).

Deploying modular, field-proven GtP units at flare sites converts an environmental liability into immediate, distributed electricity, enhancing grid stability and providing baseload power for industrial off-takers or host communities. This bypasses the need for large-scale pipeline infrastructure for power delivery.

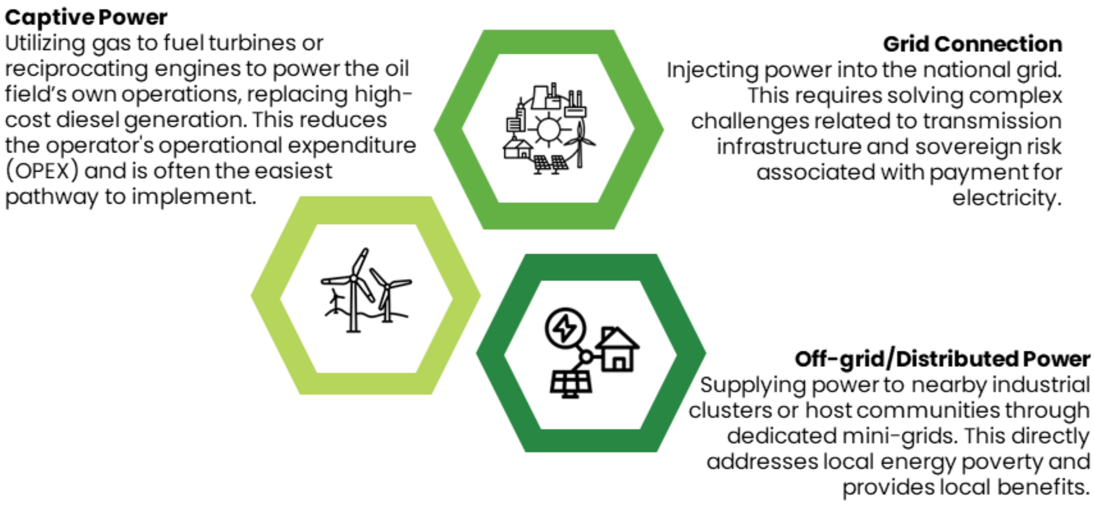

Figure 12. Power Generation.

5.2.2 Petrochemicals, Fertilisers, and Methanol

This pathway transforms methane (CH_4) from a fuel source into a high-value chemical feedstock, supporting national industrialisation and reducing dependence on imports.

Feedstock Transformation:

- Fertiliser (Urea/Ammonia): Methane is processed via Steam Methane Reforming (SMR) to produce a synthesis gas (Syngas), which is primarily hydrogen (H2) and carbon monoxide (CO). The H2 is then combined with nitrogen (N2) (derived from an air separation unit) in the Haber-Bosch process to form ammonia (NH3), the precursor to urea fertiliser.

- Methanol: Similar to fertiliser production, Syngas is synthesised from methane and then catalytically converted into methanol (CH3OH). Methanol is a fundamental building block for numerous downstream chemicals, including formaldehyde, acetic acid, and olefins, and is increasingly seen as a marine fuel.

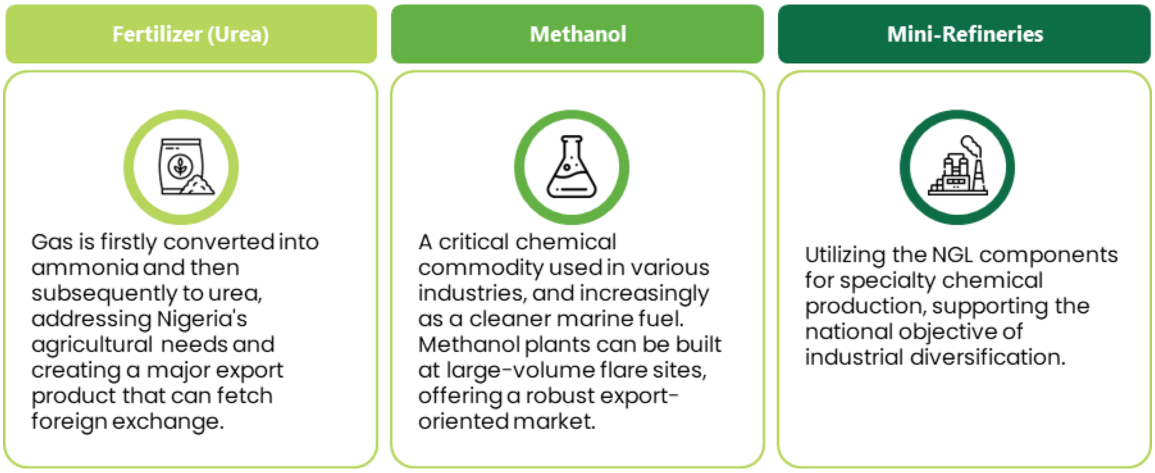

Figure 13. Petrochemicals, Fertilisers, and Methanol.

This route offers significantly higher margins than simple GtP or pipeline sales, provided the high initial Capital Expenditure (CapEX) and technical complexity are managed. It establishes robust industrial value chains far exceeding the value of the original gas.

5.2.3 Liquefied Petroleum Gas (LPG) for Households

The utilisation of flare gas to produce Liquefied Petroleum Gas (LPG) (primarily propane (C_3H_8) and butane (C_4H_{10}) is critical for addressing national energy poverty and public health.

- ***Source Suitability:*** This method is highly suited for "wet" associated gas (AG) streams, which are naturally rich in these heavier hydrocarbons.

- ***Process***: LPG is typically separated during the initial gas processing stage (as detailed in Section 5.1.2) using simple refrigeration or turbo-expander technology to condense the C_3H_8 and C_4H_{10} components. [1]

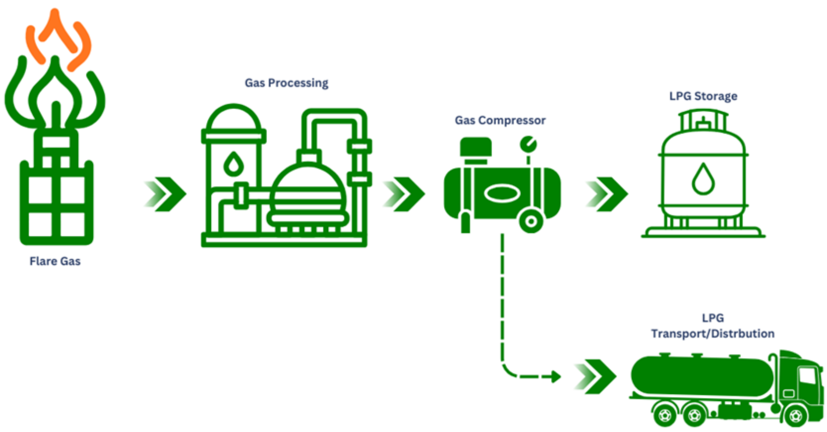

Figure 14. Flare to Value Schematic for LPG.

[3]

Social and Environmental Impact: By displacing traditional biomass (wood, charcoal) and kerosene, increased domestic LPG supply directly reduces indoor air pollution (a major public health concern) and mitigates deforestation. The guaranteed, undersupplied domestic LPG market ensures strong financial predictability and high social return on investment for such projects.

5.2.4 Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) for Transport

Converting methane into a compact, transportable fuel directly addresses the logistics of moving gas to consumers not on the pipeline network.

- **CNG (Compression):** Methane is cleaned and compressed to high pressures (typically 3,000 to 3,600psig) at ambient temperature. It is stored and transported in high-strength cylinders. Ideal for: Vehicle fleets, buses, and industrial users within a 200km radius of the compression station (e.g., solutions deployed by the ***2G consortium***).

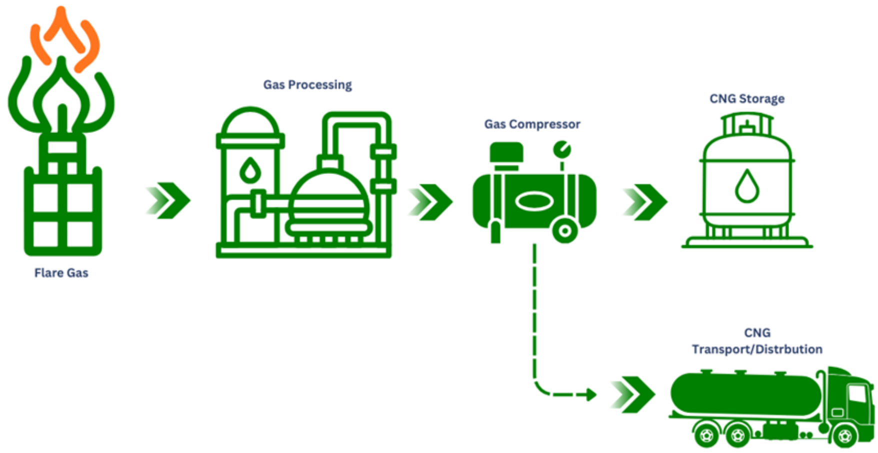

Figure 15. Flare to Value Schematic for CNG.

- **Mini-LNG (Cryogenic):** Methane is cooled to cryogenic temperatures (below -160ºC) to liquefy it, reducing its volume by a factor of over 600. Ideal for: Long-haul transport, marine bunkering, and remote industrial plants where CNG logistics become too costly. This is more complex and CapEX -intensive than CNG.[31]

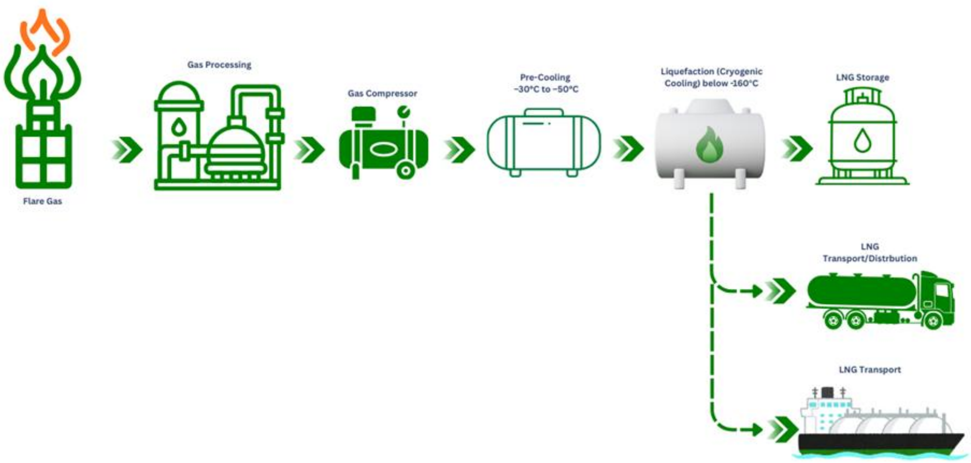

Figure 16. Flare to Value Schematic for LNG.

5.3 Virtual Pipelines, Modular LNG/CNG: Solutions for Stranded Assets

The strategy of "Virtual Pipelines" and "Modular Solutions" is the essential deployment mechanism for flare gas, particularly for the vast majority of small-to-medium, geographically stranded sites that cannot justify the multi-billion-dollar investment of a new mainline pipeline connection.

- **Virtual Pipeline Concept:** This strategy replaces a fixed steel pipeline with mobile transport (trucks, barges) carrying gas in the form of high-density CNG or LNG. The process involves: Flare Gas Recovery, Compression/Liquefaction (at the flare site), Transport, Regasification/Utilisation (at the end-user site).

5.3.1 Modular Processing Units

These units are the enabling technology for the virtual pipeline. They are factory-fabricated, skid-mounted assemblies (like Modular Gas Processing Plants (MGPP) or Mini-LNG units). Their key advantages are:

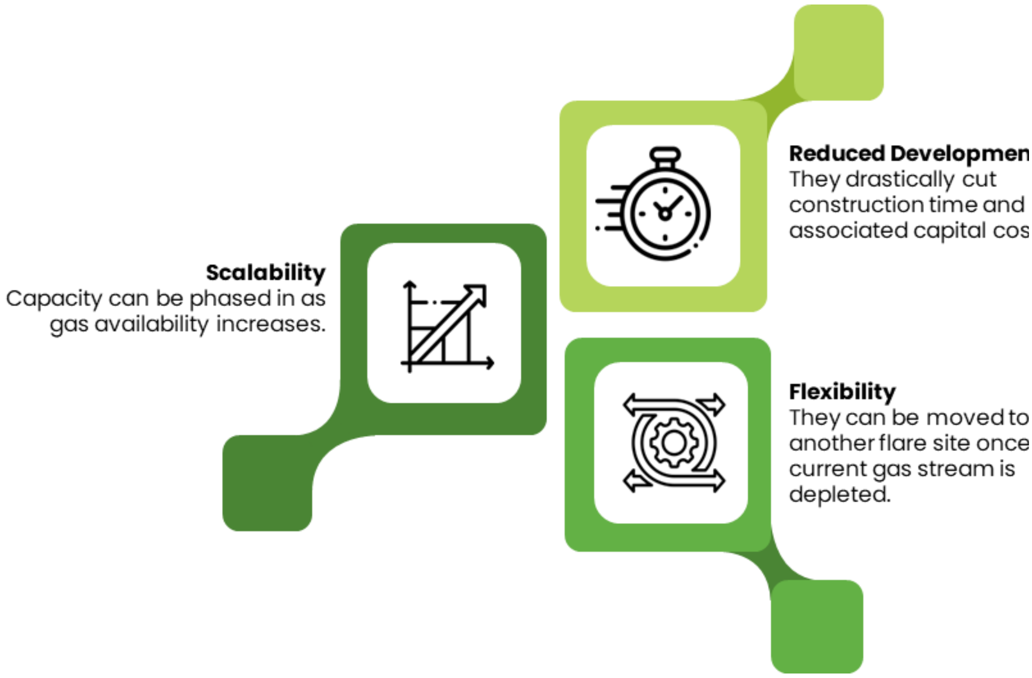

Figure 17. Modular Processing Units.

This modularity, as observed in the study tour, (Appendix A) is the single most important factor for making Nigeria's thousands of small flare points commercially viable and bankable. The primary advantage of modularity is its "plug-and-play" scalability. Because these systems are self-contained and pre-assembled, they eliminate the need for extensive site preparation and long-term capital commitment associated with permanent midstream infrastructure. Industry leaders such as Neuman & Esser (NEA) and the 2G-Consortium have pioneered these factory-fabricated solutions, providing the core compression, liquefaction, and processing skids that transform previously stranded flare gas into a transportable, bankable energy commodity. By tailoring the capacity of these modular plants to the specific gas volume of a site, developers can ensure high utilization rates and minimize the technical risk of over-sizing infrastructure.

5.3.2 Virtual Pipelines

A virtual pipeline involves transporting gas products not through buried pipelines, but via truck, rail, or barge, using specialised ISO containers or vessels. This is the enabling technology for modular solutions, as it links the remote flare recovery site to the end-use market without reliance on the congested domestic pipeline network.

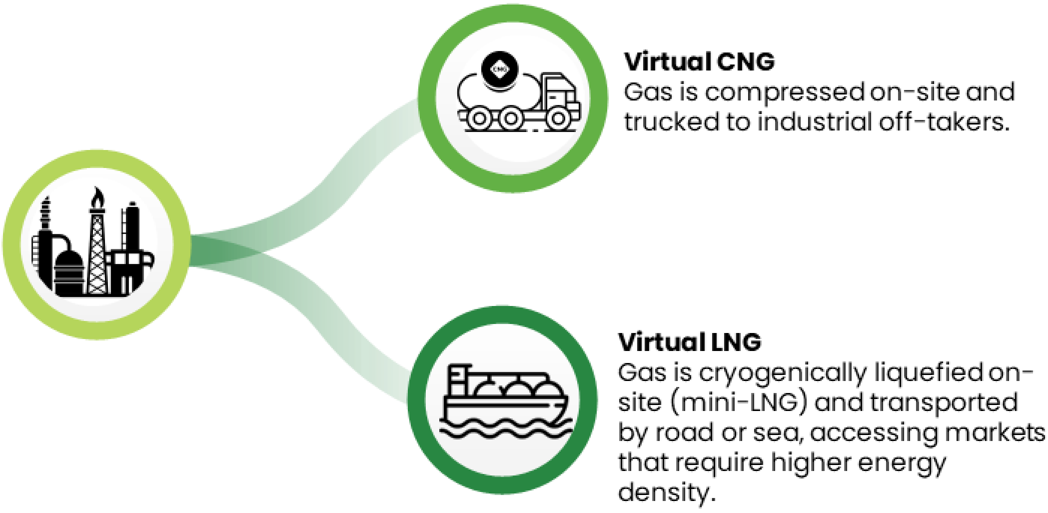

Figure 18. Virtual Pipelines.

06. Section Six

Gas Infrastructure and Market Gaps

The technical feasibility of flare gas capture, as already detailed in Section 5, is largely overshadowed by commercial and logistical constraints in the Niger Delta. The failure to eliminate routine flaring in Nigeria is less a technological problem and more a reflection of underdeveloped midstream infrastructure and distorted domestic gas markets, largely driven by weak policy frameworks.

6.1 Nigeria's Existing Gas Infrastructure

Nigeria's current gas infrastructure is characterised by a "backbone" around the Niger Delta, designed to transport high-pressure, non-associated gas (NAG) and associated gas (AG) from major fields to key processing and export facilities or large domestic power plants although NAG constitutes the larger share of throughput.[16] This infrastructure, while substantial and robust, is largely around one geographic area and it suffers from three critical issues in the context of flare gas:[14]

Innovative technologies such as ITT Bornemann's multiphase pumping systems provide an alternative to conventional gathering networks by enabling associated gas from multiple dispersed locations to be transported through a common system. Such approaches can significantly reduce capital costs while improving the commercial viability of flare gas recovery in mature onshore assets

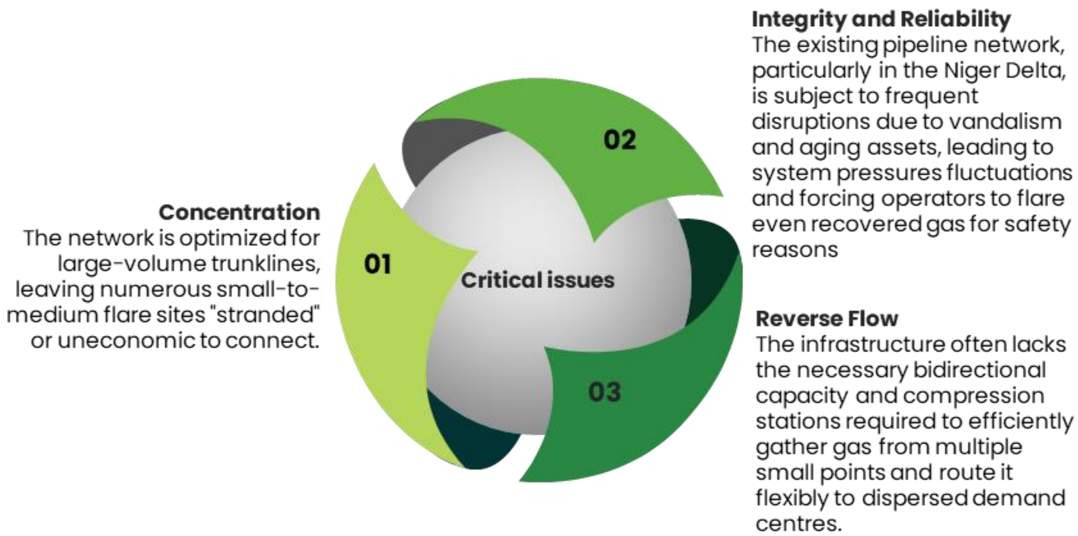

Figure 19. Existing Gas Infrastructure Overview.

6.1.2 Core Gas Transportation Infrastructure

The domestic gas market relies heavily on a robust network of transmission pipelines managed by the Nigerian Gas Infrastructure Company (NGIC), Nigeria's sole gas transporter.

1. Domestic Pipeline Networks

The following networks are critical components of the domestic supply infrastructure, primarily serving power generation and industrial clusters:

Pipeline Network	Description	Capacity
Escravos-Lagos Pipeline System (ELPS) - 1	36” X 342km	Part of the backbone supply route.
Escravos-Lagos Pipeline System (ELPS) - 2	36” X 342km	Provides redundancy and increased capacity on the western corridor.
Obiafu - Obrikom - Oben Pipeline (OB3)	36” X 128km	Key linkage between Eastern and Western gas sources.

Table 1: Nigeria’s Current Domestic Pipeline Network.

2. Growth Infrastructure (Under Development)

A major project is underway to expand gas access to the Northern region:

- **Ajaokuta-Kaduna-Kano (AKK) Pipeline:** A 40” X 614km pipeline currently under development. It is projected to transport 3.5 BCF/D upon completion, opening significant new markets in the Northern part of Nigeria.

3. Regional Infrastructure

Nigeria also serves as a regional gas supplier via the following asset:

- **West African Gas Pipeline (WAGP):** A 20” X 678km pipeline that links Nigeria to the regional markets of Ghana, Togo, and Benin.

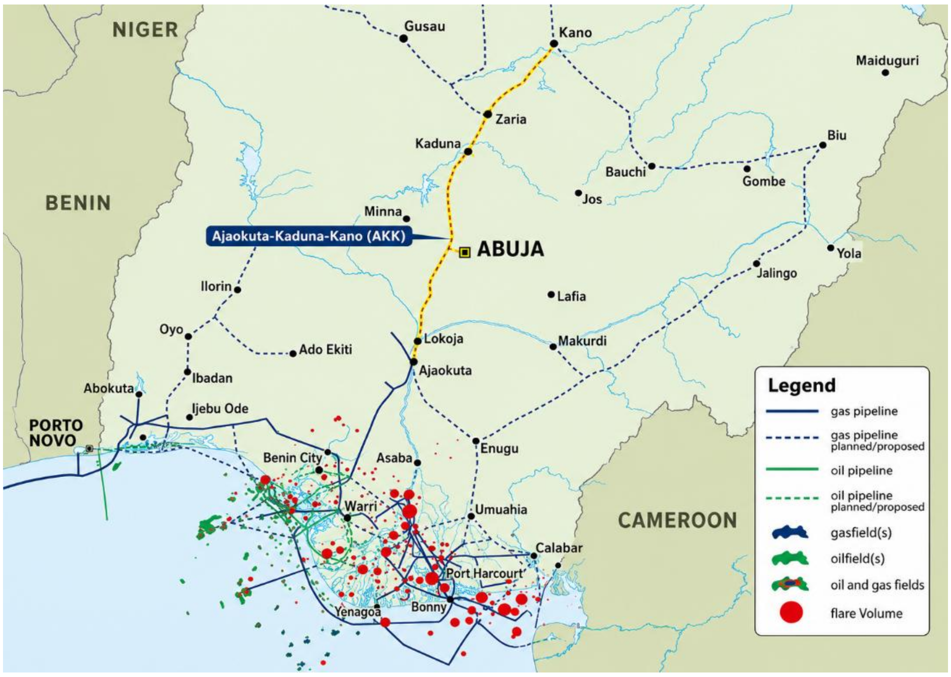

Figure 20. Map of Major Nigerian Gas Trunklines and Proximity to Known Flare Sites.

6.2 Gas Gathering, Processing, and Transport Infrastructure

For Nigeria to successfully monetise flare gas, it requires robust gas gathering and processing systems. The key challenge lies in the capital expenditure (CapEx) required to aggregate very dispersed Associated Gas (AG) volumes. And this is not a small task, because many of the flare sites only make sense in aggregate form.

6.2.1 Gathering Network Deficiencies

As already outlined, the existing gathering network is often piecemeal and fragmented. Many producing fields, particularly legacy Joint Venture (JV) assets that are onshore and in shallow water, lack adequate low-pressure gathering systems to collect the associated gas and boost it to sales pipeline specifications.[10] This is the primary reason why associated gas in Nigeria has historically been flared; the cost of installing and maintaining these gathering lines was not deemed justified under the previous regulatory regime, and even though the PIA 2021 addresses some of these challenges, more needs to be done.

6.2.2 Midstream Processing & Liquefaction Assets

The midstream segment is defined by the critical infrastructure required to process, liquefy, and export Nigeria's gas resources.

1. **Liquefied Natural Gas LNG) Terminals**
   The Nigeria LNG (NLNG) Plant/Terminal: This flagship facility is situated at Bonny Island, Rivers State. It has a current production capacity of 21 million TPA (Tonnes Per Annum), making it a globally significant gas export hub.

2. **Other Key Gas Terminals and Plants**

In addition to the main LNG facility, the midstream sector includes major gas processing plants essential for domestic supply and export readiness:

- ExxonMobil Bonny River Terminal.
- Escravos Gas Plant (EGP).

6.2.3 Processing Capacity

It is a fact that while Nigeria has world-class processing facilities associated with major LNG projects, smaller regional Gas Processing Plants (GPPs) dedicated to domestic distribution and industrial feedstock are insufficient and grossly inadequate. This forces smaller flare gas projects to utilise modular solutions (as discussed in Section 5), which, while flexible, introduce much higher operational complexity than conventional centralised plants.

6.3 Metering, Measurement, and Monitoring Challenges

Achieving decarbonisation goals is impossible without accurate Measurement, Reporting, and Verification (MRV) systems. Nigeria has historically struggled with this foundational element; therefore, it needs systems, frameworks, and capabilities to address these challenges.

6.3.1 Inaccurate Volume Data

While most flare sites now have flare meters installed pursuant to regulatory requirements, persistent challenges remain with meter reliability, recalibration, recertification, and independent verification of reported data, which leads to significant discrepancies between operator-reported volumes and satellite or third-party measurements. This opacity and dichotomy undermine the enforcement of flaring penalties and further distort the true scale of the lost resource.

6.3.2 Regulatory Technology Gaps

For effective regulatory enforcement, the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) requires real-time data integration. The current technical capacity for the continuous and real-time monitoring of flare stacks, especially for critical metrics like combustion efficiency, NOx & SOx content and methane slip, remains inconsistent across the industry. Transitioning to a standardised, certified metering protocol linked directly to regulatory dashboards (with KPIs) is a non-negotiable step for compliance and transparency.

6.4 Market Access Limitations (Domestic and Export)

The fundamental barrier to flare gas commercialisation is the lack of liquidity and a viable domestic market. Even if the gas is captured and processed, developers need reliable off-takers who can pay for the product at an attractive price. Currently, the most attractive option is gas export to NLNG or other means; however, these avenues are not available to small flare gas capture operators due to the technical and commercial challenges outlined earlier.

6.4.1 Domestic Market Risk (Power Sector)

The Nigerian power sector, which represents the largest potential off-taker (given electricity demand), is hampered by persistent payment issues and weaknesses in the electricity value chain.[7] The failure to guarantee full and timely payments to Gas-to-Power (GTP) projects creates a sovereign risk that both international and local financiers are reluctant to bear, stalling Final Investment Decisions (FIDs) for flare gas capture. This is one of the largest pitfalls of commercialising projects that target the power sector. With that said, the Presidential Initiative on Compressed Natural Gas (PiCNG) has been sounding the right notes in terms of offtake. A more in-depth consideration will be given to understand the extent to which this can help to solve these issues.

6.4.2 Pricing Distortions (Subsidies)

While the Petroleum Industry Act (PIA) provided a pricing framework, the price of domestic gas for power and industrial use has historically been subsidised or artificially suppressed. Low gas prices do not reflect the true cost of recovery and processing, making capital-intensive flare capture projects uneconomic relative to the easy profits from crude oil production. A stable, market-reflective price is necessary to attract commercial investment in the flare gas area. This has to be an area to explore for future work or a recommendation to the Nigerian state.

6.5 Private Sector Participation Barriers and Apathy

Despite clear intent from the government as exemplified in the Nigeria Gas Flare Commercialisation Programme (NGFCP), private sector enthusiasm for flare gas projects remains muted due to systemic, legal/contractual, security/force majeure and financing issues.

6.5.1 Legal and Contractual Stability

Generally, developers require long-term, stable contracts for gas supply (from the flare site) and off-take (to the buyer). And for these flare projects that are at hand, complex negotiations often involve multiple stakeholders, including the original oil operator, the gas aggregator, the transporter, and the end-user, which often leads to delays and legal uncertainties. The current framework provided by the Nigeria Gas Flare Commercialisation Programme (NGFCP) is designed to simplify these contracting complexities, but its execution must be streamlined because winning an NGFCP flare site does not automatically translate to a working plant

6.5.2 Security and Force Majeure Risks

The aforementioned vulnerabilities of pipeline infrastructure to vandalism increase the risk profile for investors. Furthermore, the prevalence of political and operational delays creates a heightened risk of force majeure, which discourages international investors seeking predictable returns.[17]

6.6 Financing and Investment Environment

Financing is the ultimate hurdle. While the global financial community is increasingly committed to funding decarbonisation projects, flare gas monetisation in Nigeria faces specific headwinds:

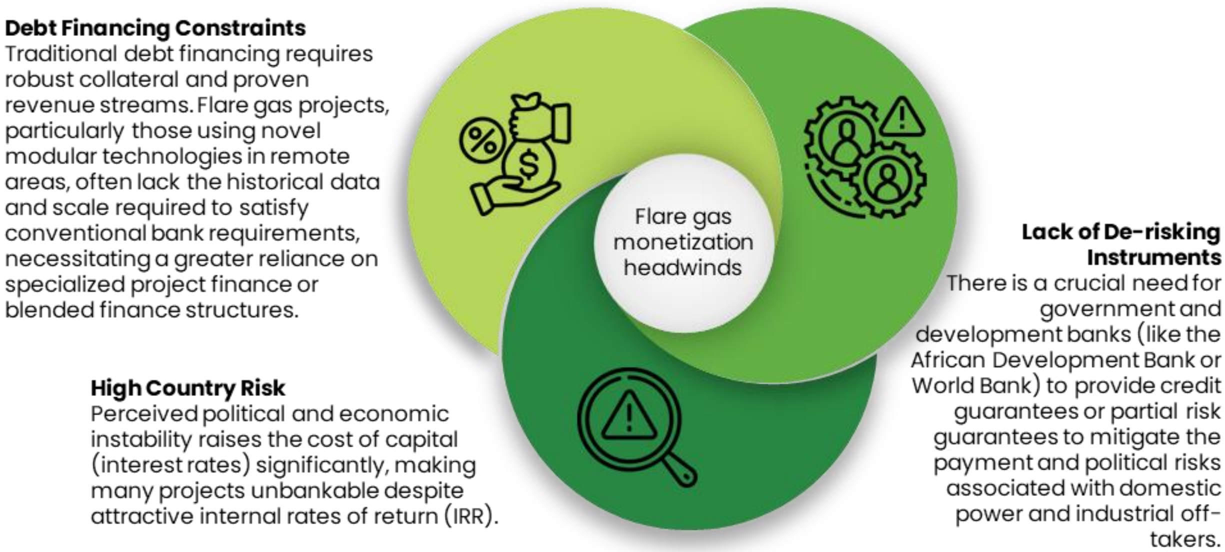

Figure 21. Financing and Investment Environment.

Risk Category	Typical Risk (Nigeria Context)	Potential Impact on Project	Core Mitigation Instruments (Project Finance View)	Contextual Explanation
Offtake/Commercial	Payment Default (Offtaker Risk)	Revenue loss, inability to service debt, and project failure.	Sovereign/NOC Guarantee (e.g., from NNPC or NBET/NBET PPA guarantees), Escrow Accounts (Offshore), Secured Power Purchase Agreements (PPAs).	The Nigeria Bulk Electricity Trading (NBET) or a creditworthy, non-affiliated, and internationally bankable off-taker is key. Lenders will demand Guarantees (e.g., World Bank Partial Risk Guarantee, or a bankable NBET PPA) to de-risk exposure to local off-takers like DISCOs. Offshore Escrow Accounts are used to trap revenues before they enter the local banking system.
Political/Force Majeure	Vandalism, Sabotage & Communal Unrest (Host Community Risk)	Infrastructure damage, production shutdowns, increased security costs, and loss of revenue.	Political Risk Insurance (PRI) (e.g., MIGA, ECAs), Vandalism & Sabotage Insurance, Community Development Agreements (CDA), PIA Host Community Trust Fund.	PRI specifically covers militant actions. The contractual inclusion of robust CDAs and alignment with the new Host Community Development Trust Fund mechanism under the PIA are vital for social license to operate and reducing local conflict. Security costs must be factored into the project's financial model from the start.
Regulatory/Legal	Regulatory/Policy Change	Loss of licence (Permit to Access Flare Gas), sudden tax hikes (PIA fiscal framework), or penalty changes eroding project economics.	Direct Agreement with the FGN (or relevant MDAs like NUPRC/NMDPRA), Contractual Stabilisation Clauses, Change-in-Law Clauses in the Gas Sales Agreement (GSA).	The Flare Gas (Prevention of Waste and Pollution) Regulations 2018 and the PIA introduce a clear framework, but historical regulatory instability requires protection. A Direct Agreement with the Government provides comfort by defining the remedies for a government-induced breach (e.g., compensation). The NGFCP itself offers some short-term protection via the Nigeria Gas Flare Revenue Account for eligible political Force Majeure events.
Supply	Flare Gas Volume Fluctuation/Shortfall (Source Risk)	Reduced feedstock, underutilised plant capacity, and debt covenant breach.	"Deliver or Pay" GSA from the Producer (Original Oil Company), Backstop Gas Supply/Alternative Fuel Source contingency,	Unlike traditional gas projects, FGCs depend on the host oil producer's upstream operations. The GSA must incorporate a strong "Deliver or Pay"

			Dedicated Gas Access Permit.	clause from the producer to ensure supply, coupled with contractual compensation for shortfalls. Lenders require a robust analysis of the flare's historical and forecast profile, including the field depletion curve.
Financial	Foreign Exchange (FX) and Currency Devaluation	Increased debt service cost (USD-denominated debt vs. Naira revenue), higher O&M costs.	Offshore Debt Service Reserve Account (DSRA), FX Pass-Through in the Offtake Agreement (e.g., Naira revenues linked to USD), Currency Swaps.	This is a major risk in Nigeria. Financing must include an Offshore DSRA funded in USD. The off-take contract (e.g., for power) must allow for a mechanism to adjust the tariff (or price) based on the USD/NGN exchange rate to maintain the project's real returns.

Table 2: Project Financing Risk Matrix for Flare Gas Projects.

07. Section Seven

Economic and Financial Assessment

The transition from flaring to flare gas monetisation is fundamentally an economic decision, driven by maximising Net Present Value (NPV), Internal Rate of Return (IRR) and managing risk. This chapter moves beyond the technical and infrastructural gaps to analyse the financial viability and required investment structures needed for decarbonising the Nigerian upstream sector.

7.1 Cost-Benefit Analysis: Flaring vs. Recovery

The primary motivation for eliminating flaring must be rooted in clear economic superiority over the status quo. This requires accurately quantifying the costs of flaring versus the benefits of recovery. To do this, a review of flaring penalties will need to be done vis-à-vis the investment for recovery, over the life of the project.

7.1.1 The Cost of Flaring

Beyond the direct loss of the energy resource itself, the costs associated with flaring include:[18]

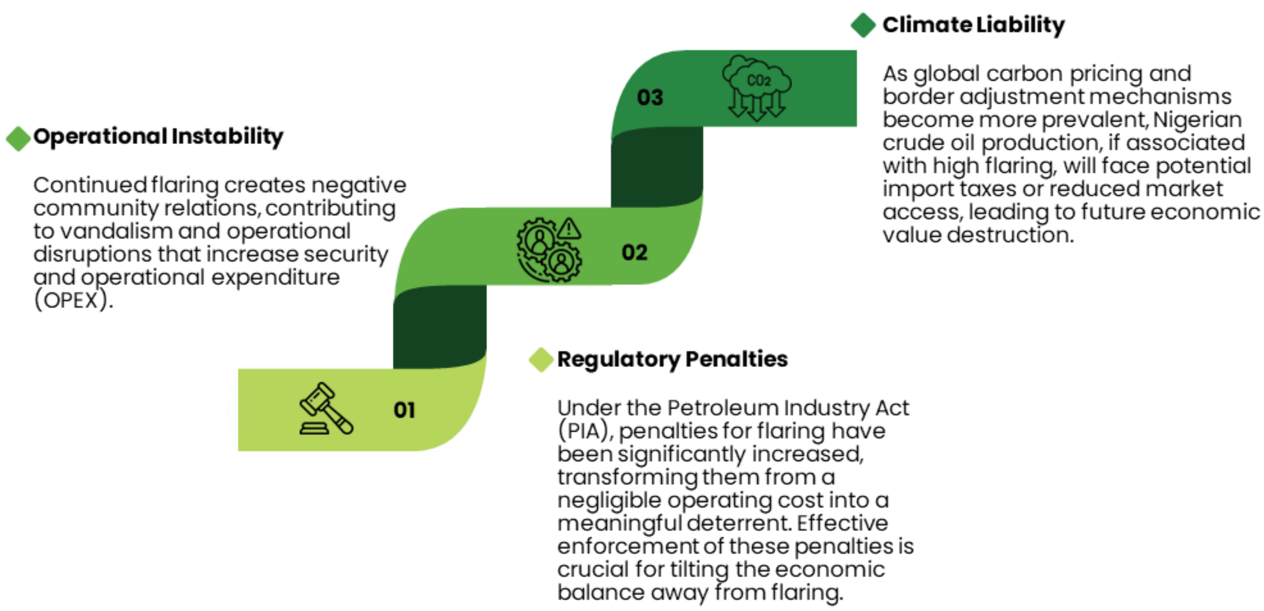

Figure 22. The Cost of Flaring.

7.1.2 The Economic Case for Recovery

Typically, flare gas recovery projects yield immediate, measurable financial benefits:

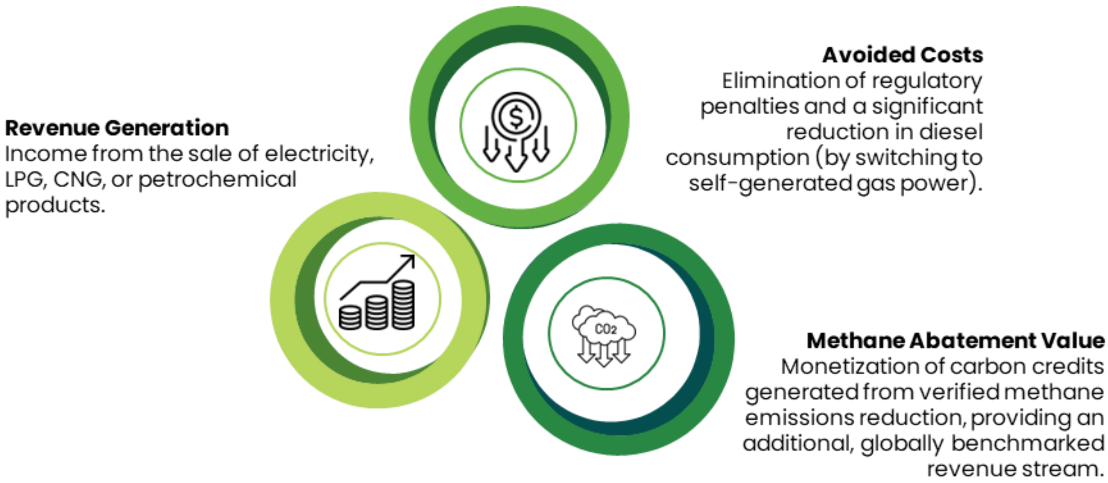

Figure 23. The Economic Case for Recovery.

7.2 Revenue Streams: Maximising Gas-to-Value

Generally, for flare gas projects to attract external capital, they must demonstrate diverse, robust, and hedged revenue streams. Diversification mitigates market concentration risk (e.g., over-reliance on the power sector, which suffers from liquidity issues we described earlier).

7.2.1 Domestic Gas Pricing and Market Structure

1. **Regulatory Pricing Framework**

The pricing mechanism for the domestic gas market is controlled and guided by legislation. The current framework is governed by:

i. Petroleum Industry Act (PIA) 2021.
ii. Gas Pricing and Domestic Demand Regulations (2023).

Prices are not freely determined across all sectors but are set annually by the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA). Current regulated domestic gas prices are tiered based on the consumer segment:

Consumer Sector	**Price (2024 Benchmark)**	**Unit**
Power Sector	$2.42	MMBTU
Commercial Sector	$2.92	MMBTU
Gas-Based Industries	$3.32	MMBTU

Table 3: Current Gas Pricing (2025).

2. **Market Segments**

The Nigerian gas market is differentiated into two primary segments based on pricing and regulatory control:

- **Regulated Market**: This covers strategic sectors where pricing is controlled by the NMDPRA, including the power sector, the commercial sector, and specific gas-based industries.

- **Unregulated Market**: This segment allows for market-driven transactions, where industrial buyers are permitted to negotiate supply terms and prices directly with gas producers.

7.2.2 Energy Sales (Power and Industrial Off-take)

The most common revenue stream, based on signed Power Purchase Agreements (PPAs) or Gas Sales Agreements (GSAs) with creditworthy industrial off-takers. The stability of these contracts is paramount to bankability. From our assessment, industrial buyers (off-takers), unlike many entities in the challenged power sector, often offer better credit quality and can pay premium prices for reliable, captive power, mitigating systemic payment risks.

7.2.3 Petrochemicals and NGLs

Projects focused on separating and monetising high-value constituents (Propane, Butane, Ethane) often yield higher margins than simple gas-to-power. These products have established international pricing benchmarks and can be exported, generating crucial foreign exchange (FX) revenue. This revenue stream acts as a natural hedge against domestic currency volatility.

7.2.4 Carbon Credits and Methane Abatement Value

For Nigeria, flare gas reduction is one of the most effective methane abatement levers, generating high-quality carbon credits under international standards (e.g., Verra or Gold Standard).[20] This creates a predictable stream of revenue denominated in hard currency (USD), which can significantly enhance project IRR, particularly for marginal flare sites. This is detailed further in Section 9.

7.3 Financing Models

Traditional project financing models are often ill-suited for the scale and risk profile of dispersed flare gas sites. A mix of innovative and blended finance models is required.

7.3.1 Public-Private Partnerships (PPP)

The successful execution of the NGFCP is essentially a PPP model, transferring the obligation and commercial right to utilise flared gas from the oil operator to a private concessionaire. Government bodies (NUPRC, NMDPRA) must act as facilitators, standardising documentation and providing clear regulatory certainty.[19]

7.3.2 Blended Finance

This model leverages concessional capital from Development Finance Institutions (DFIs) and Multilateral Development Banks (MDBs) to de-risk projects,[6] making them attractive to commercial banks. DFIs can absorb the first loss, offer subsidised interest rates, or provide long-tenor debt, enabling the project to secure the remaining commercial debt required for full funding.

7.3.3 Private Equity (PE) and Venture Capital (VC)

Modular and mobile technologies (mini-LNG, virtual pipelines) are more appropriate for PE and VC funding due to their lower initial CapEx, rapid deployment potential, and scalability.[21] These funds typically seek higher returns over shorter time horizons (3–7 years) and are more comfortable with the technological risk inherent in novel, small-scale deployments.

7.4 Bankability Factors and Risk Mitigation Strategies

The true challenge is converting a technically viable project into a bankable one—a project that meets the risk-adjusted return hurdle for international financiers.

7.4.1 Mitigating Domestic Payment Risk

For projects selling to the domestic power sector, robust de-risking instruments are mandatory. This includes:

- **Partial Risk Guarantees (PRGs):** Provided by DFIs, ensuring payment for power or gas delivered even if the off-taker defaults.
- **Escrow Accounts:** Utilising dedicated, offshore escrow accounts for revenue collection and debt servicing, isolating project cash flow from domestic liquidity issues.

7.4.2 Addressing Foreign Exchange (FX) Risk

Since most CapEx for flare recovery equipment is denominated in USD, but domestic gas/power sales are in Naira, FX volatility is a significant risk. Mitigation requires:

- **FX Pass-Through:** Structuring gas and power sales agreements with a component of the tariff indexed to USD or using an agreed-upon FX rate, allowing developers to service their dollar-denominated debt.
- **Export Revenue Streams:** Prioritising projects that generate hard currency (e.g., methanol, bulk LPG export) to naturally match revenue currency with debt obligations.

7.4.3 Streamlining Legal and Regulatory Certainty

Final Investment Decisions (FIDs) are heavily reliant on the predictable enforceability of contracts. The government must ensure a clear, timely regulatory approvals process and demonstrate an unambiguous commitment to enforcing the PIA's flaring penalties, thereby maintaining the economic imperative for developers to proceed with recovery projects.

08. Section Eight

Policy and Regulatory Review

Decarbonising Nigeria's oil and gas sector through flare gas elimination requires not just investment and technology, but a fundamental redesign of the regulatory and governance landscape. The Petroleum Industry Act (PIA) of 2021 provides the legal bedrock[1], but its effective implementation, coupled with the national climate mandate, is the true measure of success.

8.1 The Foundational Regulatory Framework

8.1.1 Petroleum Industry Act (PIA) and Supporting Regulations

The PIA represents a significant paradigm shift from previous legislation by explicitly treating Associated Gas (AG) as a strategic resource rather than a waste byproduct. The Act mandates that petroleum exploration and production activities must prioritise the utilisation of AG. Key features include:

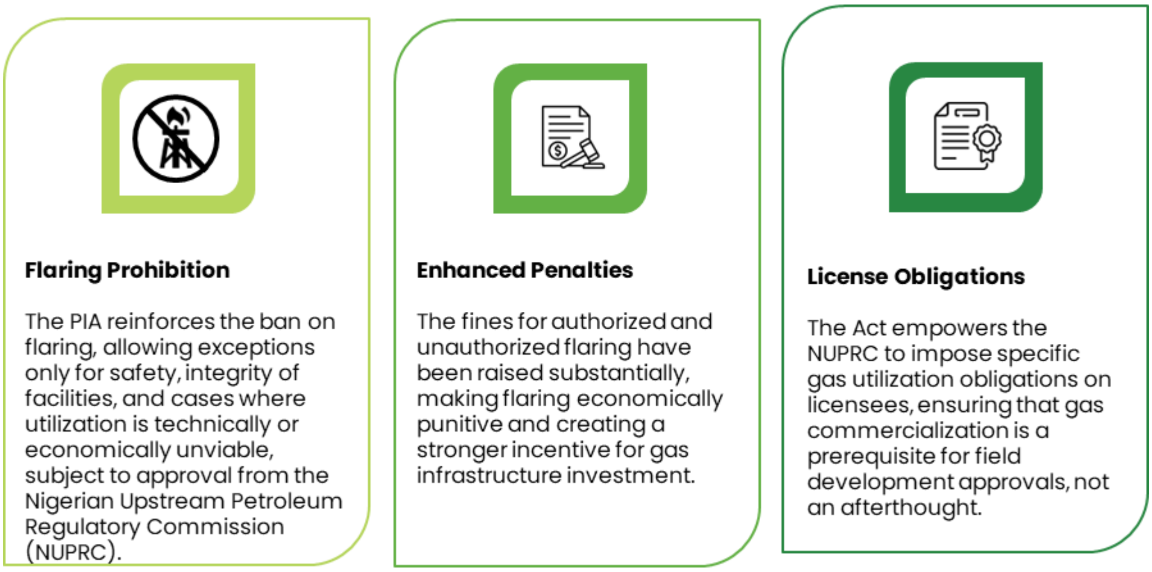

Figure 24. Petroleum Industry act (PIA) and Supporting Regulations.

8.1.2 Tariff, Pricing, and Fiscal Incentives Analysis

A reliable, market-reflective gas price is the most critical tool for driving investment.

- **Pricing Mechanism:** The PIA introduced a framework aimed at transitioning from a legacy of administratively set, "cost-plus" regulated prices (which historically undervalued the resource below production cost) toward market-based domestic gas pricing. Under the previous regime, the Domestic Supply Obligation (DSO) prices were often fixed, creating a disincentive for flare gas recovery. The new framework allows for price discovery based on the Gas-to-Sector (Power, Commercial, and Strategic Industries) model, with the ultimate goal of achieving a willing-buyer/willing-seller market. However, achieving a truly market-reflective tariff remains challenging due to socio-political sensitivities and the financial fragility of the domestic power sector. The government must ensure that the price developers receive for flare gas is high enough to justify the capital expenditure (CapEx).

- **Fiscal Incentives:** To de-risk gas projects, the government needs targeted tax allowances. This should include accelerated capital allowances for gas gathering, compression, and processing equipment, as well as reduced corporate tax rates for projects that demonstrate verifiable flare reduction and gas-to-value benefits (e.g., LPG production).[22]

Incentive Category	Specific Provision	Details Applicable to Gas/Flare Gas Projects	Reference
Tax Holidays	Initial Tax-Free Period	An initial 3-year tax holiday, renewable for an additional 2 years (up to 5 years total), for companies engaged in downstream gas utilisation or large-scale gas utilisation industries[28] (e.g., flare gas conversion to power, LPG, methanol).	CITA, S. 39(1a) (Confirmed by PIA)
Capital Allowances	Accelerated Capital Allowance	After the expiration of the tax-free period, companies are entitled to an annual allowance of 90% with 10% retention for qualifying capital expenditure on plant and machinery.	CITA, S. 39(1c) (Confirmed by PIA)
Investment Allowance	Gas Utilisation Investment Allowance	Companies that do not claim the initial tax-free period (CITA S. 39(1a))[28] are entitled to an Investment Allowance of 35% on qualifying expenditure. Alternatively, the Oil and Gas Companies (Tax Incentives, Exemption, Remission, etc.) Order, 2024[29] grants a 25% Gas Utilisation Investment Allowance on qualifying expenditure for new/ongoing midstream projects, deductible after the tax-free period.	CITA, S. 39(3); The Order, 2024 (S. 4, 5)
Pipeline Infrastructure	Extended Tax-Free Period	Companies solely involved in gas pipeline establishment and transportation are granted an additional 5-year tax-free period after the expiration of the CITA S. 39 tax holiday (making a potential total of 10 years). [28]	CITA, S. 39(4) (Confirmed by PIA)
Tax Rate	Companies Income Tax (CIT) Rate	Income from midstream and downstream gas operations is subject only to the standard corporate tax rate of 30%[1] (for large companies), compared to the Hydrocarbon Tax (HT) and higher tax burden for some upstream operations.	PIA, S. 267; Companies Income Tax Act (CITA)
Royalty Relief	Zero Royalty on Gas	Flare Gas: Gas taken from the flare stack for utilisation by a third-party permittee (under the Nigerian Gas Flare Commercialisation Programme, NGFCP) is taken free of charge and subject to 0% Royalty.	PIA, S. 105[1]; Flare Gas (Prevention of Waste and Pollution) Regulations, 2018[30]

Gas Tax Credits	Non-Associated Gas (NAG) Greenfield Tax Credit	US$1.00 per thousand standard cubic feet (MMSCF) or 30% of the fiscal gas price (whichever is lower) for new NAG greenfield projects (onshore/shallow water) with low Hydrocarbon Liquids (HCL) content, applicable for a maximum of 10 years[29].	The Order, 2024 (S. 1)
Deductible Costs	Gas Development Costs	All costs incurred on gas development up to the measurement point (separation/processing point) are fully deductible for both Hydrocarbon Tax (HT) and Companies Income Tax (CIT) purposes. [1]	PIA (Fiscal Framework Provisions)

Table 4: Key Fiscal Incentives for Gas Projects under the PIA.

8.2 Governance and Institutional Coordination

The PIA created distinct regulators (NUPRC for upstream, NMDPRA for midstream/downstream), aiming to improve efficiency. However, effective flare reduction requires seamless coordination across these bodies, alongside the Gas Aggregation Company of Nigeria (GACN).

8.2.1 Assessment of Current Governance Structure

The current structure, while clear in delineation, presents coordination gaps. Upstream decisions (field development, flaring permits, penalty enforcement) rest with NUPRC, while downstream market access, tariffs, and distribution are governed by NMDPRA and supported by GACN. A lack of synchronised regulatory timelines between NUPRC granting the gas asset and NMDPRA confirming market viability can stall projects.

8.2.2 Capacity Building and Institutional Coordination

Effective enforcement requires regulatory staff with deep technical expertise in flare measurement, methane abatement technologies, and complex commercial gas contracts.

- **Mandate:** A single inter-agency task force, potentially chaired by the Ministry of Petroleum Resources, must be established to coordinate flare gas commercialisation efforts, ensuring NUPRC's enforcement aligns with NMDPRA's market development goals.
- **Capacity:** Significant investment in NUPRC and NMDPRA personnel is necessary for specialised areas like carbon accounting, satellite monitoring data analysis, and gas network planning.

8.2.3 Long-Term Gas Strategy within Nigeria's Energy Transition

The national gas strategy must be structurally integrated into the overall Energy Transition Plan (ETP). Gas is correctly identified as a "transition fuel." This means the policy must prioritise utilising flare gas for rapid, cleaner baseload power generation, while concurrently supporting the development of renewable-gas hybrid solutions for off-grid or stranded gas assets. The long-term strategy must ensure that gas infrastructure built today is either hydrogen-ready or re-purposable in the decades leading up to the 2060 Net-Zero target.

8.3 Compliance, Enforcement, and Digital Monitoring

The pivot from a culture of compliance based on payment of fines to a culture based on technical elimination is mandatory.

8.3.1 Enforcement and Compliance Gaps

Despite rising fines, the enforcement mechanism has historically been reactive rather than preventative. Gaps include:

- **Data Reliability:** Relying solely on operator-reported data is insufficient.
- **Penalty Collection:** The effectiveness is limited if fines are not consistently collected and utilised for remediation or community compensation.

8.3.2 Embedding Flare Compliance Monitoring in NUPRC's Real-Time Production Dashboards

To solve the enforcement gap, NUPRC needs to transition to a fully digital, transparent, and automated compliance system.

- **Digital Integration:** The Commission must continue to mandate the immediate installation of independently certified flow meters at all active flare points. This metering data must be streamed in real-time, alongside oil production data, into the NUPRC's central production dashboard.[15]
-
- **Automated Penalties:** Penalties should be tied directly to a Flare Quota Breach. When a field exceeds its permitted flaring quota (calculated on a monthly or quarterly basis), the system should automatically generate a non-negotiable liability notice. This eliminates regulatory discretion and ensures predictability. Satellite-based monitoring Visible Infrared Imaging Radiometer Suite (VIIRS data) should be used as an independent check against ground-level metering.

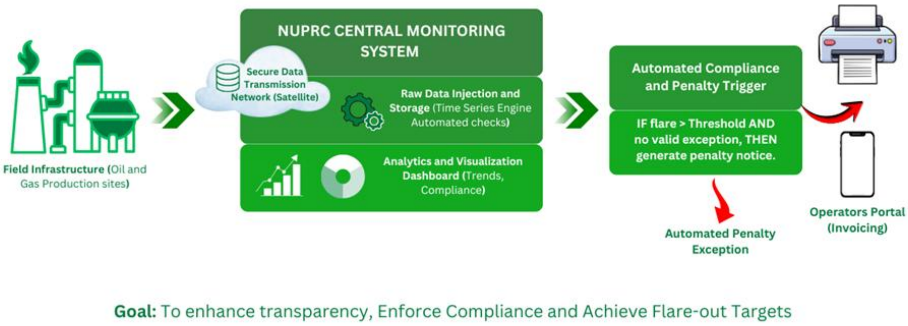

Figure 25. Proposed Real-Time Flare Monitoring Architecture.

8.4 Regulatory Landscape and Enforcement Gaps

The PIA 2021 provides the definitive legal framework, prohibits gas flaring except in specific, approved circumstances (safety, testing, or minimal volumes).[1] The PIA also introduced a robust penalty regime intended to make flaring economically unviable for operators.

However, the efficacy of this regime hinges on strong institutional coordination and enforcement. Key challenges remain:

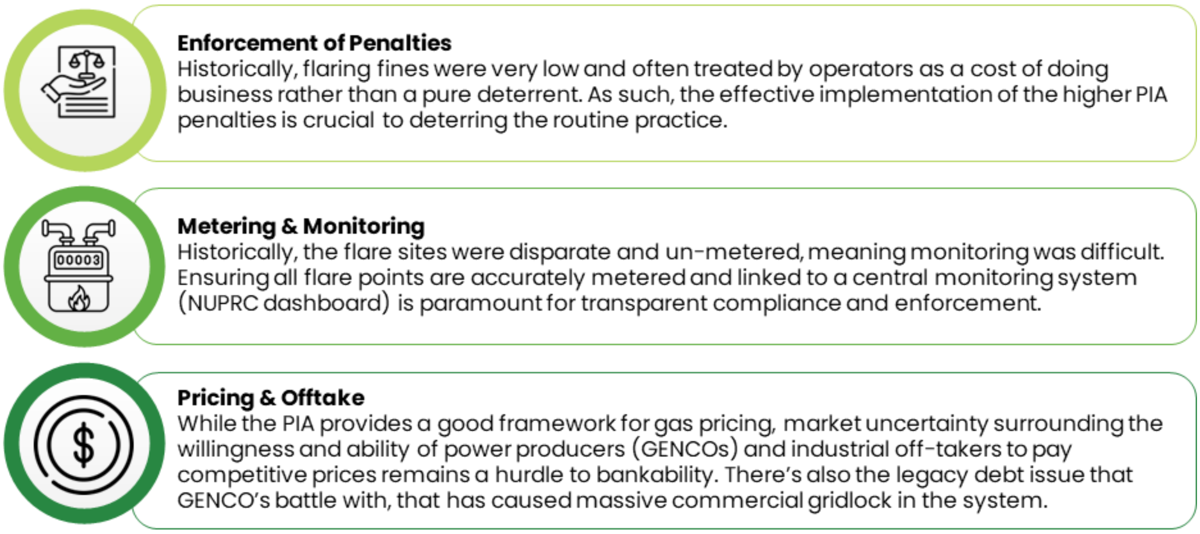

Figure 26. Regulatory Landscape and Enforcement Gaps.

8.5 Alignment with National Climate Commitments

The success of flare reduction is central to Nigeria's global climate credibility.

8.5.1 The Climate Change Act (2021) and Sectoral Carbon Budgeting

The Climate Change Act[34] provides a legal mandate for climate action and requires the National Climate Change Council (NCCC) to set national Carbon Budgets. The oil and gas sector must be allocated a stringent carbon budget that decreases annually. Flaring is predominantly a Scope 1 emission, meaning any flared gas directly consumes a portion of the sector's allocated budget.[23] This regulatory constraint provides a powerful new economic rationale for operators to eliminate flaring.

8.5.2 Analysis of NDC Targets and Flare Impact

Nigeria's updated Nationally Determined Contribution (NDC) commits to an unconditional contribution of a 20 percent emissions reduction below business-as-usual (BAU) by 2030, increasing to a conditional 47 percent with international support[35].

Currently flaring contributes to approximately 16 million tonnes of CO_2-equivalent (CO_2e) annually. To contextualize this:

- Nigeria's unconditional 2030 target requires a reduction of approximately 45.3 million tonnes of CO_2e.

- Therefore, the total elimination of routine gas flaring alone would account for nearly one-third (35 percent) of the total national unconditional commitment.

This equation demonstrates that flare monetization is not merely an energy strategy but the single most effective lever for meeting international climate obligations.

8.5.3 Strategic Recommendations for Regulatory Strengthening

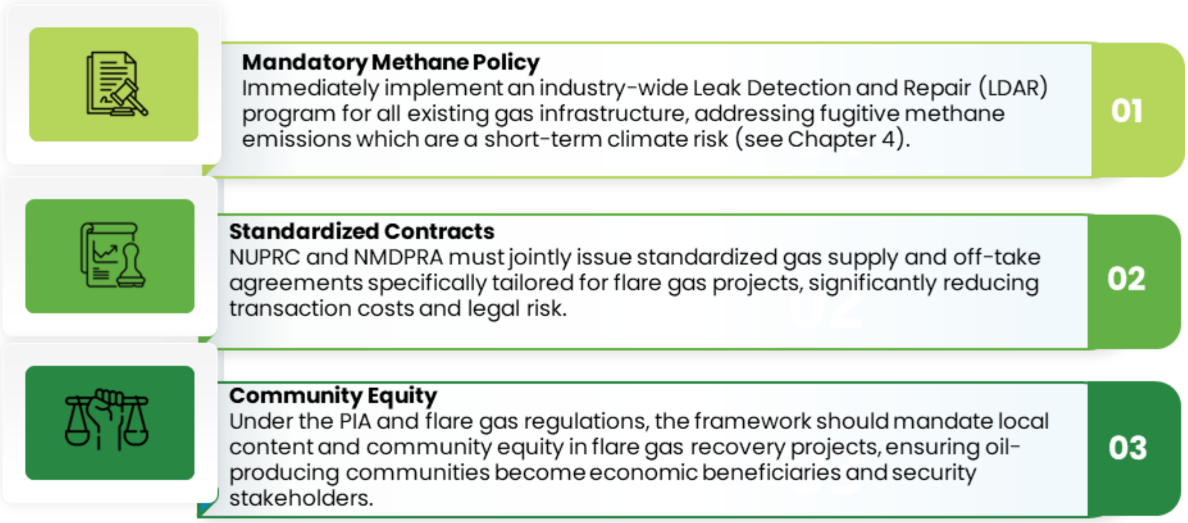

Figure 27. Strategic Recommendations for Regulatory Strengthening.

The regulatory environment must shift from merely penalising a bad outcome (flaring) to actively facilitating a good outcome (utilisation) through transparent pricing, streamlined processes, and ironclad enforcement.

8.6 Stakeholder and Community Participation

Sustainable flare gas reduction requires embedding local communities as vested partners, not just impacted bystanders. Promoting equitable participation by oil-producing communities and local stakeholders is critical for the long-term security and operational integrity of flare gas reduction and utilisation strategies. This includes:

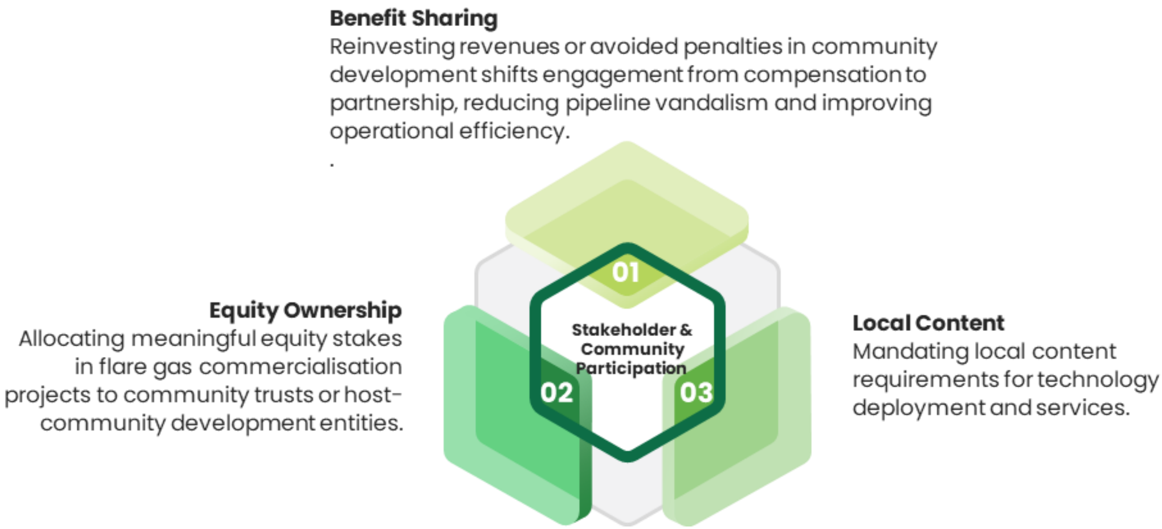

Figure 28. Stakeholder and Community Participation.

09. Section Nine

Climate Impact and National Alignment

The transition away from gas flaring is Nigeria's most potent single opportunity to meet its national and international climate commitments. The captured flare gas provides the fuel for economic growth, while the elimination of associated emissions provides immediate, high-impact reductions in the country's greenhouse gas (GHG) inventory, solidifying Nigeria's leadership role in Africa's energy transition.

9.1 GHG Reduction Potential and Contribution to Commitments

9.1.1 Scope 1 Emissions Reduction Potential

The primary climate benefit of flare gas capture is the elimination of the direct release of carbon dioxide (CO_2), uncommuted methane (CH_4), and other pollutants from the flare stack.

- **Carbon Dioxide (CO_2):** While flaring converts methane (a potent GHG) into less potent CO_2, eliminating the source removes the CO_2 entirely.

- **Methane Abatement:** Even with high combustion efficiency, flares release some uncommuted methane (known as "methane slip")[11]. Furthermore, fugitive methane leaks from associated infrastructure are a significant, often underestimated, source of emissions. Flare gas recovery and the implementation of robust Leak Detection and Repair (LDAR) programs offer a dual pathway to reduce emissions with immediate warming impact. Methane has a global warming potential over 80 times that of CO_2 over a 20-year timeframe, making its abatement the fastest way to achieve climate benefits.[12]

9.1.2 Alignment with Nigeria's NDCs and ETP

Flare reduction is central to Nigeria's commitments:

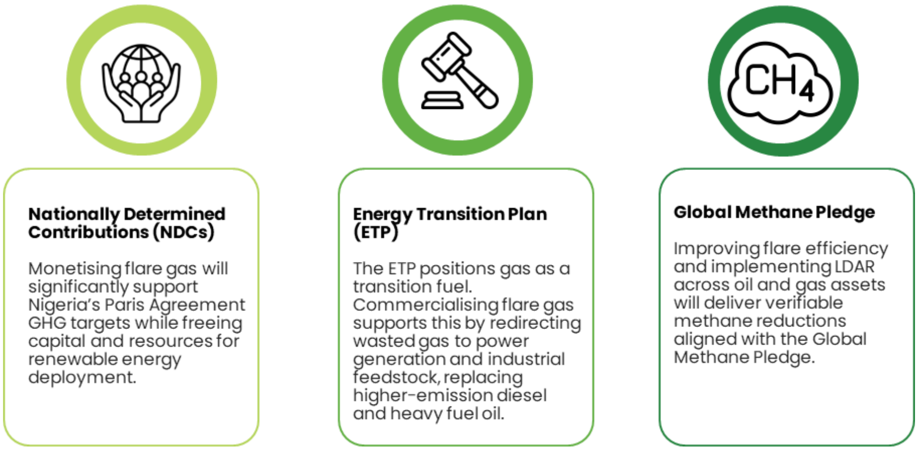

Figure 29. Alignment with Nigeria's NDCs and ETP.

9.2 Market Access Pathways and Methodologies

Flare gas capture projects are ideally suited for generating internationally recognised carbon credits.

- **Methodology Development:** Developers and regulators must collaborate to adopt and validate international methodologies (e.g., from Verra or Gold Standard) tailored for flare gas reduction and utilisation (e.g., gas-to-power, LPG).
- **MRV Systems:** Robust, digital MRV systems (as discussed in Chapter 8) are the foundation, ensuring the permanence, additionality, and leakage avoidance required for certification.[13]

9.3 Climate Finance Linkages

Monetising flare gas can access several dedicated international climate finance pools:

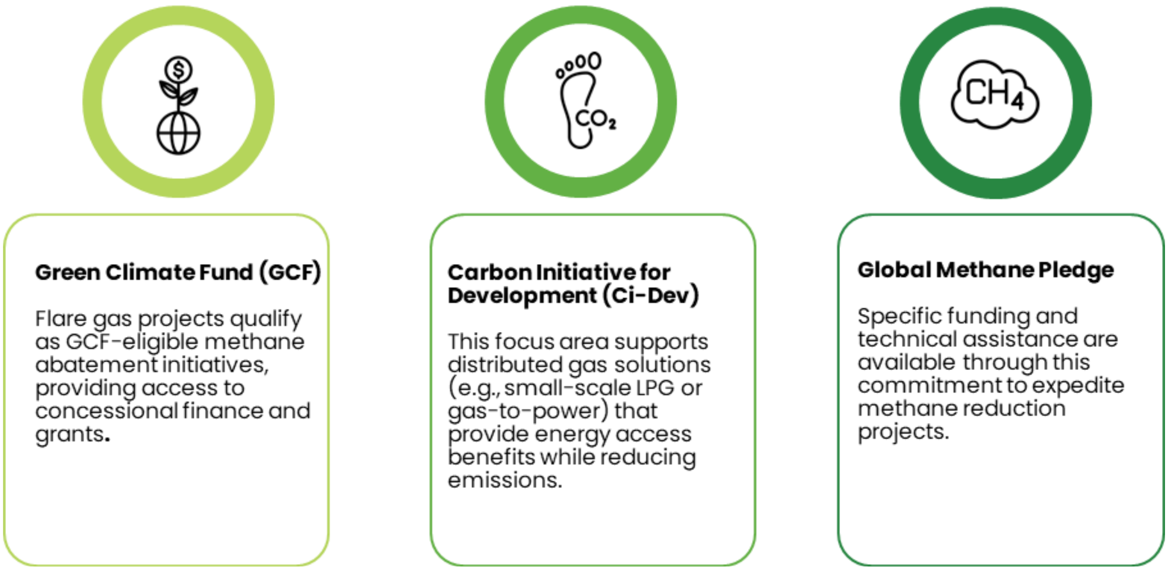

Figure 30. Climate Finance Linkages.

9.4 Carbon Registry Roadmap and Credit Value Chains

Establishing a national carbon registry is essential for transparency and attracting Article 6 market linkages.

- **National Registry:** The NCCC must prioritise the development of a secure, transparent **National Carbon Registry** to track the issuance, transfer, and retirement of all domestically generated carbon credits. This registry should be designed for future linkage with international platforms.

- **Carbon Credit Value Chains:** Flare gas projects serve as the point of Origination. NUPRC/NMDPRA-validated data enables Certification (via international or national standards). The credits are then passed to Aggregators before Sale to domestic compliance buyers or international voluntary/Article 6 markets.

9.5 Incentives

To spur the market, specific financial incentives for carbon credit generation are needed:

- **Tax Reliefs:** Providing tax holidays or accelerated depreciation specifically tied to the revenue generated from the sale of verified carbon credits.
-
- **FX Retention:** Guaranteeing that carbon credit revenue, which is typically in USD or Euros, can be retained by the project developer for debt servicing or equipment import, avoiding punitive currency conversion requirements.

10. Section Ten

Technology, Innovation, Local Content and International Cooperation

The success of Nigeria's flare gas monetisation and decarbonisation drive hinges on the strategic adoption, adaptation, and domestication of proven technologies. A fragmented approach relying solely on imported solutions will be financially unsustainable and unable to address the diverse technical profiles of the country's over 170 flare sites. This chapter explores the technological imperatives and the vital role of local content, skills development, and international partnerships.

10.1 Technological Levers for Flare Abatement

Flare sites in Nigeria vary drastically in volume, pressure, and gas composition, requiring a flexible suite of solutions, not a one-size-fits-all approach.

10.1.1 Modular and Mobile Flare Capture Technologies

For the majority of marginal and stranded flare sites (those producing less than 5 MMscfd of associated gas), large, centralised infrastructure is cost-prohibitive. The solution lies in smaller, skid-mounted, factory-fabricated units:

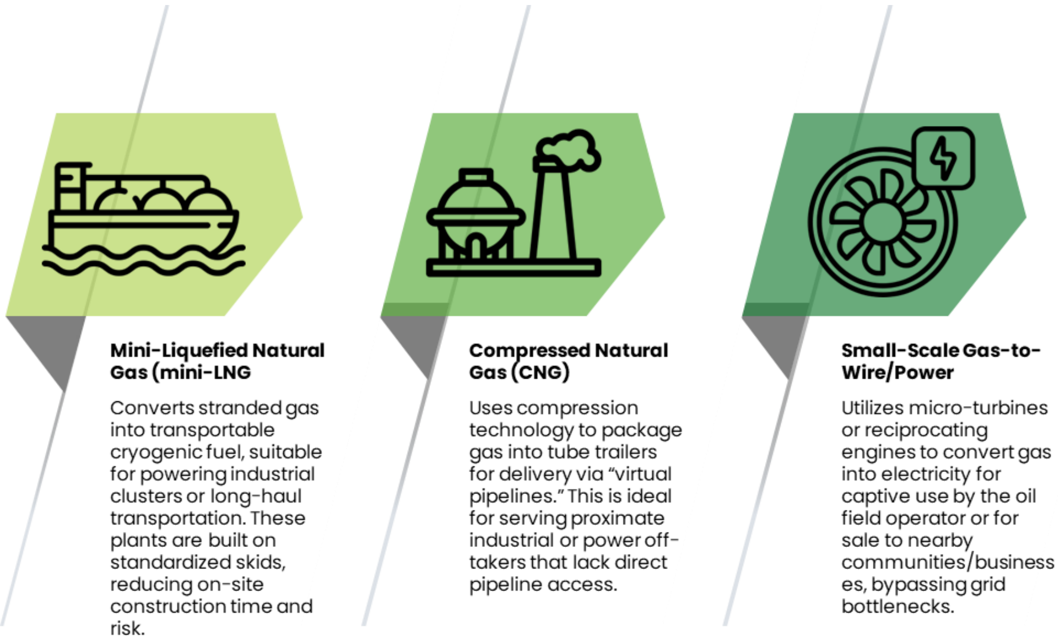

Figure 31. Modular and Mobile Flare Capture Technologies.

10.1.2 Digital Tools: Leak Detection, Repair (LDAR), and MRV Systems

Decarbonisation is not complete without addressing the secondary source of emissions: fugitive methane.

- **Methane LDAR Programs:** Mandatory implementation of LDAR programs across all upstream and midstream facilities is necessary. This requires specialised equipment (infrared cameras, drones, or satellite surveillance) to detect methane leaks at valves, flanges, and compressors. Rapid repair of these leaks offers near-immediate and cost-effective emissions reductions.[13]

- **Advanced MRV Integration:** The NUPRC's push for real-time monitoring (Section 8) requires the adoption of digital Measurement, Reporting, and Verification (MRV) systems.[13] These systems combine satellite data (VIIRS for heat detection) with ground-based flow meters to provide an auditable, reconciled inventory, which is crucial for compliance and for generating certified carbon credits.

10.2 Renewable–Gas Hybrid Models and Future Fuels

As the energy transition matures, gas must serve as a bridge to a truly low-carbon system. Hybrid solutions and future-proofing infrastructure are vital to minimise stranded asset risk.

10.2.1 Gas-Renewable Hybrid Solutions

For remote or off-grid flare gas power projects, integrating gas generation with renewable sources (solar PV or battery storage) offers significant advantages:

- **Enhanced Reliability:** The gas turbine provides firm, dispatchable power when renewables are intermittent.

- **Optimised Gas Use:** During peak solar hours, the gas turbine can throttle down or shut off, conserving the gas resource and further reducing operational GHG emissions. This model provides the high-quality power required by industrial users.

10.2.2 Hydrogen Readiness

Any significant new gas infrastructure investment (pipelines, compression stations, turbines) should be assessed for hydrogen readiness. While blue or green hydrogen production is nascent in Nigeria, designing pipelines and processing equipment to handle a percentage of hydrogen blending in the future ensures long-term asset utility and aligns with the post-2040 deep decarbonisation goals of the ETP.[13]

10.3 Driving Local Content and Capacity

Moving flare gas projects from concept to operation requires domestic engineering, fabrication, and maintenance support. Local content must transition from merely providing non-technical services to delivering core technological value.[25]

10.3.1 Local R&D and Fabrication Capacity

The focus must shift towards domestic assembly and fabrication of modular units.

- **Standardised Skid Fabrication:** Incentivise local companies to fabricate the structural skids, pipe spooling, and electrical integration systems for mini-LNG or CNG plants. This dramatically reduces the FX component of CapEx, making projects cheaper and faster to deploy.

- **Technical Centres of Excellence:** Establish focused research and development partnerships between Nigerian universities, NCDMB (Nigerian Content Development and Monitoring Board), and international technology providers to adapt imported technologies to the specific high-wet gas compositions often found in Nigerian reservoirs.

10.3.2 Workforce Development and Skills Transfer

A lack of local technical expertise is a bottleneck to project scalability and long-term maintenance.

- **Targeted Training:** Develop certification programs focused on flare gas technologies: cryogenics (for LNG), compression systems (for CNG), and advanced metering/control systems (MRV).

- **Mandated Transfer:** Regulatory approval for large-scale technology import should be explicitly tied to a verifiable skills transfer program that ensures Nigerian engineers and technicians are trained to operate and maintain the equipment for its full lifespan.

10.4 Strategic International Cooperation

International cooperation provides access to specialised financing, derisking tools, and cutting-edge technology transfer, accelerating Nigeria's transition timeline.

10.4.1 International Cooperation Frameworks

Nigeria should actively leverage existing bilateral and multilateral agreements:

- **Partnerships with Germany (or similar):** Germany, for example, is keen on supporting gas infrastructure and decarbonisation in Africa. These partnerships can provide access to advanced combustion technology, hydrogen expertise, and dedicated development finance for flare abatement projects.

- **Global Methane Pledge Support:** Technical assistance from the World Bank and other development partners should be utilised specifically for deploying LDAR and advanced MRV monitoring systems.

10.4.2 Investment Opportunities for Technology Partners

International Original Equipment Manufacturers (OEMs) should be encouraged to transition from purely selling equipment to establishing **local assembly/maintenance hubs** in Nigeria. Opportunities include:

- Joint ventures with local partners for gas compressor and turbine maintenance.
- Investment in local software firms to customise MRV and SCADA systems for flare gas facilities.
- Partnerships to provide specialised equipment leasing, which lowers the initial CapEx burden for local flare gas developers.

11. Section Eleven

Roadmap and Recommendations

The elimination of routine gas flaring and the decarbonisation of Nigeria's oil and gas sector require a coordinated, multi-stakeholder strategy executed over three distinct time horizons. This chapter consolidates the technical options, policy reforms, and financial mechanisms discussed throughout this report into a prioritised action plan with defined key performance indicators (KPIs).

11.1 Phased Action Plan: Short, Medium and Long-Term

The strategy proposed moves sequentially from establishing regulatory credibility to achieving large-scale, sustainable commercialisation.

11.1.1 Short-Term (0–3 Years): Foundation and Compliance

The immediate focus is on enforcement, metering, and market access security for pilot projects.

Action Focus	Key Initiative	Responsible Stakeholders
Enforcement	Mandatory, independent flare metering roll-out (NUPRC).	NUPRC, Operators
Regulatory	Automate penalty issuance for quota breaches (Chapter 8).	MPR, NUPRC
Market	Finalise template Gas Sale Agreements (GSAs) for flare gas.	NMDPRA, GACN
Finance	Launch dedicated flare gas credit window (de-risked CapEx loans).	CBN, BOI, Development Partners
Technology	Implement industry-wide Leak Detection and Repair (LDAR) programs.	Operators

Table 5: Short-Term Recommendations (0–3 Years).

11.1.2 Medium-Term (3–7 Years): Scale-Up and Diversification

The focus shifts to infrastructure build-out, carbon pricing, and diversification of end-use applications.

Action Focus	Key Initiative	Responsible Stakeholders
Infrastructure	Commissioning of virtual pipeline hubs (CNG/mini-LNG) and associated logistics.	Private Developers, NMDPRA
Policy	Introduction of a modest, escalating sectoral Carbon Tax on GHG emissions.	NCCC, FIRS

Carbon Market	Operationalise the National Carbon Registry for NDC tracking and credit certification.	NCCC, NUPRC, NMDPRA
Local Content	Establish domestic assembly and maintenance hubs for modular flare capture units.	NCDMB, OEMs
Energy Mix	Scale deployment of gas-renewable hybrid power solutions for industrial clusters.	Private Sector, GENCOs

Table 6: Medium-Term Recommendations (3–7 Years).

11.1.3 Long-Term (7+ Years): Deep Decarbonisation and Integration

The final stage involves systemic resilience, CCS scaling, and hydrogen readiness.

Action Focus	Key Initiative	Responsible Stakeholders
Flaring Goal	Achieve and maintain **near-zero routine flaring** across all active fields.	NUPRC, Operators
Future Fuels	Mandate Hydrogen-Ready design for all major new gas infrastructure.	MPR, NUPRC, NMDPRA
Mitigation	Scale CCS capacity to service large industrial corridors (< 5 CO_2/yr).	Operators, NUPRC (Storage Licensing)
Policy	Full integration of carbon pricing revenues into climate transition funds.	NCCC, FMOF
Innovation	Pilot advanced BECCS and Direct Air Capture technologies.	Research Institutions, MPR

Table 7: Long-Term Recommendations (7+ Years).

11.2 Priority Pilot Projects and Quick Wins

The momentum required for this transition must be established through immediate, visible wins. These should focus on the Nigeria Flare Gas Commercialisation Programme (NFGCP) sites that offer the highest MMscfd volumes and the shortest distance to a commercial off-taker.

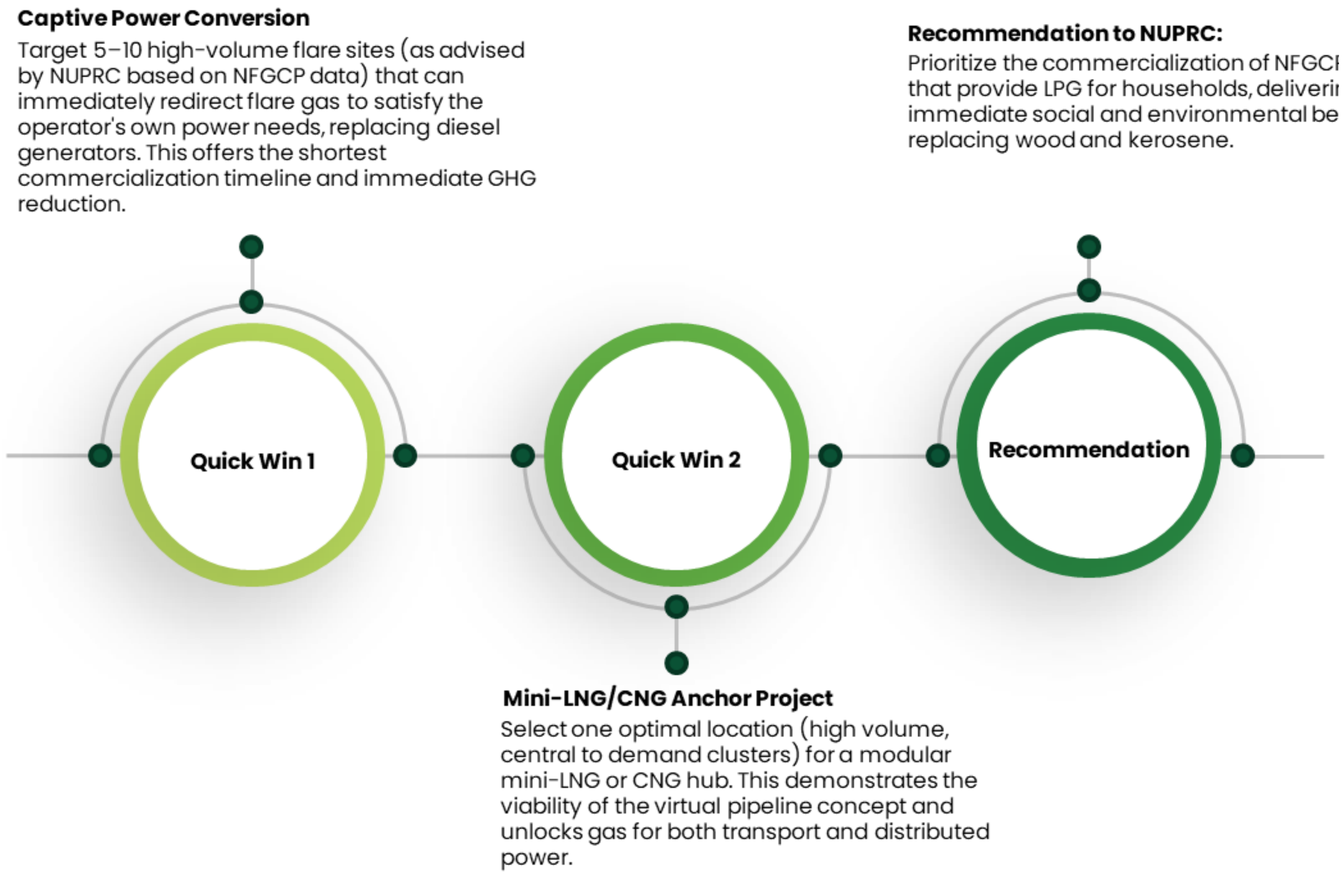

Figure 32. Priority Pilot Projects and Quick Wins

11.3 Stakeholder Roles and International Cooperation

The responsibility for success is shared across the public, private, and civil sectors.

Stakeholder Group	Core Responsibility
Government (MPR, NUPRC, NMDPRA)	Policy coherence, regulatory stability, data integrity, and enforcement (licensing/penalties).
Operators (IOCs & Independents)	Primary accountability for zero-flaring mandate, LDAR compliance, and technical execution of recovery projects.
Financiers (FMOF, Banks, Private Equity)	De-risking capital, providing low-interest or concessional loans tied to verified GHG reductions and ESG performance.
Oil-Producing Communities	Enabling security, local partnership, equitable participation (Chapter 8), and serving as anchor LPG or power off-takers.
International Partners / Dev. Partners	Providing concessional finance, technical assistance, MRV expertise, and technology transfer for CCS and methane abatement.

Table 8: Stakeholder Roles.

11.4 MRV, KPI Framework, and Benchmarking

Measurable progress requires a robust framework for monitoring and accountability, moving beyond simple flaring volumes.

11.4.1 Key Performance Indicators (KPI's)

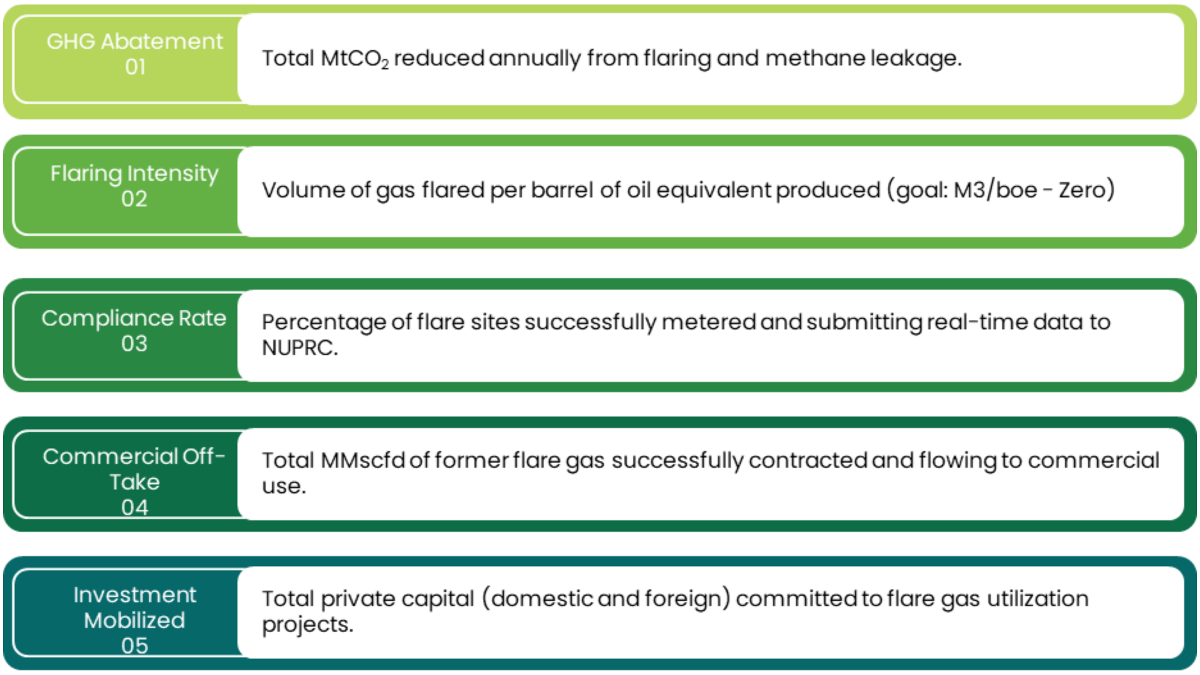

Figure 33. Key Performance Indicators (KPI's).

11.4.2 Regional and International Benchmarking

Nigeria should benchmark its flaring intensity against successful jurisdictions:

- **Norway:** Demonstrated global best practice with near-zero flaring, achieved through strong regulation and carbon pricing.
- **United Arab Emirates (UAE):** Successfully monetised associated gas, becoming a major global gas exporter while drastically cutting flaring.

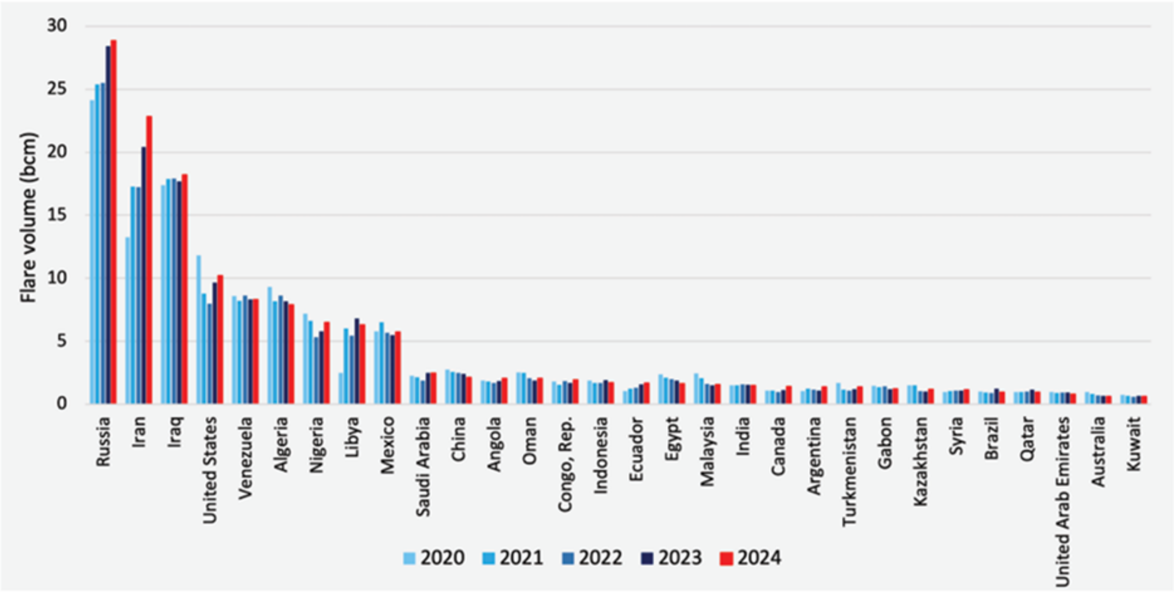

Figure 34. Benchmarking Nigeria's Flare volume vs Global Standard.

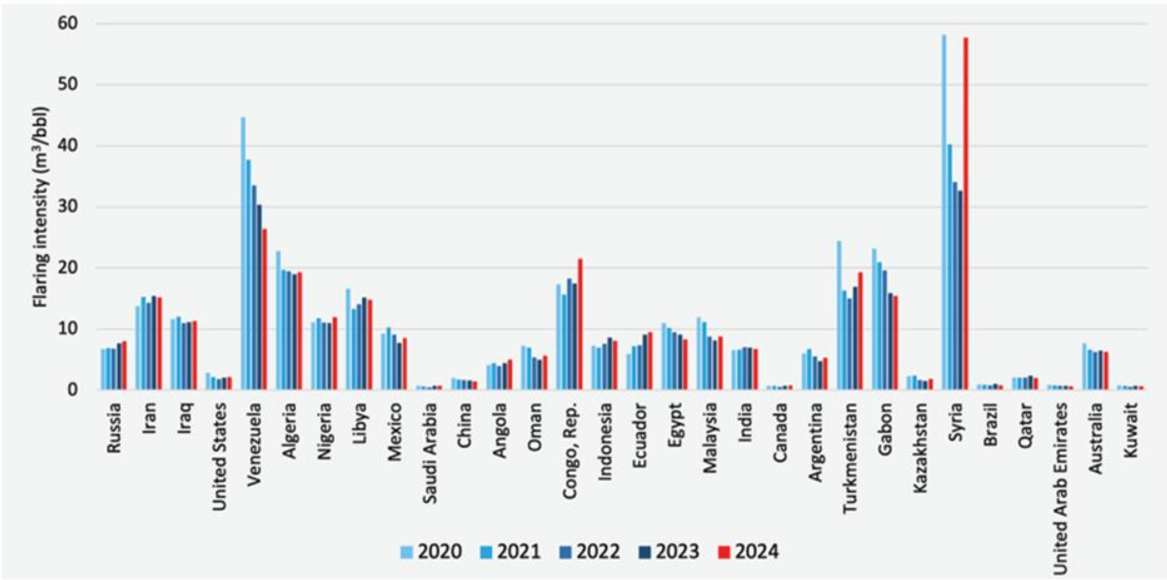

Figure 35. Benchmarking Nigeria's Flare intensity vs Global Standard.

11.5 ESG and Social Impact Considerations

Gas flare elimination is an ESG triple-win: it reduces climate risk (E), provides clean energy access and improved health outcomes (S), and demonstrates good corporate governance (G).

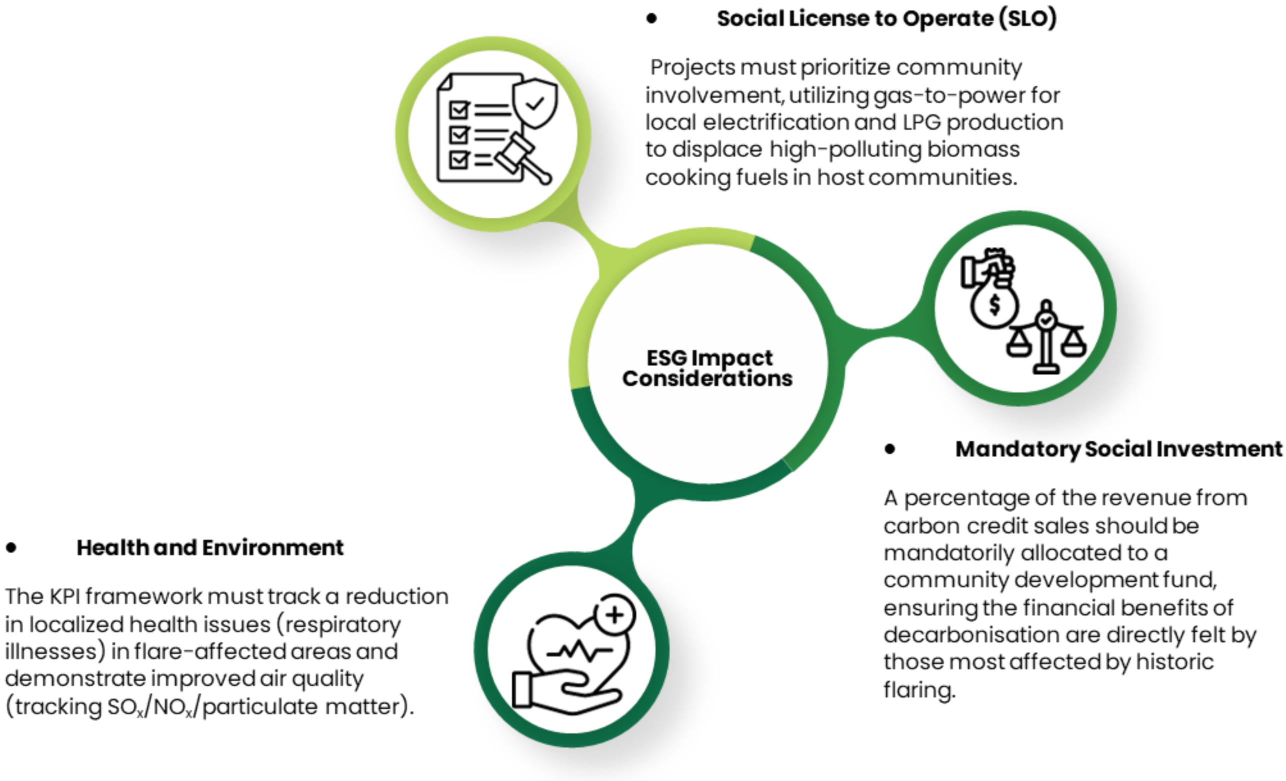

Figure 36. ESG and Social Impact Consideration.

12. Section Twelve

Conclusion and Strategic Next Steps to Zero Flaring

The analysis presented throughout this whitepaper confirms that the successful elimination of gas flaring in Nigeria is no longer a matter of technical feasibility; it is a question of strategic execution. The path to achieving the **Zero Flaring target** hinges on the concerted, logical next steps taken by three core stakeholders: the government/regulators, the upstream operators, and the financial community.

The Strategic Roadmap: Logical Next Steps

1. For Government and Regulators (The Enabling Environment)

The primary responsibility of the Federal Government of Nigeria (FGN) and its agencies (NUPRC, MPR, CBN) is to finalise the institutional and legal frameworks necessary to de-risk projects post-auction.

Action Area	Logical Next Step	Stakeholder
Payment Assurance	**Finalize the Payment Assurance Mechanism (**PAM**).** The CBN and NUPRC must provide a clear, legally binding framework for FGN guarantee/backing for domestic gas sales (especially GtP off-take), thereby eliminating the major payment risk identified by financiers.	FGN, CBN
License Ring-Fencing	**Issue** NFGCP **Direct Agreements.** Translate NFGCP winners' obligations into fully executed Direct Agreements that insulate the project's economic terms from retrospective policy changes and regulatory price shifts (e.g., changes to the Domestic Supply Obligation (DSO) price).	NUPRC, MPR
Infrastructure De-Risking	**Establish a Dedicated Security Fund/Insurance Pool.** Partner with international Political Risk Insurance (PRI) providers to create a tailored, sector-specific fund that addresses the high political and vandalism risks in the Niger Delta, easing the burden on individual project CapEx.	FGN, NCDMB, NMDPRA (MDGIF)

Table 9: Logical Next Steps for Government and Regulators.

2. For Upstream Operators (The Pivot to Commercialisation)

Operators must shift their mindset from minimising fines to maximising asset value. This involves a change in internal capital allocation and commercial strategy.

Action Area	Logical Next Step	Stakeholder
Volume Commitment	**Execute Minimum Volume Guarantee** (MVG) **Contracts.** Immediately negotiate and execute binding MVG or Take-or-Pay agreements with NFGCP project sponsors. This formally transfers gas supply risk from the utilisation project back to the upstream asset, meeting a core bankability requirement.	Upstream Operators (IOCs, Independents)
Product Prioritisation	**Prioritise** LPG\NGL **Schemes for** FX **Generation.** Focus internal investment on projects with the highest FX-earning potential to service USD-denominated debt and maximize shareholder returns, thereby addressing the currency risk Table 6.1.	Upstream Operators
Community Engagement	**Integrate CDAs into Project** CapEx**.** Recognise that community engagement and security provisions are a fixed, non-negotiable cost of doing business. Formally budget for and implement robust Community Development Agreements (CDAs) to secure the Social License to Operate (SLO).	Project Sponsors

Table 10: Logical Next Steps for Upstream Operators.

3. For Project Sponsors and Financial Institutions (The Investment Mandate)

The financial community must recognise the opportunities presented by de-risked gas projects and deploy capital using tailored structures.

Action Area	Logical Next Step	Stakeholder
Risk Structuring	**Utilise the Full Mitigation Stack.** Instead of rejecting projects based on Nigeria's perceived risk profile, apply the structured mitigation instruments (PRI, Escrow, PAM) to achieve bankability. Debt-to-Equity ratios should reflect the reduction in risk achieved through these instruments.	Commercial Banks, DFIs, Export Credit Agencies
Local Capacity Funding	**Create Naira** (NGN) **Denominated Funding Channels.** Local financial institutions must develop structured financing products in Naira to fund the domestic portion of the, reducing reliance on debt where possible, and mitigating partial exposure.	Local Banks, BOI, NDIC
Carbon Finance	**Integrate Voluntary Carbon Market Credits.** Actively structure project revenue streams to include the value of certified carbon emission reduction (CER) credits. This secondary revenue stream enhances project IRR and provides a necessary buffer against market volatility.	Project Sponsors, Carbon Funds

Table 11: Logical Next Steps for Project Sponsors and Financial Institutions.

The convergence of regulatory necessity, clear commercial viability, and structured risk mitigation creates an undeniable mandate for action. Zero flaring is within reach, provided the roadmap detailed above is pursued with urgency and collaboration. The benefits extend far beyond compliance, establishing a new foundation for sustainable energy and economic prosperity in Nigeria.

Appendix A

Case Study - Leveraging German Technology for Gas Flare Reduction in Nigeria

1. Introduction and Context

The German-Nigerian Flare4Value Project Study Tour (October 27th-31st, 2025) provided a crucial platform for high-level Nigerian stakeholders to engage with leading German technology providers, policy experts, and financing institutions. The central objective of the tour was to gather actionable intelligence and technological solutions to inform the Roadmap for Flare Gas Reduction in Nigeria and accelerate the successful implementation of the Nigerian Gas Flare Commercialisation Programme (NGFCP). This case study synthesises the key technological highlights and strategic lessons learned from the site visits, focusing on their direct applicability to solving Nigeria's persistent gas flaring challenges.

2. Objectives of the Site Visits

Nigeria's 210.54 trillion Cubic Feet (TCF) gas reserves are significantly underutilised, with 5.3 billion cubic meters flared in 2022. The NGFCP faces specific hurdles: low gas volumes at remote sites, infrastructure gaps, and financing scarcity.

The study tour was specifically curated to identify German solutions that could:

1. **Commercialise Small, Remote Flares**: Identify modular, scalable technologies suitable for small, dispersed flare sites (less than 5 MMSCF/D)**.**
2. **Improve Midstream Efficiency:** Explore advanced compression and processing technologies to handle diverse gas compositions.
3. **Advance Future Utilisation:** Review technologies related to cleaner energy carriers, such as Hydrogen **(**H_2**)**, aligning with the "Decade of Gas" and Nigeria's new hydrogen development initiatives.

3. Key Technological Solutions from Site Visits

The delegation visited the plant sites of technology providers who specialise in various aspects of gas handling, processing, and monetisation. The feedback from these visits highlighted specific, viable technological pathways for Nigerian flare sites.

Technology Provider	Core Solution / Function	Relevance to Nigerian Gas Flaring

Siemens Energy	Monetises flare gas via power generation using its gas turbines for on-site data centres or local grids.	Provides a high-value, direct monetisation pathway for generating electricity from associated gas, potentially for captive power use in oil fields or remote communities.
ITT Bornemann	Manufactures multiphase pumps that circumvent the conventional oil and gas production operation by pushing all products (gas, oil, water) to a central processing facility for separation.	Eliminates the need for separation infrastructure at the production site, reducing equipment requirements and operational complexity at remote wellheads, enabling more efficient flare gas recovery.
2G and Consortium (PRG Tech, Fornovogas, Hexagon Agility)	A complete, end-to-end value chain solution: capture, clean, compress, transport the flare gas via CNG, depressurise and utilise it at the end-use site in a gas generator for electricity generation.	Offers a ready-made, deployable solution for small-volume, remote flare sites, creating a virtual pipeline for gas delivery using CNG transport (road logistics). This is highly relevant to NGFCP's goal of small-scale monetisation.
Neuman & Esser	Provides **reciprocating compressor systems** for natural gas, as well as **hydrogen production solutions**. Their solution includes aggregating/clustering gas flare sites.	Addresses the need for high-pressure compression (essential for gas injection or long-distance transport) and offers a strategic approach to **clustering** multiple small flare sites to achieve an economic volume threshold for monetisation.

Table 1A: Plant Sites Visited and their Core Solution.

4. Strategic Application to the Nigerian Roadmap

The technologies observed directly address the core challenges of the NGFCP:

Challenge in Nigeria	German Technological Solution	Strategic Application
Low Volumes, Remote Sites	Modular, containerized Mini-LNG/CNG/Power units (e.g., 2G, Siemens Energy).	Accelerate NGFCP site monetisation by eliminating dependence on central pipelines and leveraging road-based transport (CNG).
Handling Complex Gas Streams	Multiphase pumping technology (ITT Bornemann).	Simplifies upstream operations, making the recovery of associated gas more efficient and cost-effective by reducing on-site processing.
Infrastructure Gaps & Scale	Compression and clustering solutions (Neuman & Esser).	Creates new, self-contained gas value chains outside the existing NGIC network or aggregates low-volume flares into bankable projects.
Long-term Energy Transition	H_2 production and CCUS technologies (Neuman & Esser, Siemens Energy).	Positions Nigeria to transition its gas exports to cleaner carriers and attract climate finance, future-proofing the gas economy.

Table 2A: Nigeria's Challenges and German Technology Core Solution.

5. Conclusion

The Study Tour successfully achieved its objective of grounding the Flare Gas Reduction Roadmap in tested, implementable technologies. The focus on modularity, scalability, and clustering (exemplified by the solutions from 2G, Siemens Energy, and Neuman & Esser) directly provides the missing link for monetising the smaller, geographically dispersed flares that have historically challenged the NGFCP. The next steps for the Nigerian delegation must involve fostering commercial partnerships to pilot and deploy these specific, relevant German technologies in the identified NGFCP sites.

Appendix B

Tables

Year	Gas Reserve (TCF)	Gas Production (BSCFD)	Flare (BSCFD)	% Flare
2023	208.83	6.91	0.51	7.38
2024	209.26	6.99	0.53	7.55
2025 (YTD July 31)	210.54	7.59	0.54	7.16

Table 1B: Nigeria's Gas Reserve, Production and Flare Percentage.

YEAR	AG PRODUCTION (MMSCF)	NAG PRODUCTION (MMSCF)	TOTAL GAS PRODUCTION (MMSCF)	FIELD USE (MMSCF)	DOMESTIC SALES (MMSCF)	EXPORT SALES (MMSCF)	TOTAL GAS UTILISED (MMSCF)	% UTILISED	TOTAL GAS FLARED (MMSCF)	% FLARED	GAS SHRINKAGE (MMSCF)
2021	1,459,589	1,284,724	2,744,313	759,483	580,893	1,138,645	2,479,021	90.00%	252,579	9.00%	12,713
2022	1,515,630	975,540	2,491,170	761,967	647,381	919,258	2,328,606	93.47%	162,564	6.53%	7,654
2023	1,506,770	984,712	2,491,481	803,992	649,930	847,755	2,301,676	92.00%	183,526	7.00%	6,397
2024	1,440,742	1,067,585	2,508,276	733,949	673,645	905,342	2,312,926	92.20%	192,887	7.69%	2,462

Table 2B: Nigeria's Gas Production and Utilisation.

YEAR	TOTAL GAS FLARED (BCM)	FLARE INTENSITY (m3/BBL)
2021	7	12.0978
2022	5	9.1519
2023	5	9.6821
2024	5	9.5872

Table 3B: Nigeria's Gas Flared and Intensity.

YEAR	CO2 (Tonnes/Yr)	CH4 (Tonnes/Yr)	N2O (Tonnes/Yr)	TOTAL GHG EMISSIONS (CO2e) (Tonnes/Yr)
2002	4,200,000	650,000	0	4,850,000
2003	4,800,000	700,000	0	5,500,000
2004	5,000,000	750,000	0	5,750,000
2005	4,850,000	720,000	0	5,600,000
2006	4,600,000	700,000	0	5,200,000
2007	4,400,000	650,000	0	5,050,000
2008	3,000,000	400,000	0	3,400,000
2009	2,900,000	350,000	0	3,250,000
2010	3,200,000	500,000	0	3,700,000
2011	3,500,000	550,000	0	4,000,000
2012	3,400,000	500,000	0	3,900,000
2013	2,500,000	300,000	0	2,800,000
2014	1,700,000	200,000	0	1,900,000
2015	1,800,000	200,000	0	2,000,000
2016	2,000,000	250,000	0	2,250,000
2017	2,300,000	200,000	0	2,500,000
2018	1,900,000	200,000	0	2,100,000
2019	1,500,000	200,000	0	1,700,000
2020	1,100,000	150,000	0	1,250,000
2021	1,600,000	300,000	0	1,900,000
2022	1,100,000	200,000	0	1,300,000
2023	1,000,000	200,000	0	1,200,000

2024	1,100,000	250,000	0	1,350,000

Table 4B: Nigeria's Green House Gas Emission Data.

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