

# Leveraging Enhanced Marginal Abatement Cost Curves for Methane Risk Management in the African Oil & Gas Sector

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Methane abatement in the oil and gas sector is widely recognised as one of the fastest and most cost-effective climate mitigation opportunities available today.<sup>1</sup> Reducing methane emissions presents a dual opportunity: curbing climate change and harnessing a wasted resource for economic gain. From an energy systems perspective, methane losses also represent a direct failure of energy productivity, signalling inefficiencies in upstream and midstream operations where commercially valuable gas is produced but not delivered to end use. In gas-producing African countries, these losses translate into foregone power generation potential, reduced domestic gas availability, and weakened energy security at a time of growing electricity demand. Much of the methane emitted in the oil and gas sector comes from avoidable sources, such as flaring, venting, and fugitive emissions from leaky infrastructure.<sup>2</sup> Effective methane management in this sector can yield new energy supplies, revenue streams, and health benefits for communities.<sup>3</sup>

The literature on methane mitigation in the oil and gas sector has firmly established that a wide range of technically viable abatement options already exists with direct implications for operational efficiency. These include improved detection and quantification and quantification technologies such as aerial surveys, satellite monitoring, and continuous

<sup>1</sup> IEA (2025), Global Methane Tracker 2025, IEA, Paris <https://www.iea.org/reports/global-methane-tracker-2025>, Licence: CC BY 4.0

<sup>2</sup> Boakye, B., Ofori, C. G., Yaatse, K. (2023). Examining Methane Management in the Climate Action Plans of Oil Producing African Nations. Africa Centre for Energy Policy

<sup>3</sup> Ofori, C. G., Osei, C. S. (2024). Environmental and Health Impacts of Methane Emissions. Africa Centre for Energy Policy.

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sensors, which provide systematic visibility over the presence, location, and in some cases the magnitude of methane emissions across assets and production basins. This enables operators and regulators to prioritise high-loss sites and target interventions where gas recovery potential is greatest. Additionally, structured Leak Detection and Repair (LDAR) programmes reduce avoidable gas losses and improve throughput reliability. Replacing or retrofitting high-bleed pneumatic devices improves process efficiency while lowering fuel gas consumption. Additionally, installing Vapour Recovery Units (VRUs) converts previously vented gas into saleable volumes, helping redirect gas away from venting or flaring into more productive uses.<sup>4,5</sup> Beyond emissions reduction, these measures increase deliverable gas volumes, improve utilisation of existing infrastructure, and strengthen the commercial and fiscal performance of gas assets without requiring new upstream investment.

In principle, deploying all these measures would deliver substantial emissions reductions and improved economic benefits. In practice, however, companies and regulators face real constraints. Capital is limited, implementation capacity varies, infrastructure is uneven, and not all measures are equally feasible or urgent across assets and jurisdictions. These constraints create a clear need for prioritisation that maximises abatement potential at minimum cost. One of the most widely used tools to support such prioritisation is the Marginal Abatement Cost Curve (MACC).

MACC is a graphical tool that ranks available mitigation options according to their cost per unit of emissions reduced, while also showing the volume of abatement each option can deliver. MACCs have become a tool for stakeholders and firms to systematically and economically identify and sequence methane abatement actions. To make MACCs truly actionable in Africa's oil and gas context, we must enhance them with risk and bankability factors such that companies, financiers, and insurers can use them to make real decisions.

## What is a MACC?

The Marginal Abatement Cost Curve for methane is typically presented as a bar chart that visualises both the cost and the scale of available emissions-reduction measures. Each bar represents a specific methane-abatement option, with the vertical axis showing the cost per tonne of methane abated and the horizontal axis showing the abatement potential. The width of each bar, therefore, indicates how much methane can be abated by that option, while its height reflects the cost per tonne of reduction.

In practical terms, the sign of the cost reflects whether the economic value obtained from implementing an abatement measure exceeds or falls short of its implementation cost.

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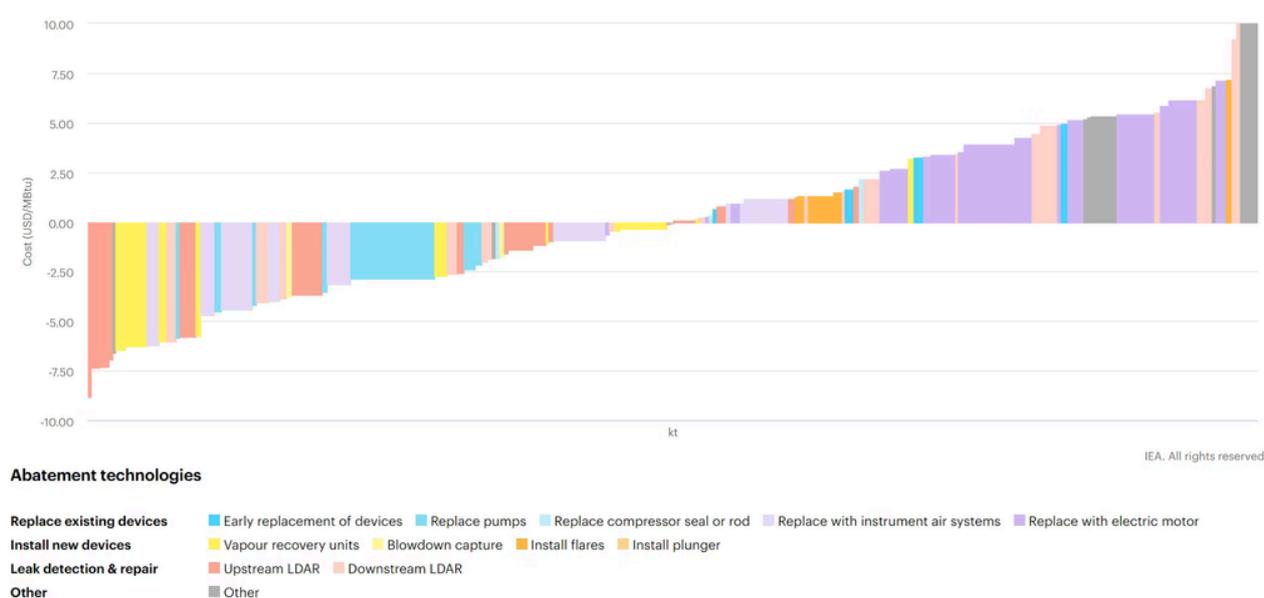
<sup>4</sup> IEA (2021), Driving Down Methane Leaks from the Oil and Gas Industry, IEA, Paris <https://www.iea.org/reports/driving-down-methane-leaks-from-the-oil-and-gas-industry>, Licence: CC BY 4.0

<sup>5</sup> Deng, W., Xie, X., Guo, Y., & Hu, G. (2024). Breakthroughs in CH<sub>4</sub> capture technologies: Key to reducing fugitive methane emissions in the energy sector. *Carbon Capture Science & Technology*, 13, 100316.

Measures with negative costs indicate that the benefits generated by the intervention (e.g., gas recovery and commercialisation) exceed the associated capital and operating expenditures. Measures with positive costs, by contrast, require net expenditure to achieve emissions reductions, but this does not imply limited relevance or impact. Many such measures deliver substantial abatement volumes and generate benefits that are difficult to fully quantify, including improved environmental performance, reduced health risks, enhanced regulatory compliance, and longer-term system resilience.

Traditional MACCs are used to highlight the cheapest or money-making projects first and to indicate where the largest emissions reductions can be achieved at the lowest cost. It also helps determine the cumulative cost of methane abatement options. For example, the International Energy Agency (IEA) estimates that globally, 72% of oil and gas sector methane emissions can be reduced using measures that cost no more than USD 10 per tonne, and about 38% of emissions could be abated at zero net cost when revenues from gas sales are considered.<sup>6</sup>

Figure 1: IEA estimated oil and gas abatement potential for the world



Source: International Energy Agency (IEA)

Marginal abatement cost curves vary significantly from country to country because methane emissions profiles, infrastructure availability, operating practices, labour costs, and regulatory environments differ across jurisdictions. As a result, the relative costs and scales of abatement options, as well as the sequencing of “low-cost” measures, are highly context specific. For example, estimates by the IEA show that about 58% of methane emissions from Nigeria’s oil and gas sector could be abated at zero net cost. When measures costing up to USD 10 per tonne of methane abated are included, the total abatement potential rises to about 74%.

<sup>6</sup> International Energy Agency (2023), Methane Tracker Database, IEA, Paris. License: Creative Commons Attribution CC BY 4.0.

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The IEA constructs methane MACCs using a bottom-up methodology that assesses individual mitigation measures based on both cost and effectiveness. Each abatement option is assigned a capital cost and an expected operational lifetime, with capital expenditures annualised and combined with recurring operating and maintenance costs such as labour, repairs, and servicing. While baseline cost data are often drawn from mature markets, these estimates are adjusted to reflect country- and region-specific conditions, including differences in labour costs, whether equipment is imported or domestically manufactured, applicable import duties, and variations in capital costs.

## Why Context Matters for Methane MACCs: Constraints, Risks, and Hidden Value

While MACCs provide a transparent and consistent framework for ranking methane mitigation options, their practical use is shaped by the context in which abatement measures are implemented. By construction, traditional MACCs rely on a set of simplifying assumptions about rational behaviour, frictionless implementation, static costs, and limited uncertainty, which can distort policy conclusions if left implicit.<sup>8</sup> Many measures that appear cost-effective on paper face hidden constraints related to infrastructure gaps, market access, institutional capacity, regulatory uncertainty, or cost of capital.

For example, addressing large methane leaks may require additional compressors, power supply upgrades, or even cross-border pipeline connections, introducing capital needs, permitting delays, and coordination challenges that may not be captured in a simple cost-per-ton metric. These challenges can be compounded by foreign exchange constraints, import duties on equipment, limited availability of skilled labour, and weak enforcement of methane regulations.

Standard MACCs may also fail to capture essential co-benefits and value streams that can materially improve the real economic case for methane abatement. These include gains in operational efficiency, reduced safety risks, strengthened social licence to operate, and improved access to climate finance and enhanced energy system reliability.<sup>8</sup>

Additionally, many methane mitigation measures can reduce the likelihood of explosions and unplanned shutdowns. These events are central drivers of operational and insurance risk in the oil and gas sector. Improved methane management can therefore lower a company's overall risk profile and support more favourable insurance outcomes, such as reduced premiums. While these effects are not yet systematically quantified or incorporated into standard MACC methodologies, they represent tangible sources of value that influence investment and risk management decisions.

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<sup>7</sup> Kesicki, F., & Strachan, N. (2011). Marginal abatement cost (MAC) curves: confronting theory and practice. *Environmental science & policy*, 14(8), 1195-1204.

<sup>8</sup> United Nations Framework Convention on Climate Change (UNFCCC). (2014). Technical paper: Mitigation benefits of actions, initiatives and options to enhance mitigation ambition. <https://unfccc.int/sites/default/files/resource/tpMitigation.pdf>

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Beyond insurance, strong methane performance can enhance a company's reputation and credibility with regulators, financiers, and international partners, particularly as adherence to national regulations and global standards such as OGMP 2.0 becomes an increasingly important signal of governance quality. These reputational and compliance benefits can reduce regulatory uncertainty, ease access to finance, and strengthen social licence to operate, further improving the accurate risk-adjusted returns of methane abatement investments.

Importantly, these points do not undermine the value of the existing MACC methodology, which provides a consistent and transparent basis for comparison across countries and technologies. Rather, they point to the need for all stakeholders to go a step further by integrating context-specific variables into MACC analysis.

## Enhancing Methane MACCs with Contextual and Co-benefit Considerations

Recognising the defined scope of standard MACCs, this section explores how additional contextual and co-benefit variables can be introduced to enhance their usefulness for decision-making. Extending marginal abatement cost curves for decision-making does not require revisiting the calculation of abatement costs in established methodologies. In standard approaches, abatement costs already reflect a detailed assessment of capital and operating expenditures, equipment lifetimes, labour costs, and some region-specific adjustments. These core variables form the analytical backbone of the MACC and should be preserved to ensure transparency and comparability.

A stylised illustration helps to clarify this relevance. Consider an offshore oil field in a resource-rich African country where associated gas is partially flared due to limited processing capacity. Under a standard MACC, the installation of gas gathering and compression equipment would be evaluated based on its capital and operating costs relative to the volume of methane abated, with the commercial value of any captured and sold gas explicitly reflected in the abatement cost calculation.

However, in practice, the recovered gas may be directed to domestic power plants that would otherwise rely on expensive liquid fuels or operate intermittently due to fuel shortages when government finances are constrained. In such a case, the benefits of methane abatement extend beyond the direct value of gas sales captured in the MACC. These benefits include reduced generation costs, improved reliability of electricity supply, lower exposure to fuel price volatility, and potential downward pressure on electricity tariffs.

At the same time, the feasibility and timing of such an intervention are shaped by several contextual factors that sit outside the MACC calculation. These may include delays in securing firm gas offtake agreements with power producers, constraints in expanding

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processing or compression capacity, and prolonged permitting and construction timelines for offshore infrastructure. In some cases, uncertainty around grid readiness or payment discipline in the power sector can further delay project commissioning, even where the underlying abatement option remains cost-effective.

These downstream and system-wide effects can materially influence energy security, fiscal outcomes, and economic performance, underscoring the need to interpret MACCs alongside broader energy system considerations.

MACCs can therefore be extended by introducing contextual variables and co-benefit variables as explicit overlays alongside established core cost estimates. This approach complements, rather than replaces, existing methodologies and allows MACCs to function as decision-grade, multi-variable tools.

- A. **Contextual variables** determine whether cost-effective methane abatement options can be implemented in practice. These variables capture the local conditions that influence project delivery, financing, and timing. Contextual variables often include access to capital, availability of supporting infrastructure, certainty of gas offtake, and exposure to foreign exchange risk.<sup>9</sup> These variables explain why options that appear attractive in standard MACCs may face delays or fail to materialise, and they are critical for sequencing actions realistically and identifying where policy or financial support is required.
  
- B. **Co-benefit variables** capture indirect but material sources of value that are typically excluded from standard MACC calculations. In the context of methane abatement, these include improvements in operational safety, potential improvements in insurance terms, enhanced regulatory compliance, and stronger alignment with international standards and investor expectations. While these benefits are not always immediately monetised, they influence corporate risk profiles, access to finance, and long-term asset viability. Recognising co-benefits allows MACCs to better reflect the accurate risk-adjusted returns of methane abatement investments, particularly in environments where non-financial risks are significant.

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<sup>9</sup> Eni S.p.A. (2024). Risk factors and uncertainties. In Annual Report 2024. [https://report.eni.com/annual-report-2024/en/\\_assets/downloads/risk-factors-uncertainties-eni-ar24.pdf](https://report.eni.com/annual-report-2024/en/_assets/downloads/risk-factors-uncertainties-eni-ar24.pdf)

Variable category	Variable	Description	How it affects MACC interpretation
<b>Contextual</b>	Upfront capital requirement	Initial investment needed relative to the company's balance sheet	May delay or prevent implementation despite the negative cost.
	Gas offtake availability	Existence of pipelines, processing, or buyers for captured gas	Determines whether negative-cost measures remain viable or additional infrastructure costs can inflate abatement costs
	Infrastructure dependence	Need for compressors, power supply, or new pipelines	Delays or comparatively higher than estimated costs may increase delivery risk and timelines
	Regulatory certainty	Clarity and enforcement of methane rules and penalties	Affects investment confidence and prioritization
	Implementation timeline	Time required to design, permit, and deploy measures	Influences the sequencing of abatement actions
	Downstream willingness to pay for monetised gas	The extent to which buyers of gas (e.g., power generators, industrial users, LPG marketers, or export markets) are able and willing to pay prices that cover supply costs	Determines whether revenues assumed from captured methane can be realised, affecting whether "negative cost" abatement options remain viable
	Market access and pricing structure	Availability of domestic, regional, or export gas markets and the pricing mechanisms that govern them	Conditions the stability and predictability of revenue streams from methane monetisation
<b>Co-benefit</b>	Operational safety improvement	Reduced leak-related fires, explosions, or shutdowns	Lowers risk profile beyond emissions reduction
	Insurance implications	Potential reduction in premiums or improved coverage	Improves risk-adjusted project economics
	Compliance with standards	Alignment with national rules or OGMP 2.0	Enhances credibility with regulators and financiers
	Reputational value	Demonstrated environmental performance	Supports social license to operate and access to capital
	Access to climate finance	Eligibility for concessional finance or carbon credits	Can shift projects into the bankable range

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This framework allows policymakers and regulators to move beyond ranking methane abatement options by cost alone and instead assess how different interventions align with broader energy and economic objectives. Government institutions can prioritise measures that deliver emissions reductions and improve gas availability for power generation.. For example, abatement options with relatively higher costs but strong downstream gas offtake, short implementation timelines, and clear regulatory backing may be more strategically valuable than lower-cost measures that face infrastructure or market constraints. In this way, the framework supports more informed sequencing of interventions, helping governments identify abatement actions that simultaneously advance emissions performance, energy security, and investment confidence.

These adjustments suggest that the MACC can become a dynamic planning map. Analysts can even extend the MACC to include scenarios and some sensitivity analysis. For example, one can determine the impact on abatement cost shift if a modest carbon price is applied. These assessments can produce a tailored MACC that communicates exactly what support is needed to make a project bankable.

## Stakeholders and uses of enhanced methane MACCs

Enhanced MACCs can serve as a common analytical reference point for a wide range of stakeholders involved in methane management across Africa's oil and gas sector. While each group uses the MACC for different purposes, the value of the tool lies in its ability to create a shared, transparent basis for prioritisation, dialogue, and coordination.

However, across these factors, a common underlying requirement is the availability of credible data. Voluntary initiatives such as OGMP 2.0 and company-led methane reduction commitments have already demonstrated that operator-driven data disclosure and performance tracking can materially improve the quality of methane analysis, providing a practical foundation for more robust, bottom-up MACC development. In many African oil and gas contexts, the data required to construct credible, asset-level MACCs is held primarily by operating companies rather than governments. As a result, effective MACC development cannot rest solely with public institutions. International oil companies, national oil companies, and other operators must play a central role in generating, updating, and applying MACCs, while governments focus on creating enabling regulatory and policy environments that encourage transparency and uptake.

Additionally, the following provides the various means stakeholders can apply enhanced MACCs in their activities.

- a. **Oil and gas companies:** Oil and gas operators can use enhanced MACCs to prioritise methane abatement actions within capital and operational constraints. A combination of costs, abatement potential, and contextual variables can help

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companies distinguish between measures that can be implemented immediately with internal resources and those that require external support or enabling conditions. Additionally, enhanced MACCs can provide a structured way to communicate abatement plans to justify sequencing decisions based on feasibility rather than cost alone.

- b. **Financial institutions and development financiers:** Banks, investors, and development finance institutions can use the extended MACC to assess the cost-effectiveness, scale, and risk profile of methane abatement investments. Financiers can identify projects that deliver high emissions reductions per unit of capital and determine where concessional finance, guarantees, or blended finance instruments may be required. For development financiers, the enhanced MACC can support portfolio-level decisions by highlighting where limited public or donor resources can unlock the largest mitigation impact.
- c. **Insurers and risk underwriters:** Insurance providers can use risk-adjusted MACCs to identify methane abatement projects that are technically viable but constrained by performance, delivery, or revenue uncertainty. Insurers can use this information to design targeted products, such as performance insurance, output guarantees, or operational risk cover, for various methane abatement schemes. In this way, MACCs support the development of insurance solutions that improve bankability and reduce the cost of capital for methane mitigation projects.
- d. **Policymakers and regulators:** Governments and regulators can use MACCs to inform methane policy design, regulatory sequencing, and enforcement strategies. The enhanced MACCs can help identify which abatement measures can be expected to proceed under existing market conditions and which require regulatory intervention. They also support evidence-based target setting by showing the trade-offs between ambition, cost, and feasibility, providing a practical bridge between emissions reduction objectives and the realities faced by operators.
- e. **Researchers, academic institutions, and policy think tanks:** a. These organisations can use enhanced MACCs as analytical tools to study mitigation pathways, test policy scenarios, and assess the implications of different assumptions about costs, technologies, and market conditions. They provide a stronger basis for empirical research on implementation barriers, risk allocation, and the interaction between climate policy and sectoral reform, particularly in developing-country contexts.
- f. **Media, CSOs, and public-interest communicators:** Media, civil society organisations, and policy communicators can use enhanced MACCs as an evidence-based tool to translate complex methane data into accessible public narratives. Enhanced MACCs clearly show where low-cost or even negative-cost methane abatement options remain unimplemented, making visible the scale of wasted gas and

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system inefficiencies across the sector. This evidence can be used to frame credible public narratives around foregone public revenues, missed climate gains, and avoidable development losses. In this way, the framework strengthens public scrutiny, supports advocacy and campaigning, and helps ground public debate in transparent, comparable data.

## Conclusion

Marginal abatement cost curves remain one of the most widely used and credible tools for understanding the cost and scale of methane mitigation options in the oil and gas sector. Their strength lies in their transparency and comparability, particularly when constructed using established methodologies that allow stakeholders to benchmark opportunities across countries and technologies. However, as this discussion has shown, the usefulness of MACCs in African oil and gas contexts depends not only on how accurately abatement costs are calculated, but on how well the tool reflects the conditions under which mitigation actions are implemented.

In practice, decisions about methane abatement are shaped by factors that sit outside standard cost calculations, including infrastructure availability, access to capital, market and offtake conditions, regulatory certainty, implementation risk, and a range of operational and reputational co-benefits. When these factors are left implicit, MACCs risk being interpreted as mechanical rankings rather than as inputs into real-world decision-making. Extending MACCs to incorporate additional contextual and co-benefit variables does not undermine their analytical integrity; it enhances their relevance.

For African policymakers, national oil companies, financiers, insurers, researchers, media and civil society, the implication is clear. Methane MACCs should be treated as adaptable, decision-grade frameworks that can be tailored to specific assets, stakeholders, and policy objectives, rather than as static cost-ranking exercises. When extended to reflect operational constraints, investment risks, and system-level co-benefits, MACCs can help align emissions-reduction ambitions with financial and institutional realities, support credible sequencing of abatement actions, and improve coordination across actors.

Critically, methane mitigation in African oil and gas sectors should be understood not only as a climate intervention, but as an energy productivity and efficiency imperative. Reducing methane losses directly improves gas availability, strengthens energy security, protects fiscal revenues, and enhances the economic performance of existing energy systems. Framing methane mitigation in this way situates enhanced MACCs as tools for advancing development, resilience, and fiscal stability alongside emissions reduction, rather than as climate-only instruments.

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