Methane Management Roadmap for Oil and Gas in ASEAN

June 2025

Report

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ASEAN Centre for Energy

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Foreword from ACE

As a region grappling with rapid population and economic growth, the Association of Southeast Asian Nations (ASEAN) requires a significant amount of energy to fuel development. In the 8th ASEAN Energy Outlook, the ASEAN Centre for Energy projects that energy demand will increase almost threefold by 2050 from 2022 levels, reaching up to 1,108 million tonnes of oil equivalent, and will still be dominated by oil, gas, and coal, resulting in a significant amount of energy-related greenhouse gas (GHG) emissions.

Within the GHG emissions mix, methane has risen to prominence as the second-largest GHG contributing to global warming, with a global warming potential of 84 times more than carbon dioxide over a 20-year period. As several key oil and gas producers are located within the region, ASEAN emitted 0.32 million tonnes (Mt) of methane in 2023, equivalent to the effect of 9 Mt of carbon dioxide.

While there is regional acknowledgement that reducing methane emissions from oil and gas production is a *quick win* that can be accomplished at a net negative cost, ASEAN faces several challenges in methane management. In view of this, on behalf of the Centre for Energy, I am pleased to share this *Methane Management Roadmap for Oil and Gas in ASEAN,* along with the ASEAN Council on Petroleum (ASCOPE) and the World Bank Group's Global Flaring and Methane Reduction initiative. This report reflects the ASEAN energy ministers' affirmation of the need to actively engage in the global shift toward decarbonisation targets and to welcome methane emissions abatement initiatives in the energy sector, as per the *Joint Ministerial Statement of the 42nd ASEAN Ministers on Energy Meeting* held in September 2024, and the *Joint Statement on Decarbonisation and Methane Emissions Reductions,* where the Centre and several ASEAN national oil companies have joined efforts in charting ASEAN's path forward as a progressive methane emission reduction leader.

The report explores the existing methane reduction commitments, targets, and challenges in ASEAN. From the findings, a methane management roadmap entailing governance, technology, and implementation strategies is proposed, covering four focus areas recommended to operators: (1) monitoring, (2) reporting, (3) verification, and (4) abatement.

I would like to extend my appreciation to ASCOPE and the World Bank Group for their valuable support and guidance in developing this report. I sincerely hope that this report will be a valuable resource for operators and policy makers as they plan to initiate greater methane abatement efforts in the energy sector that would lead to a more resilient and sustainable future for the region, as envisaged by the regional energy blueprint document, our ASEAN Plan of Action for Energy Cooperation (APAEC).

Dato' Ir. Ts. Razib Dawood
Executive Director
ASEAN Centre for Energy

Foreword from ASCOPE

The global energy landscape is undergoing a profound transformation, and methane management has emerged as a critical strategic priority for the oil and gas sector. As ASEAN continues to advance its energy transition agenda, addressing methane emissions presents a unique opportunity to enhance environmental sustainability, reinforce energy security, and demonstrate leadership in responsible energy development.

Methane, with its significant short-term climate impact, is an area where decisive action can drive substantial benefits. Recognising this, ASEAN has prioritised methane abatement as a core element of its regional energy cooperation. Key milestones, including participation in the Global Methane Pledge, OGMP 2.0, and the COP28 Oil and Gas Decarbonization Charter, have underscored the region's commitment to tackling emissions.

This *Methane Management Roadmap for Oil and Gas* (MAESTRO) is a testament to our collective commitment, developed through the collaborative efforts of the ASEAN Centre for Energy (ACE), the ASEAN Council on Petroleum (ASCOPE), and the World Bank. It serves as a guiding framework to support ASEAN Member States and industry stakeholders in implementing effective methane reduction strategies while ensuring economic and operational efficiency.

This roadmap underscores the power of regional cooperation in tackling shared challenges. By leveraging best practices, innovative technologies, and policy alignment, ASEAN can unlock new pathways for emission reduction, enhance industry competitiveness, and contribute meaningfully to global climate goals.

I extend my appreciation to all stakeholders who have contributed to this initiative. The successful implementation of this roadmap will require sustained collaboration, investment, and commitment from both the public and private sectors. Together, we can position ASEAN as a global leader in methane management, reinforcing our dedication to a more sustainable and resilient energy future.

Henricus Herwin
Secretary in Charge
ASEAN Council on Petroleum

Foreword from The World Bank

ASEAN members' oil and gas sectors are at a critical juncture on the region's journey toward a more sustainable energy system. The reduction of gas flaring and methane emissions could provide a triple win: significantly increase revenue, enhance regional energy security, and address harmful carbon dioxide and methane emissions resulting from oil and gas production.

This study highlights that in 2023 alone, the ASEAN region emitted approximately 0.5 billion cubic meters (bcm) of methane. This loss is significant, representing nearly a 10th of Singapore's liquefied natural gas imports that year. This amount of methane, if captured and sold, would generate up to US$87 million in revenue for the region.

It is imperative that operators dramatically reduce oil and gas sector flaring and methane emissions due to their immense environmental impacts. Mitigating methane, given its excessive global warming potential, is a high-value, relatively low-cost opportunity to address the challenge of climate change.

ASEAN's Oil and Gas Methane Emissions Dashboard, developed with assistance from the World Bank's Global Flaring and Methane Reduction Partnership (GFMR), serves as a valuable benchmark and tool in the effort to better manage the region's natural resources and boost economic development. It builds on momentum generated by global initiatives, such as the Global Methane Pledge (GMP) and the Oil and Gas Decarbonization Charter (OGDC). The roadmap provides a clear path forward, underscoring the importance of regional cooperation, robust monitoring, and the adoption of best practices in methane abatement.

ASEAN countries have already made notable strides, with key oil and gas producers like Indonesia, Malaysia, and Thailand leading the way. These countries' commitments to initiatives such as the World Bank's Zero Routine Flaring by 2030 (ZRF) initiative and the Oil and Gas Methane Partnership (OGMP) 2.0 demonstrates the necessary political will.

However, much more remains to be done.

This report highlights the urgent need for improved regional stakeholder coordination and the establishment of clear incentives for flaring and methane abatement and reporting. By leveraging the strategies and tools outlined in the report, we can achieve significant flaring and methane emission reduction.

It is time to harness the economic potential of methane, rather than continuing to wastefully and irresponsibly emit it to the atmosphere. It is also time to remain steadfast in our commitment to a collaborative approach, ensuring more effective natural resource management. Together, we can ensure the ASEAN region not only meets but exceeds its methane reduction targets, paving the way for a more sustainable future.

Zubin Bamji
Manager, Global Flaring and Methane Reduction (GFMR) Partnership
The World Bank

Contents

List of Figures

List of Tables

Executive Summary

This report outlines a strategy to significantly reduce methane emissions from the oil and gas sector across member nations of the Association of Southeast Asian Nations (ASEAN). The region emitted 0.32 million tonnes (Mt) of methane in 2023 (equivalent to 9 Mt of carbon dioxide), representing a substantial loss of gas and contributing to climate change. Key emitters are Indonesia, Malaysia, and Thailand.

The roadmap focuses on four key areas:

Enhanced monitoring 	This includes conducting leak detection campaigns utilising various technologies to accurately measure and monitor methane emissions.
Standardised reporting 	Adopting frameworks like the Oil and Gas Methane Partnership (OGMP) 2.0 to ensure consistent and transparent reporting of methane emissions across the region**.**
Certification programs 	Implementing certification programs to incentivise emission reductions, potentially commanding a premium for low-emission liquefied natural gas.
Abatement strategies 	Prioritising cost-effective technologies such as leak detection and repair, vapor recovery units, and flare reduction. Many abatement opportunities offer net negative costs due to the monetisation of captured methane

Challenges include limited regulatory focus, lack of awareness, and coordination difficulties. The roadmap proposes initiatives to address these, including awareness building, defining monitoring targets, and establishing a regional certification program. A phased approach is suggested, starting with pilot projects and scaling up regionally.

Successful implementation could generate up to US$87 million in additional gas sales revenue and contribute significantly to ASEAN's climate goals, aligning with international commitments like the Global Methane Pledge (GMP) and Oil and Gas Decarbonization Charter (OGDC). Adoption of the Charter's 0.2 percent intensity target is presented as an ambitious but achievable goal.

In summary, the *Methane Management Roadmap for Oil and Gas* in ASEAN provides a clear and actionable plan to reduce methane emissions, enhance economic efficiency, and contribute to global climate efforts.

1 Methane Emissions from Oil and Gas Operations in ASEAN

Landscape

Methane is a potent greenhouse gas (GHG), with a global warming potential (GWP) 84 times higher than carbon dioxide (CO_2) over a 20-year period. In the coming two decades, methane is expected to be responsible for more than two-fifths of GHGs, making it a central focus of global climate change mitigation strategies. Over a 100-year period, methane emissions are projected to account for approximately a fifth of global warming levels compared with preindustrial levels, as shown in **Figure 1**.

The energy sector ranks as the second-largest contributor to global methane emissions, with nearly three-fifths coming from oil and gas activities. Methane leakage from the gas sector is a particularly pressing issue, given the potential loss of value. Methane emissions occur at various stages, but the most significant source is production at the wellhead.

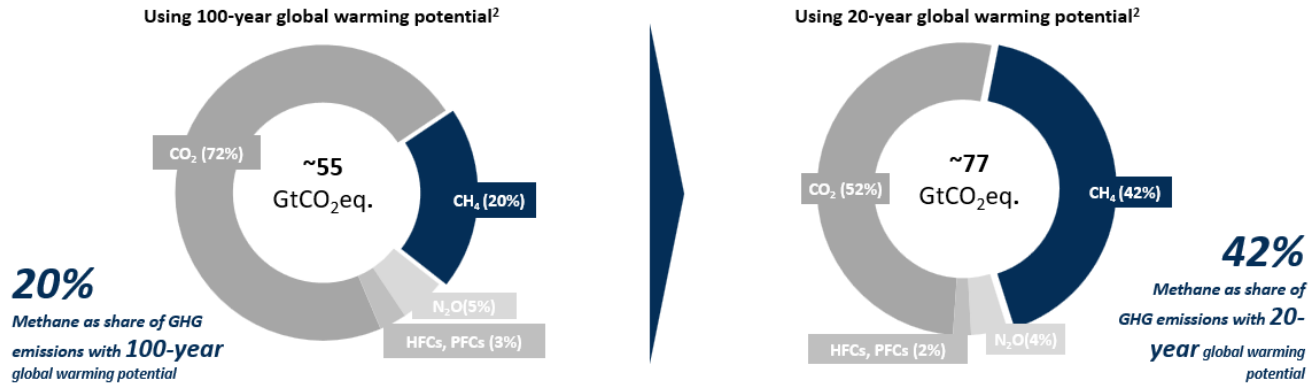


Figure 1. Global Anthropogenic Emissions, 2023

Note:

(1) Anthropogenic emissions originate from human activities, as opposed to natural sources;

(2) GHG emissions exclude emissions from land-use change. Methane emissions converted from kilograms to CO_2eq. The global warming potential (GWP) factor over a 20- and 100-year horizon uses factors published by the Intergovernmental Panel on Climate Change (IPCC); N_20, HFC, and PFC emissions split estimates are from 2020. CH_4 = methane; CO_2 = carbon dioxide; GHG = ; $GtCO_2$eq = gigatons of carbon dioxide equivalent; HFC = hydrofluorocarbons; N_20 = nitrous oxide; PFC = perfluorocarbons.

Source: Rystad Energy research and analysis

Efforts to reduce methane emissions could generate an estimated US$45 billion in global revenue by 2030, through the sale of captured methane. Targeting methane emissions from oil and gas production represents a relatively straightforward and impactful approach to addressing climate change, and is vital in aligning the global energy sector with the 1.5-degree global warming scenario. Approximately a fifth of anthropogenic methane emissions originate from the oil and gas industry, with half of these emissions originating in developing countries. Leveraging the full potential of methane reduction solutions in this sector could prevent roughly 0.1 degree Celsius of warming by mid-century.

In 2023, the Association of Southeast Asian Nations (ASEAN) region emitted 0.32 Mt of methane, equivalent to 9 Mt of CO_2. This accounts for the loss of approximately 0.5 billion cubic meters of gas, or about 7 percent of Singapore's liquified natural gas (LNG) imports in 2023. Key oil and gas producers in the region—Indonesia, Malaysia, and Thailand—account for nearly 90 percent of the region's methane emissions, largely from offshore activities.

ASEAN Oil and Gas Methane Emissions Baseline

The first step in managing methane effectively is to accurately measure emissions from oil and gas operations. Measuring gas losses is crucial to identifying key areas for intervention. With technical assistance from the World Bank Group's Global Flaring and Methane Reduction Partnership (GFMR), a baseline of methane emissions in the ASEAN region was developed and hosted on the website of the ASEAN Centre for Energy (ACE). The **ASEAN Oil and Gas Methane Emissions Dashboard** builds awareness and identifies large methane emission sources from the oil and gas sector across the region.

The Dashboard, as depicted in **Figure 2**, displays key emission hotspots and allows for visualisation of emissions for countries across different segments of the value chain. It also estimates the financial impact of gas loss, valued at domestic gas prices, and the average intensity of emissions. This serves as a valuable first step in understanding the scale of the problem and deciding the appropriate actions to manage emissions effectively.

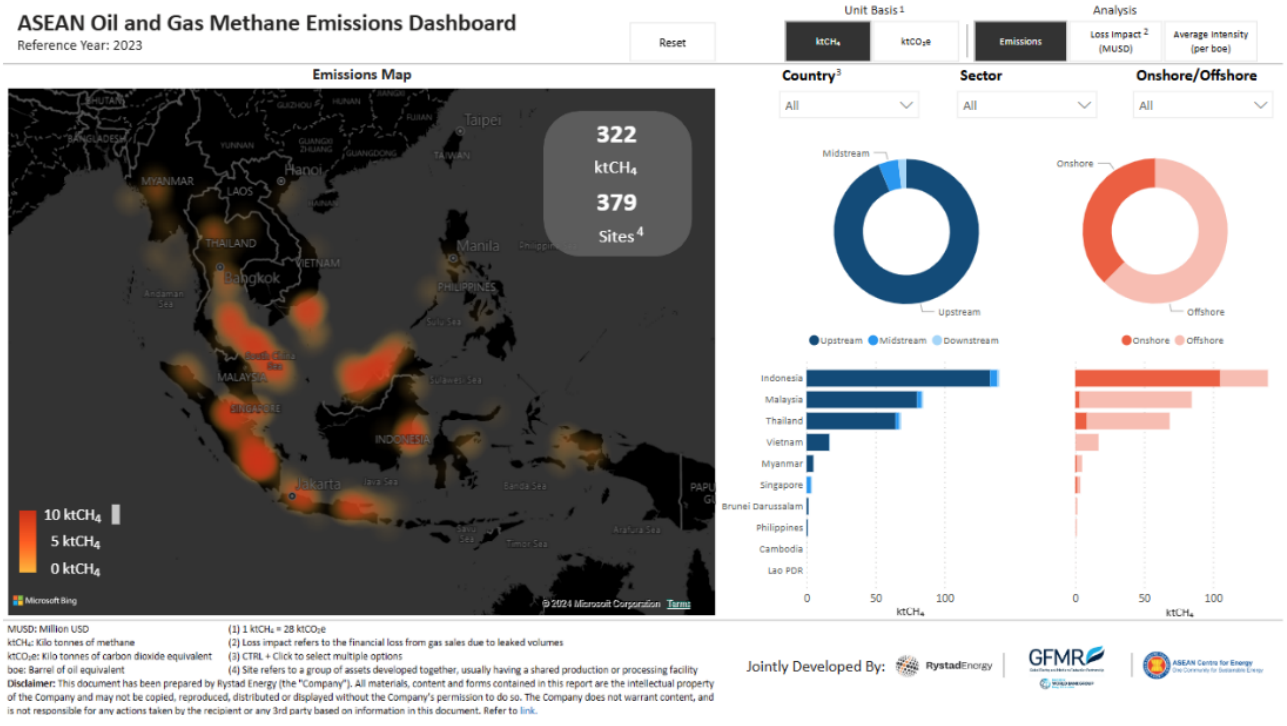


Figure 2. ASEAN Oil and Gas Methane Emissions Dashboard

Note:
Loss impact refers to the monetary loss impact of emissions calculated by valuing emissions based on 2023 gas prices. boe = barrel of oil equivalent; $ktCH_4$ = kilotons of methane; MUSD = million US dollars.
Source: Rystad Energy research and analysis

These data will enable policy makers, industry stakeholders, and researchers to identify key areas for intervention, prioritise abatement efforts, and track progress over time.

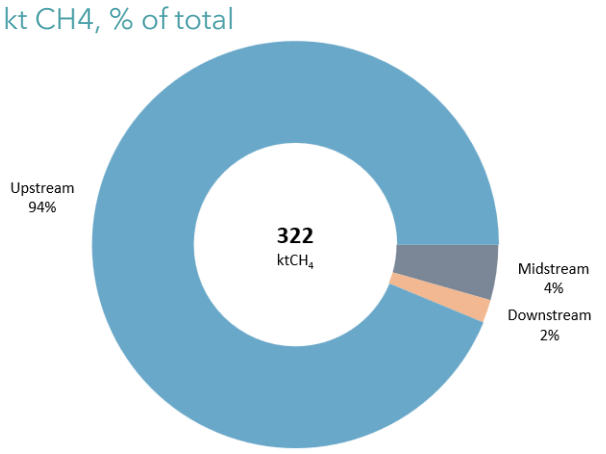


Figure 3. Southeast Asia Oil and Gas Methane Emissions (2023) by Sector

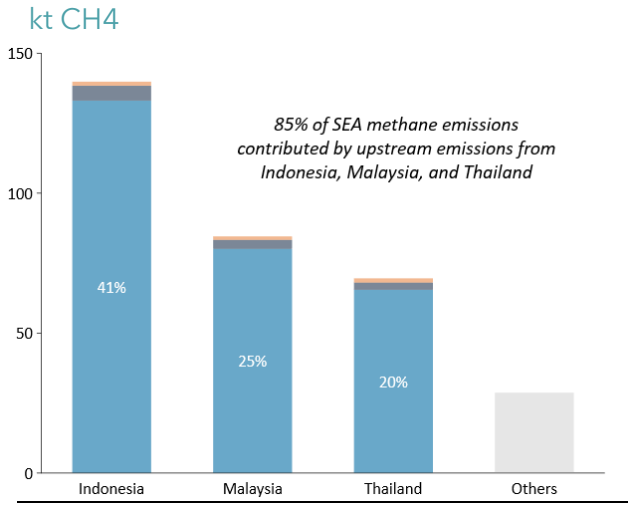


Figure 4. Southeast Asia Oil and Gas Methane Emissions (2023) by Country and Sector

Note:

(1) Excludes methane emissions estimated using satellite imagery. $ktCH_4$ = kilotons of methane

Source: Rystad Energy research and analysis

Figure 3 and **Figure 4** illustrate ASEAN's oil and gas emissions by sector and country. Approximately half of the region's emissions originate from Indonesia, with a large portion attributable to Sumatra, primarily from onshore production. Upstream assets in three key production areas—Peninsular Malaysia, Sarawak, and Sabah—account for more than 90 percent of Malaysia's emissions. In Thailand, offshore emissions in the Gulf of Thailand make up three-fifths of the country's total emissions. Flaring operations account for a quarter of emissions in the region.

Despite initiatives like **Zero Routine Flaring by 2030 (ZRF),** and the **Oil and Gas Methane Partnership (OGMP) 2.0,** being endorsed by major national oil companies in the region such as Malaysia's PETRONAS and Indonesia's Pertamina, further action is needed, particularly to address flaring, fugitive, and venting emissions. The successful implementation of effective monitoring and abatement measures in the region could generate an additional **US$87 million** in gas sales annually. This underscores the importance of continued commitment and action to reduce emissions and capitalise on the economic benefits of methane capture and reduction.

2 Methane Reduction Commitments and Targets in ASEAN

Global efforts to reduce methane emissions have gained significant momentum, with initiatives like the **Global Methane Pledge (GMP)** at the forefront of these efforts. Launched at the 2021 United Nations Climate Change Conference, this international initiative aims to collectively reduce global methane emissions by 2030. The pledge has garnered widespread support, with 159 participating countries representing over 50% of global anthropogenic methane emissions.

Building on this global commitment, the **Oil and Gas Decarbonization Charter (OGDC)** was introduced at COP28. This charter represents a significant step toward addressing oil and gas sector methane emissions, with 54 signatory companies, including both national oil companies and major international oil companies, demonstrating global engagement.

The ASEAN oil and gas sector has made notable progress toward methane reduction, as shown in **Table 1.** Several countries in the region have committed to the GMP. In 2022, Vietnam has approved its ***Action Plan for Methane Emission Reduction by 2030*** which targets to **reduce overall emissions by at least 30% below 2020 levels by 2030,** specifically limiting methane emissions to **8.1 metric tonnes** from oil and gas extraction, **2.0 metric tonnes** from coal mining, and **0.8 metric tonnes** from fossil fuel consumption. In May 2025, Cambodia followed the progress with the adoption of its first ***Methane Reduction Roadmap,*** which lays down several methane emission targets across the energy, agriculture, and waste sectors. For the energy sector, Cambodia targets a 5% methane emission reduction and 6% by 2050.

The national oil companies (NOCs) of Indonesia, Malaysia, and Thailand have joined the **OGMP 2.0**, a voluntary reporting framework by the United Nations Environment Programme and Climate and Clean Air Coalition. PETRONAS and Pertamina have also formally endorsed the World Bank's **ZRF** initiative, while Indonesia regulates gas flaring nationally through the Regulation of the Ministry of Energy and Mineral Resources No. 17/2021.

Table 1. Methane-specific Emission Targets Announced in ASEAN

Country	Country Energy Methane Targets	Global Methane Pledge	NDC with stated Methane Targets	OGMP 2.0 Member[1]	COP 28 Charter[2]
Brunei Darussalam	✗	✗	✗	✗	✗
Cambodia	✓	✓	✗	✗	✗
Indonesia	✗	✓	✓	✓	✓
Lao PDR	✗	✗	✗	✗	✗
Malaysia	✗	✓	✓	✓	✓
Myanmar	✗	✗	✗	✗	✗
Philippines	✗	✓	✗	✗	✗
Singapore	✗	✓	✗	✗	✗
Thailand	✗	✗	✓	✓	✓
Viet Nam	✓	✓	✗	✗	✗

Note:

(1) Countries with national oil companies that have joined the OGMP 2.0; (2) COP28 UAE Oil and Gas Decarbonization Charter. COP28 = 2023 United Nations Climate Change Conference; NOC = national oil company; O&G = oil and gas; OGMP = Oil and Gas Methane Partnership

Source: Rystad Energy research and analysis

Companies in ASEAN committed to the OGDC aim to reduce the methane intensity of their oil and gas operations to 0.2 percent (near zero emissions) by 2030, which would require a **64 percent decrease** from current emission levels. PETRONAS, Pertamina, and PTTEP have already signaled their commitment to the OGDC. The companies have made progress by implementing methane quantification and monitoring to reduce fugitive emissions, reducing routine flaring, and forming partnerships with technology providers. Their influential roles in the three countries comprising nearly 90 percent of the region's emissions will be central to achieving near-zero methane emissions.

Regionally, there is a strong acknowledgement of the need for methane abatement. Through the **Joint Ministerial Statement of the 42nd ASEAN Ministers on Energy Meetings,** the implementation of the **ASEAN Energy Sector Methane Leadership Program** **(MLP)** has been highlighted as a key area of cooperation, which was superseded by the launch of MLP 2.0. Organised by the United States Agency for International Development (USAID) Southeast Asia Smart Power Program in collaboration with ACE and the ASEAN Council on Petroleum (ASCOPE), the program encouraged support from various entities in addressing methane emissions from ASEAN's oil and gas sector.

Further regional cooperation was demonstrated through a **Joint Statement on Decarbonization and Methane Emissions Reduction from Organisations in the Southeast Asian Energy Sector,** signed during COP29. Signatories including ACE, the Ministry of Mines and Energy of Cambodia, PT Pertamina (Persero), PETRONAS, Myanma Oil and Gas Enterprise, Philippine National Oil Company, Singapore LNG Corporation Pte Ltd, and the PTT Public Company Limited. They agreed to call for a progressive, collaborative, and inclusive approach to methane emission reduction in ASEAN's energy sector as part of a just energy transition that puts nature, people's lives, and livelihoods at the heart of climate action.

To further enhance collaboration and accelerate progress, there is an opportunity for a regional sector-specific target in ASEAN. Adopting the OGDC as an ASEAN-wide target would be an ambitious yet achievable goal, setting a course for a global industry standard. This commitment could make the varied GHG emission reduction goals in the countries' Nationally Determined Contributions significantly more achievable.

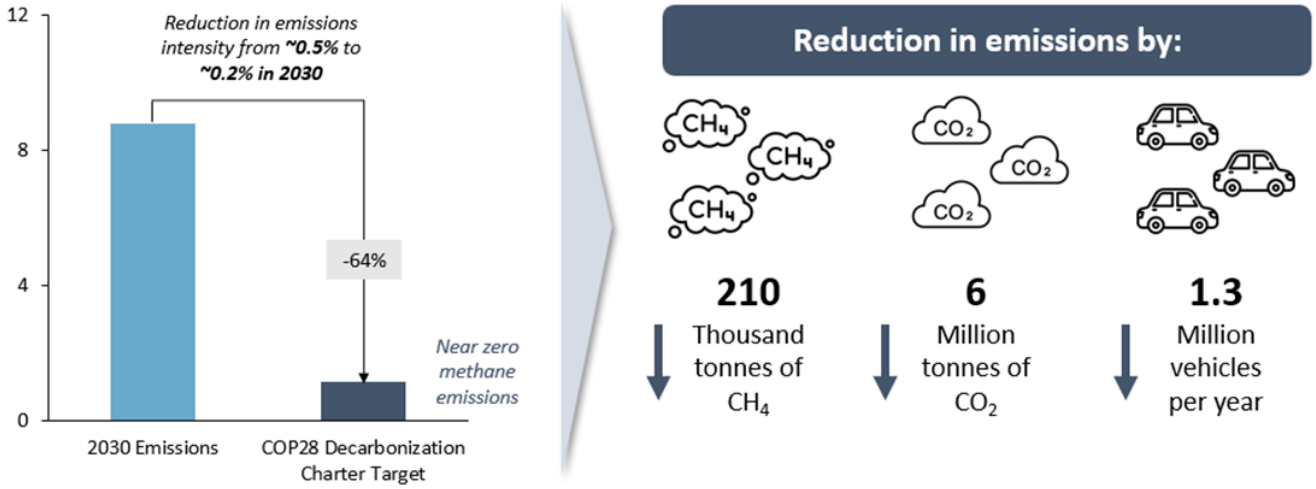


Figure 5. ASEAN Oil and Gas Emissions Reduction Pathway

Note: CH_4 = methane; CO_2 = carbon dioxide; COP28 = 2023 United Nations Climate Change Conference
Source: Rystad Energy research and analysis

Achieving near-zero methane emissions in the ASEAN region would be comparable to eliminating the emissions produced by approximately 1.3 million vehicles each year, as illustrated in **Figure 5**. With sustained commitment from independents and NOCs, the OGDC represents a feasible target that could significantly bolster the ASEAN methane management landscape, potentially attracting funding and investment in mitigation technologies and delivering economic co-benefits to the region.

3 Challenges Associated with Methane Management in ASEAN

Operators are expected to face several challenges while conducting methane emissions management campaigns in the ASEAN region, as indicated in **Table 2**.

Table 2. Key Challenges Associated with Methane Management in ASEAN

Category	Details
General	• **Awareness of the importance of methane management.** Limited regulatory focus on methane abatement at present highlights the need to enhance education and promote best practices. Improved understanding of methane's significance, both in terms of climate impact and potential monetisation opportunities, could drive methane management to emerge as one of the quickest and most cost-effective ways to combat global warming. • Recent initiatives in the Association of Southeast Asian Nations (ASEAN), such as the ASEAN Energy Sector Methane Leadership Program (MLP), demonstrate growing recognition of this issue. Countries and institutions are beginning to address methane emissions, but **specific regulations targeting methane abatement are still under development** across the region
Monitoring	• **Clarity on recommended technologies for monitoring methane emissions.** The variety of survey methods and technologies available could prove to be a challenge for operators. Some may need precise source-level measurements for reporting, while others might need to scan multiple sites. This requires a balance of cost, efficiency, and accuracy among options like handheld inspections, drones, aircrafts, and continuous monitoring systems. Additionally, consolidating data from various leak detection sources may be challenging due to differing methods employed by monitoring, reporting, and verification (MRV) providers. • **Selection of MRV providers.** Variation across the region's MRV service providers adds complexity to selecting a suitable partner. Certain regional providers may lack the technical expertise needed to meet reporting framework requirements, particularly concerning the auditability of reported emissions with data management tools. Additionally, there is limited availability of specialised local MRV service providers in the ASEAN region. This may require operators to engage with higher-cost international providers who may be less suitable for their monitoring and verification efforts. • **Coordination in methane monitoring.** Methane measurement and quantification relies on effective coordination among multiple stakeholders and departments, which makes implementing large campaigns challenging. Given that different departments have unique roles in methane abatement, it is critical to ensure collaboration such that production continuity could be aligned with emission reduction goals. • As regulations develop, companies are likely to **face increasing pressure to adopt standardised monitoring technologies.** The establishment of the Southeast Asia Methane Emissions Technology Evaluation Centre (METEC) indicates a growing focus on promoting effective monitoring solutions.

Category	Details
Reporting	• **Use of generic emission factors.** Generic emission factors, which may be conservative or outdated, could result in an overestimation of emissions. This uncertainty could lead to hesitation in adopting these factors, as reported values may not accurately reflect emissions until direct measurements are conducted. There may also be a lack of alignment on which emission factors to use, creating measurement discrepancies across operators. • As policies develop, companies may be required to use more accurate, locally relevant emission factors. With more industry players in the region joining the Oil and Gas Methane Partnership (OGMP) 2.0, an **increasing level of accuracy** in methane reporting is expected over the next five years.
Verification	• **Lack of clear incentives to pursue MRV and abatement.** It would be beneficial for operators to have an external mechanism to reward successful methane emission reduction. A pathway for additional financial benefits would go beyond brand building. Regulation on carbon pricing could be developed further to incentivise oil and gas operators toward compliance. • The ASEAN Energy Sector MLP provides direction on methane detection, measurement, quantification, and mitigation, indicating a move toward standardised verification processes. Companies are likely to **face more stringent verification processes** as policies evolve.
Abatement	• **Allocation of limited funding for abatement.** Companies could enhance their methane abatement strategies by not only allocating funds for monitoring but also considering the necessary investments for equipment to address venting and flaring emissions. By optimising budget allocations, prioritising emissions abatement, and increasing the frequency of leak detection surveys, organisations could more effectively identify and address critical areas for emissions reduction. • **Case for technology deployment at oil assets.** Oil assets may lack the necessary infrastructure to monetise volumes of associated gas, resulting in higher abatement costs. A balanced approach to abatement opportunities may help prioritise harder-to-abate emissions and achieve more widespread emission reduction. • Operators in the region are likely to **face more stringent requirements for methane reduction**, particularly in hard-to-abate areas like oil assets, as policies mature and align with global commitments. Initiatives like the ASEAN MLP 2.0 aim to strengthen emission reduction targets and enhance regional coordination.

Source: Rystad Energy research and analysis

4 Methane Management Roadmap

To address existing challenges and improve methane management in the region, **four focus areas** have been identified where ASEAN operators could take significant steps to reduce their methane emissions, as depicted in **Figure 6**.

Figure 6. ASEAN Methane Management Roadmap – Focus Areas

Source: Rystad Energy research and analysis

Within these four focus areas, a set of strategic initiatives has been proposed to enhance methane management endeavours, as detailed in **Table 3**. Regional institutions and facilities are expected to play a key role in supporting the efforts of operators.

Table 3. Strategic Initiatives Proposed for Effective Methane Management in ASEAN

Category	Details
General[1]	• **Facilitate awareness building opportunities for regional players:** A platform could be established for operators to gain a comprehensive understanding of key trends in methane emissions and how their assets align with these trends.
Monitoring	• **Define specific monitoring targets:** A concrete target could be established by regulators at a country or region level. This could involve operators conducting standardised measurement and reporting on some of their assets, reducing total emissions intensity to a certain level, or participating in existing initiatives. • **Implement a well-organised Leak Detection and Repair campaign:** A comprehensive, regional Leak Detection survey targeting key clusters of assets could be organised to improve visibility of operators' methane footprint. • **Engage and partner with MRV providers to grow regional presence:** Opportunities could be created for service providers to connect with potential clients, while operators could become better acquainted with key considerations for selecting providers.
Reporting	• **Adopt a suitable framework to report emissions:** Operators could adopt an appropriate guideline or framework that enables them to conduct standardised reporting of methane emissions at a level required.

Category	Details
Verification	• **Certify LNG as low emissions to attract premium buyers:** A facility for certifying low-methane emissions gas could be created to incentivise operators to reduce the methane intensity of their sites.
Abatement	• **Utilise Marginal Abatement Cost Curve (MACC) analysis to identify appropriate abatement technologies:** The MACC could be utilised to identify and evaluate the most suitable technologies for addressing emissions, considering factors such as onshore/offshore, country of origin and emission type. • **Extend budget to methane abatement activities:** Resources could be allocated for methane management though prioritisation of projects based on emissions addressed, sustainability and project replicability.

Notes:
(1) General strategic initiatives focusing on building awareness have been elaborated in Chapter 1.
Source: Rystad Energy research and analysis

Monitoring, Reporting and Verification

With the ASEAN region making gradual progress in methane management, preliminary steps have been proposed that are expected to incentivise operators to better manage their emissions. This includes the implementation of leak detection campaigns, adoption of MRV frameworks like OGMP 2.0, and certification of gas and LNG exports. Facilities that provide financial assistance through loans or grants could be established to support the region's methane management goals.

Monitoring: Leak Detection campaigns

Leak detection campaigns are a key enabler of the gas and LNG certification. They are required both prior to and following the implementation of abatement measures. A focused leak detection campaign is expected to help operators report at OGMP 2.0 Levels 4 and 5, which present the most technical challenges, due to the need for on-site measurements. Achieving broad coverage for assets is a challenge, since operators have several sites, making it time consuming and expensive to cover them all. Operators also often find it difficult to reconcile emissions, given the requirement for technical expertise to measure emissions accurately.

Key steps for advancing progress in **emissions monitoring** involve:

- Identification of common leak sources and assessment of existing methods of leak detection.
- Establishment of leak detection campaign objectives and identification of target facilities
- Selection of technologies for leak detection and assessment of data collection methods
- Implementation of pilot leak detection campaigns, monitoring of campaign performance
- Expansion of leak detection operations to more facilities in the region

For a facility to successfully conduct a leak detection campaign, effective alignment between operators and MRV service providers is crucial.

Prior to implementation of Leak Detection Campaigns: Planning and Preparation Phase

Gather input from operators 	○ Conduct **dialogues with operators** to gauge their progress, that is, existing initiatives and concrete plans. ○ Compile **site-specific data** including location, size, maturity, and so on, to be used in **site prioritisation.**
Engage with MRV service providers 	○ Screen for service providers according to their **areas of expertise** and **track record.** ○ Evaluate technical capabilities based on **minimum detection limits** of the technology. ○ Evaluate **capacity** and **geographical mobility** of service providers to gauge the scale of potential involvement.
Formulate Action Plan 	○ Use a **site prioritisation framework** to shortlist potential sites to target. ○ Define the **duration** and **scope** of the Leak Detection campaign. ○ Work with best-in-class technology providers to maximise **measurement efficiency.** ○ Estimate **cost** and **budget** of the campaign.

During Leak Detection Campaigns: Execution and Monitoring Phase

Track Progress 	○ Use a **project management software** to ensure campaign is proceeding according to schedule. ○ **Monitor KPIs** to measure the effectiveness of the service providers, such as the number of leaks detected, response times, repair completion rates.
Communicate with Stakeholders 	○ Maintain **clear communication channels** among field teams, facility operators and service providers. ○ Schedule **regular meetings** with service providers to review progress, discuss challenges, and make necessary adjustments.
Plan for Leak Repair 	○ Ensure repair prioritisation **best practices,** to fix detected leaks efficiently. ○ Facilitate **collaboration** between service providers and operators' asset integrity teams. ○ Monitor and record leaks data in a **centralised database** to identify trends and avoid recurring leaks.

After Leak Detection Campaigns: Evaluation and Follow Up Phase

Evaluate Programme Performance 	○ Summarise programme effectiveness by **compiling** total emissions addressed through leak repair. ○ **Quantify programme efficiency** by comparing the total expenditure relative to the emissions reduction.
Promote Best Practices 	○ Communicate the **successes** and **best practices** of the programme to internal/external stakeholders. ○ Share case studies and data to **support industry-wide** methane reduction efforts and **promote best practices.**
Plan for Future Campaigns 	○ Use insights from the current campaign to **plan for future leak detection and repair** (LDAR) campaigns. ○ Consider **scaling up** the programme regionally or adopting **more comprehensive** monitoring approaches for broader impact. ○ Examine potential **follow-up** with incorporation of **abatement measures** for venting and flaring emissions.

A tiered leak detection campaign could use a combination of complementary technologies to address gaps in emissions measurement.

Continuous monitoring 	involves the deployment of monitoring systems at critical points such as compressor stations and processing facilities. This setup can include low-cost sensors that provide real-time data on methane emissions. Such systems can instantly detect leaks, providing immediate alerts for high-emitting sources.
Aerial and satellite surveys 	use drones or aircraft to cover large areas and identify leaks that ground-based systems might miss. These could be used to complement continuous monitoring by focusing on high-emission areas across multiple sites.
Periodic manual inspections 	may also be conducted, where traditional handheld detectors are used at quarterly or monthly intervals. These measurements may be able to detect smaller leaks missed by continuous monitoring and aerial surveys.

While ground-based surveys have low costs and are most commonly conducted, continuous monitoring and aerial surveys allow for greater efficiency in measurement.

There are some technical limitations with the use of **satellite data**, that makes it relatively unsuitable for aerial surveys in the ASEAN region. Satellites have poorer detection capabilities than other technologies as they take measurements per pixel rather than per component or facility. Emission volumes below a minimum limit thus remain undetected. In addition, satellite measurements are sensitive to other conditions. Cloudy days obstruct the infrared signals used by satellites to measure methane concentrations. Water surfaces reflect and scatter detection signals, while severe wind could disperse the methane plume, that directly affects results. Overlapping emission signals could also complicate source attribution. In contrast, **aerial surveys** conducted by drones and aircrafts may be effective, depending on the scale of operations.

Two **handheld** technologies, the **flame ionisation detector (FID)** and the **optical gas imaging (OGI)** camera are most widely used for detecting leaks at oil and gas facilities. The FID is an older technology, while the OGI is relatively new, and its effectiveness is still being studied. Using both technologies together leverages their strengths and provides a more robust approach than relying on any one method exclusively.

Reporting: OGMP 2.0 and Other Frameworks

Reporting and addressing methane emissions is a reliable way for companies to demonstrate their progress in meeting methane reduction targets, and their commitment to the goals of the Paris Agreement and the GMP. This also indicates that a company is operating in an efficient and cost-effective way, given that asset integrity and product loss are key industry concerns. Adhering to OGMP 2.0 can also provide a significant competitive edge in a market where environmental, social, and governance criteria are becoming key differentiators. Companies that adopt these standards are better positioned to respond to investor demands for transparency and sustainability.

Key steps for advancing progress in **emissions reporting** involve:

- Evaluation of various reporting frameworks, assessing applicability to operations.
- Selection of appropriate reporting framework based on progress in leak detection efforts.
- Development of a monitoring plan, ensuring compliance with reporting framework.
- Reporting of emissions for pilot projects, using the selected frameworks.
- Expansion of emissions reporting to more operated and non-operated facilities.

MRV frameworks, detailed in **Table 4** and **Table 5** offer varying levels of guidance for operators looking to address methane emissions. Over the last decade, different frameworks that are linked to detection, measurement, reporting, and verification of methane emissions have been developed. The guidelines in each framework vary to some extent, allowing operators to adopt the framework that is most suitable for their operations. While some frameworks focus on methane specifically, others may focus on all GHGs.

Table 4. Overview of Frameworks/Guidelines for Methane Emissions MRV

Organisation	UNEP	IOGP	Methane Guiding Principles	UNECE	UNFCCC
Framework/Guideline for MRV	Mineral Methane Initiative OGPMP 2.0 Framework	Recommended practices for methane emissions detection and quantification technologies - upstream	Best Practice Guide: Identification, Detection, Measurement and Quantification	Best Practice Guidance for Effective Methane Management in the Oil and Gas Sector	Handbook on MEASUREMENT, REPORTING AND VERIFICATION for Developing Country Partners
Sector	Oil and Gas	Oil and Gas	Oil and Gas	Oil and Gas	All sectors
Scope	M R V	M R V	M R V	M R V	M R V
Targeted GHG	Methane	Methane	Methane	Methane	All GHG
Members	Over 140 member organisations	93 member organisations	47 member organisations	Member states of the UNECE	198 countries ratifying the UNFCCC
Introduced in	2020	2023	2024	2019	2014

Note:

(1) Areas of focus within monitoring, reporting, and verification;

(2) all companies that have joined OGMP 2.0 have committed their adherence to the OGMP 2.0 Reporting Framework. GHG = greenhouse gas; MRV = monitoring, reporting, and verification; UNECE = United Nations Economic Commission for Europe; UNEP = United Nations Environment Programme; UNFCCC = United Nations Framework Convention on Climate Change.

Source: Rystad Energy research and analysis

While methane measurement is a primary focus of most industry guidelines, the OGMP 2.0 Framework, which has advocated for systematic reporting of methane emissions, has garnered the most interest globally. Its transparent and comprehensive approach has also led to its increased prominence in the ASEAN region.

Table 5. Frameworks/Guidelines for Methane Emissions MRV: Focus Areas

	Measurement methods across the entire value chain using advanced technology	**Detailed guidelines for selecting and deploying appropriate tools and technology**	**Detailed guidelines for selecting and deploying appropriate tools and technology**	**Direct measurement and estimation techniques employed to improve emissions data reliability**	**Measurement methods provided in the IPCC Guidelines for all GHG**
Measurement					
Reporting	A 5-level reporting system with companies going from basic to advanced	No detailed reporting framework provided	Overview of best practices in reporting for creating and updating emissions inventories	Overview of best practices for improving company-level reporting processes	Reporting guidelines for national communications and biennial updates
Verification	Third-party verification of reported data to ensure transparency	Guidelines for technology validation methods, reconciliation processes and uncertainty	Guidelines for technology validation methods, reconciliation processes and uncertainty	Combination of internal and third-party verification procedures, with periodic audits	Guidelines for verification (ICA[2]) process by expert review teams
ASEAN relevance[3]	High	Medium	High	Low	Low

Note:

(1) Only UNECE's Best Practice Guidance document provides guidelines for abatement technologies; the others provide guidelines for MRV only;

(2) International Consultation and Analysis;

(3) ASEAN relevance reflects the degree to which these guidelines have been discussed and accepted by policy makers in the ASEAN region. GHG = greenhouse gas; IPCC = Intergovernmental Panel on Climate Change

Source: Rystad Energy research and analysis

OGMP 2.0's framework offers clear guidance and achievable targets for companies' reporting processes. Companies that have joined OGMP 2.0 aim to gradually improve the quality of their emissions reporting, progressing from Level 1, which makes use of generic emission factors at the venture and asset level, to Level 5, which aims to integrate bottom-up source-level reporting with independent site-level measurements. As companies progress to more advanced levels of reporting, reporting criteria become more stringent, and more specific emissions factors need to be used. There are key considerations at the various OGMP 2.0 reporting levels that have implications for the companies reporting at those levels, as detailed in **Table 6.**

Table 6. Overview of OGMP 2.0 Reporting Levels

Level	Level 1	Level 2	Level 3	Level 4	Level 5
	Venture/Asset level	**Emissions Category**	**Equipment at the Source Level (Generic EF)**	**Equipment at the Source Level (Specific EF)**	**Site and Source Level Reconciliation**
Details	• Single, consolidated emissions number • Applicable where **limited information** is available	• Emissions reported based on **IOGP and Marcogaz categories** • Based on **generic emission factors**	• Emissions reported by detailed source type • Based on **generic emission factors**	• Emissions reported by detailed source type • Based on **specific emission factors** calculated from direct measurements	• **Integration** of bottom-up source level reporting with independent site level measurements
Key Considerations	• Companies could select the emission factors that **best fit their facilities** • A non-exhaustive list of emission factors is provided by OGMP - **alternative factors** could be used without approval, but must be thoroughly documented		• Involves developing a **full inventory** of potential emission sources, which is a relatively time consuming process	• Serves as a crucial **starting point for reconciliation** - different measurement methods could yield varying accuracy	• Reconciliation is intended to be an **iterative process** performed annually. Repeated engagement with MRV players is required

Note:

(1) Examples have been obtained from the OGMP 2.0 Technical Guidance Documents. EF = emissions factor; IOGP = International Association of Oil & Gas Producers; OGMP = Oil and Gas Methane Partnership; MRV = monitoring, reporting, and verification

Source: Rystad Energy research and analysis; OGMP 2.0

To maintain gold standard reporting, OGMP 2.0-aligned companies are required to report their emissions at Level 4 or Level 5 for all material operated assets within the third year of joining the programme, and all material non-operated assets within the fifth year of joining. Companies are required to gradually increase their reporting levels according to their implementation plans.

- In 2024, 55 companies achieved Gold Standard reporting, out of OGMP 2.0's first cohort of 68 companies that joined in 2020 and 2021.
- OGMP 2.0's other 72 member companies that reported data in 2024 (OGMP 2.0 companies are expected to submit their first report the year after they join) are earlier on their journey.
- Petronas is currently the only ASEAN national oil company that is on track to achieving the Gold Standard reporting. By 2025, the company has set a target to achieve 50% reduction in methane emissions from PETRONAS groupwide natural gas value chain, based on 2019 estimates.

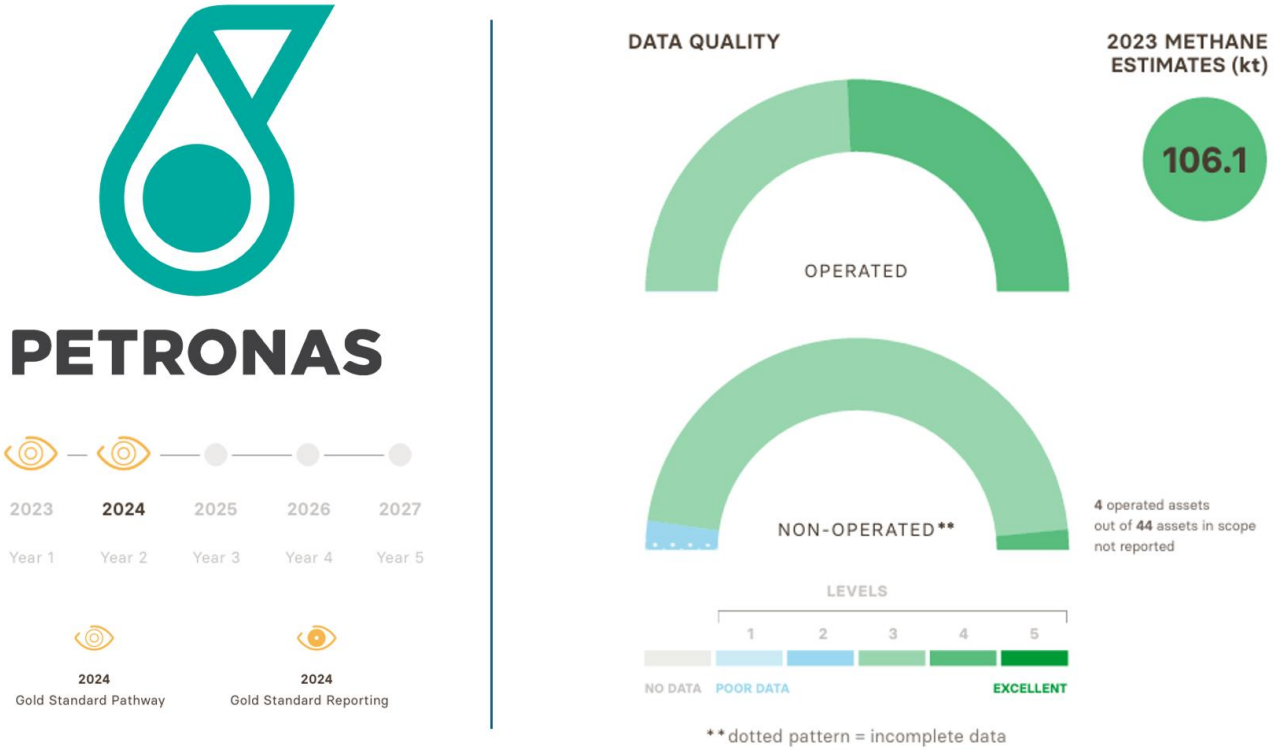


Figure 7. Overview of Petronas' pathway to achieving OGMP 2.0 Gold Standard reporting

Source: UNEP OGMP 2.0-Wide Factsheet

Although OGMP 2.0 is recognised as a leading reporting framework globally, some operators are hesitant to join due to uncertainties surrounding the initiation of emissions reporting. The absence of prescribed technologies may lead to measurement discrepancies, and reconciling reported emissions reported at Levels 4 and 5 could be costly. As a result, companies would need strong internal and external capabilities to effectively reconcile measurement results.

Verification: Certification Programme

Verification of emissions reporting is a crucial step in ensuring transparency in methane reporting. This process enhances credibility by providing an independent assessment of emissions data, which builds trust among stakeholders, ultimately driving efforts to reduce methane emissions.

Key steps for advancing progress in **Emissions Verification** involve:

- Evaluation of certification programmes and assessment of suitability for ASEAN.
- Assessment of business case for certification of regional facilities, including potential costs and benefits.
- Establishment of clear roles and responsibilities for stakeholders including auditors and certifiers.
- Launching of a pilot programme; engagement of operators to certify specific facilities.
- Expansion of certification efforts to include more facilities.

Despite minimal carbon pricing and low levels of political commitment in ASEAN, the rising demand for low-emissions LNG from key importers such as Japan, the Republic of Korea, and Singapore could serve as a significant motivator for LNG producers in the region to reduce methane emissions. In 2023, Japan and Korea accounted for over 50 percent of gas exports from ASEAN. Additionally, these countries have launched low-emissions LNG initiatives to reduce emissions from their imported LNG cargoes. Notable initiatives include:

- The CLEAN (Coalition for LNG Emission Abatement toward Net-zero) partnership launched by Korea Gas Corporation (**KOGAS)** and **JERA** in 2023, aims to engage in dialogue with LNG producers and develop best practices for methane reduction. The two firms are also encouraging LNG suppliers to provide more information about their methane footprints by focusing on individual projects. Twenty-two Japanese utilities and trading houses have now joined the partnership, which could add pressure on suppliers to reduce emissions across their gas supply chains.
- **The Japan Organization for Metals and Energy Security's (JOGMEC's)** Joint Study Agreement with **Pertamina** focuses on strengthening cooperations on methane emissions measurement and quantification. JOGMEC selected Japanese technology provider JGC to perform a study on methane emissions at PETRONAS' offshore facilities. In addition, they have signed a memorandum of understanding with Woodside for collaboration on methane detection and quantification technology.

The purchase of certified gas is expected to provide a tangible contribution to the strategies of these companies. Certification of LNG exported from Southeast Asia is expected to command a substantial premium, which could be reinvested to boost emissions abatement efforts.

Several voluntary certification programs with different levels of stringency have emerged over the past few years, as detailed in **Table 7**. While certification has primarily focused on upstream operations, efforts are underway to expand its applicability across the entire gas value chain, ensuring comprehensive coverage and impact.

Table 7. Summary of Voluntary Initiatives for Emissions Reporting

Certification	Organization	Emissions data	Audit level	Methodology	Tradeability	Engagement
The MiQ Standard	MiQ	CH_4, Scope 1	Third-party	Publicly Available	Tradeable	50-100 companies
EO100™ Standard		CO_2e, Scope 1,2,3	Third-party	Publicly Available	Tradeable	25-50 companies
TrustWell Environmental Assessments 2.0	PROJECT CANARY	None	Administering Organization	Partially Publicly Available	Not Tradeable	25-50 companies
TrustWell Low Methane Rating Protocol	PROJECT CANARY	CO_2e, Scope 1	Administering Organization	Publicly Available	Not Tradeable	25-50 companies
SGE Methodology	QatarEnergy	CO_2e, Scope 1,2,3	Third-party	Publicly Available	Not Tradeable	6 issuances
Digital Natural Gas and MPC	Xpansiv	CH_4, Scope 1	Third-party	Publicly Available	Tradeable	50-100 companies
MRV and GHG Neutral LNG Framework		CO_2e, Scope 1,2,3	Third-party	Publicly Available	Not Tradeable	85 members

Note: CH_4 = methane; CO_2e = carbon dioxide equivalent; EO = Equitable Origin; GHG = greenhouse gas; LNG = liquefied natural gas; MPC = methane performance certificate; MRV = monitoring, reporting, and verification; SGE = Statement of Greenhouse Gas Emissions.
Source: Rystad Energy research and analysis; Highwood Emissions Management.

MiQ's standard is widely recognised as an independent methane emissions certification for oil and gas facilities, while the **Statement of Greenhouse Gas Emissions (SGE)** is a more life-cycle-focused quantification of LNG cargo GHG intensity. The **EO100** certification from Equitable Origin has a wider range and requires a mostly qualitative environmental, social, and governance–focused assessment (**Table 8**).

Table 8. Comparison of Key Certification Entities

Organization	MiQ Certification	Statement of Greenhouse Gas Emissions (SGE)	EO 100
Focus	Quantitative and qualitative methane focused certification for individual facilities across value chain	Lifecycle-focused quantification of LNG cargo GHG intensity	Wide-ranging and mostly qualitative ESG focused assessment (water use, impacts on indigenous communities, etc)
Methane-related requirements	Annual methane intensity figure, assessment of deployment of monitoring technology and implemened company practices	Methane intensity to be calculated per cargo with 12-month average data	Requires an annual GHG emissions inventory (including methane)
Certified facilities	Relatively high - 18 participants in 2023	Low - only 6 cargoes delivered to date, with limited information and engagement since 2021	Relatively high - 25 participants in 2023
Source-level measurement requirements	Minimum of one annual baseline source level inspection over the entire facility, more frequently for higher grades	Only requires that calculations take into account actual data from production, processes etc.	Only requires that methodology for measurement/calculation be disclosed to stakeholders

Highly relevant for certification · Relevant for certification · Less relevant for certification

Note: EO = equitable origin; ESG = environmental, social, and governance; GHG = greenhouse gas; LNG = liquefied natural gas.
Source: Rystad Energy research and analysis.

Depending on the methane intensity of the facility, certified gas could command a premium of approximately **0.01–0.05 US$/million British thermal units**. The theoretical premium is derived by calculating the savings on carbon taxes should methane emissions be taxed. In addition, different segments of the value chain with varying methane intensities could command different premiums for certified gas, depending on the baseline intensity of the facility.

Case study: MiQ's certification of facilities

MiQ certifies facilities based on specific criteria across three key pillars—methane intensity, monitoring technology, and company practices. The overall grade achieved by the facility, depicted in **Figure 8**, is based on the lowest achieved score across all three pillars. The company also engages and accredits third parties like auditors and MRV service providers, resulting in a smoother certification process. Certificates are traded via established bilateral agreements, or on independent trading platforms like the CG Hub and CBL Global Spot Exchange.

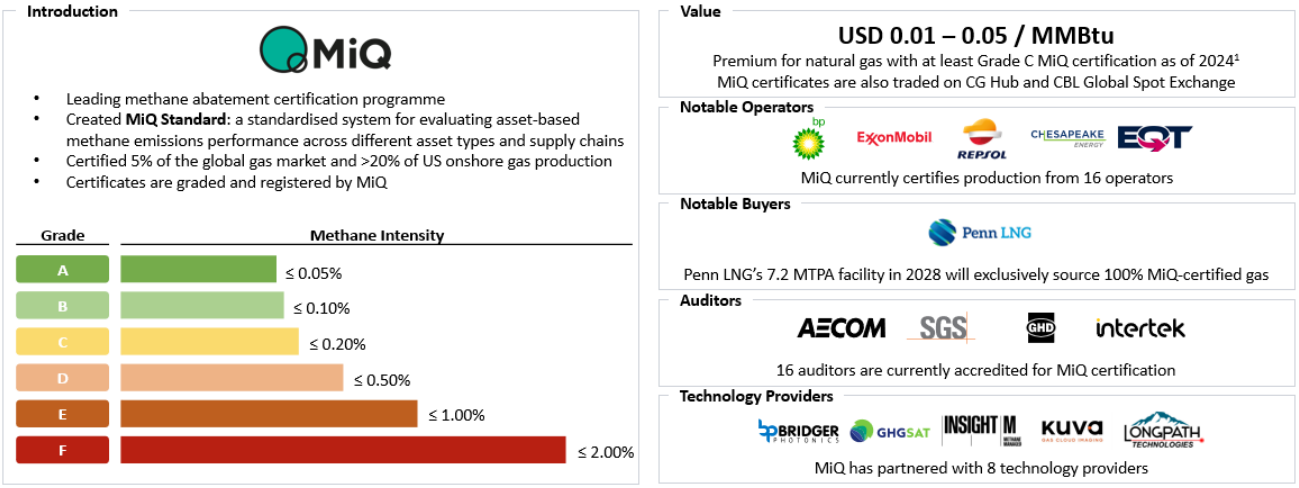


Figure 8. Overview of MiQ's Certification Standard

Note: Data source from S&P Global. LNG = liquefied natural gas; MMBtu = million British thermal units; MTPA = million tonnes per annum.
Source: Rystad Energy research and analysis.

Abatement

The effective MRV of methane emissions from oil and gas operations are expected to facilitate the implementation of emissions abatement methods. Key insights gained from MRV processes could be leveraged to develop actionable strategies.

Key steps for advancing progress in **Emissions Abatement** involve:

- Evaluation of funding needs for emissions abatement projects.
- Formulation of a funding strategy outlining eligibility criteria for funding.
- Development of clear guidelines for project selection; selection of suitable abatement solutions.
- Implementation of abatement measures for selected pilot projects.
- Expansion of abatement efforts to more projects, monitoring progress over time.

Abatement Technology Solutions

The methane marginal abatement cost curve, depicted in **Figure** 9, represents the total emissions in the ASEAN region with their associated unit cost of abatement. Key technologies have been considered that could address more than 90 percent of the region's emissions. These are detailed further **Figure** 9, Abatement costs tend to differ across countries due to a variation in material and labor cost components. The implementation of most technologies to reduce methane leaks results

in gas savings, and potential revenue. A country-specific gas price has been used to incorporate gas savings into the unit cost for each technology, if there is a valid pathway for gas monetisation.

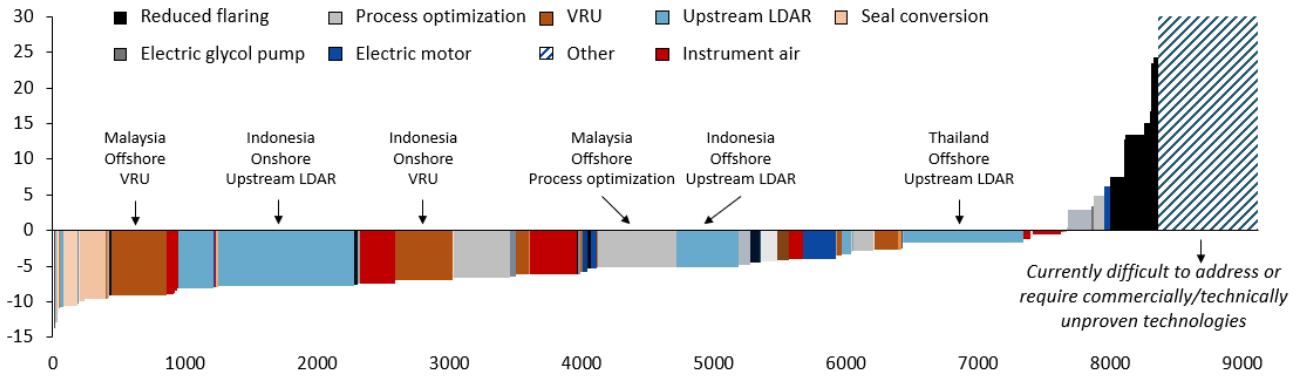


Figure 9. Methane Marginal Abatement Cost Curve (MACC) for the ASEAN Oil and Gas Sector

Note:

(1) MACC curve costs are illustrative and based on a high-level analysis of different abatement opportunities. Project costs and technical viability of abatement technology deployment vary heavily from site to site. Costs for replacement with dry compressor seals, electric glycol dehydrator, VRUs, electric motors, and instrument air systems modelled using publicly available methane emissions abatement data with capital cost annualised as per operational lifetime. LDAR = leak detection and repair; VRU = vapor recovery unit.

Source: Rystad Energy research and analysis, EPA, Methane Guiding Principles, CCAC OGMP Technical Guidance Documentation.

Overall, 84 percent of the region's emissions could be addressed at a net negative cost, assuming the gas is monetised at local gas prices. In terms of emissions addressability:

- **Upstream** LDAR could address the largest portion of emissions, equivalent to 2,900 kilotonnes of carbon dioxide equivalent (kt CO_2 eq), or 32 percent of total emissions. It has a wide cost range due to the various types of possible equipment (handheld sensors, drones, aircraft) and frequency of measurement (annual, quarterly, monthly).
- **Vapour Recovery Units** (VRUs) are able to address the largest share of the region's emissions after LDAR, and tend to have an average net negative cost around -7 US$/t$CO_2$eq if the captured gas can be monetised.
- **Flaring-related technologies** could address 22 percent of regional emissions but tend to have a relatively high cost, at an average of 14 US$/t$CO_2$eq for flare modification and -4 US$/t$CO_2$eq for flare reduction, if volumes are monetised. Gas could be monetised via flare reduction if the volumes are diverted to sales channels.

Table 9. Methane Abatement Technology Solutions

Technology	Details
Flaring emissions reduction	• This refers to **modifying a flaring system** or **optimising it** to improve efficiency and reduce emissions from combustion. • Various methods exist to optimise the combustion process, such as **improving fuel/air mixing** and creating more **effective combustion zones**. • Operational enhancements could also improve processes to **reduce the need for emergency flaring**. • Technologies that could be considered include enclosed flaring, air-assisted/smokeless flares, and software optimisation solutions.
Leak detection & repair (LDAR)	• This involves employment of a range of detection equipment and techniques to **reduce fugitive emissions** from sources such as pipelines, valves and flanges. • They typically involve **regular inspections and maintenance schedules**, followed by **repair protocols** to promptly address leaks. • Technologies such as infrared cameras, laser sensors, and acoustic detection devices are typically deployed.
Seal conversion	• This involves **replacing wet compressor seals** with **dry gas seals** to reduce fugitive and vented emissions from compressors. • Dry seals use pressurised nitrogen or similar substances rather than oil, thereby **preventing methane absorbed by seal oil** from being **vented to the atmosphere**. • Additionally, dry seals are designed to minimise leakage and are more reliable and efficient, reducing the likelihood of **methane leaks over time**.
Instrument air systems	• This involves replacing **pneumatic controllers powered by natural gas** with **compressed air-powered components** to reduce fugitive and vented emissions. This eliminates methane emitted from continuous or intermittent **gas bleeding**. • A typical instrument air conversion project includes air compressors, an electrical power source, air dryers and a volume tank.
Electrification	• This refers to fitting **electric glycol circulation pumps** to replace **traditional gas-assist glycol circulation pumps** or using **electric motors** to replace **combustion engines** and reduce combustion and vented emissions. • Using electric glycol pumps eliminates the need for an **assist gas stream**, which otherwise causes **absorbed methane** to be **vented during dehydration.** • Replacing combustion engines with electric motors is expected to eliminate methane emissions from **leaks in the fuel gas supply lines**, compressor blowdown, gas starters and due to **incomplete combustion**.
Vapour recovery unit (VRU)	• This pertains to **capturing methane emissions from storage tanks** and other low-pressure sources such as from tanks, compressors, dehydrators, and other components to reduce fugitive and vented emissions while **turning them into a revenue stream**. • A VRU typically uses a compressor to collect and **route the gas to a sales line** or on-site fuel system.

Source: Rystad Energy research and analysis

The six technologies are represented on a prioritisation matrix, as depicted in **Figure** 10, with the vertical axis representing the range of absolute emissions addressed, and the horizontal axis representing the ease of implementation, which is primarily based on absolute cost estimates. The

size of each rectangle varies to account for the costs and addressability ranges. For example, technologies like LDAR and VRUs could address 20–30 percent of the region's emissions, but only 0–5 percent could be tackled by seal replacement. In terms of costs, vapor recovery has an estimated cost range of 3–6 US$/tCO$_2$eq. The costs for LDAR, flaring technologies, and electrification may range from 2–15 US$/tCO$_2$eq, depending upon the equipment selected and the frequency of repair.

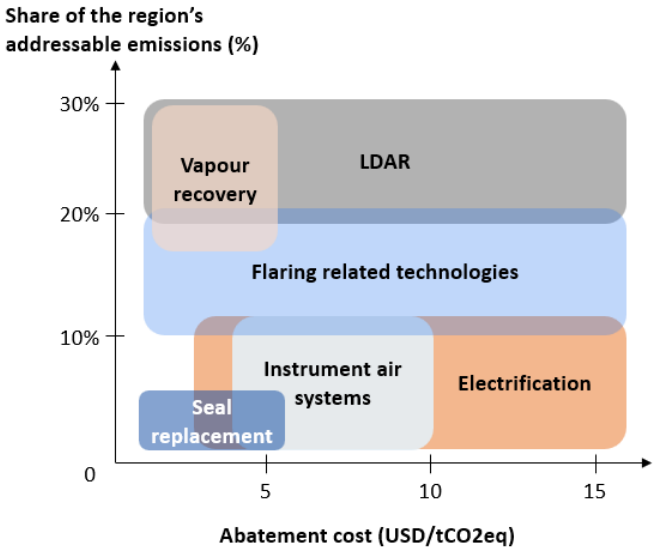


Figure 10. Abatement Technologies - Prioritisation Matrix

Note: Technologies are plotted in the matrix based on their range of deployment cost and addressable emissions.
LDAR = leak detection and repair; tCO2eq = ton of carbon dioxide equivalent
Source: Rystad Energy research and analysis; Company websites; Interviews; Secondary research articles.

Indonesia, Malaysia, and Thailand, the three largest methane emitters in ASEAN, are likely to adopt distinct approaches in selecting abatement technologies. Their choices will vary based on their unique emissions profiles, with specific technologies tailored to address specific emission types.

Indonesia

In Indonesia, fugitive emissions account for approximately 51 percent of methane emissions, addressable largely through low-cost technologies like minor repairs following leak detection campaigns. LDAR deployment costs are estimated at 6 to 7 US$/tCO$_2$eq for gas assets, assuming monetisation of captured gas, and approximately 4 to 5 US$/tCO$_2$eq for oil assets, where captured gas may not be monetised. Most fugitive emissions originate from old onshore oil assets in Sumatra.

Beyond LDAR, key technologies for Indonesia include process optimisation for reduced flaring, deployment of VRU for excess gas capture, and conversion of gas-powered controllers to compressed-air-powered controllers. These could cumulatively address up to 43 percent of the country's emissions, primarily from venting and combustion. Absolute deployment costs are estimated at 3 to 4 US$/tCO$_2$eq for VRUs, 5 to 6 US$/tCO$_2$eq for both instrument air systems and process optimisation.

Malaysia

In Malaysia, 45 percent of emissions are combustion related, primarily from large offshore projects in Peninsular Malaysia and Sabah. Key abatement technologies include reduced flaring and electrification. Switching pump motors from fuel drive to electric drive costs approximately 4–5 US$/tCO$_2$eq, while process optimisation for flare reduction costs approximately 5 US$/tCO$_2$eq. If captured gas is monetised, the net abatement cost could decrease to 6 to 7 US$/tCO$_2$eq for both technologies.

Other key technologies for Malaysia to address venting and fugitive emissions include the use of VRUs and deployment of LDAR campaigns. These could cumulatively address 35 percent of the country's emissions. The absolute deployment cost is assessed to range from 2 to 3 US$/tCO$_2$eq.

Thailand

Thailand's emissions stem from a few large projects that have a high share of venting and fugitive emissions. Leak detection campaigns and minor repairs could address nearly 60 percent of the country's emissions. With gas monetisation pathways, the net LDAR cost could be approximately 3 to 4 US$/tCO$_2$eq, making it the primary abatement technology for Thailand.

Beyond LDAR, deployment of VRUs and conversion of seals from leak-prone wet seals to dry seals are key technologies that could address venting and fugitive emissions in the country. The absolute deployment cost of these technologies is estimated to be in the 2 to 4 US$/tCO$_2$eq range.

Abatement Funding

Operators should consider several key factors when selecting methane abatement projects for funding:

- **Addressability** – Implementation of abatement methods that can address a large volume of emissions ensures that funding is directed towards initiatives with the largest overall impact on emissions reduction.
- **Replicability** - Projects that employ abatement methods that can easily be replicated for other assets in the region could be prioritised. Best practices from an operator's efforts could be shared in regional forums to build awareness and accelerate action by the peer group.

Operators could design projects by identifying the most prevalent emission type across facilities and selecting suitable technologies. Identifying a representative site with similar characteristics to other sites and exploring abatement technologies relevant to it could be an alternative approach.

(kt CO_2eq)

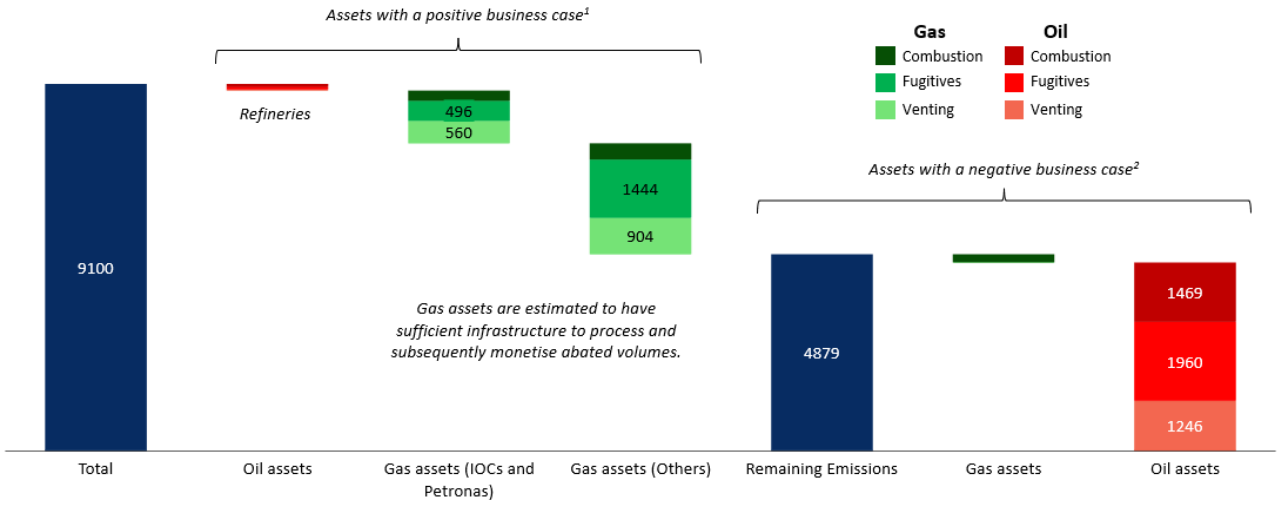


Figure 11. ASEAN Methane Emissions, 2023: Business Case for Abatement

Note: (1) Assets with significant gas production or processing capabilities across the value chain; (2) Assets with insufficient gas processing capabilities, or where volumes cannot be monetised. IOC = Internation Oil Companies; Kt CO_2eq = kilotons of carbon dioxide equivalent.
Source: Rystad Energy research and analysis.

Total emissions in the region could be categorised by the project's business case for abatement, and emission type, as indicated in **Figure** 11 The business case largely hinges on a facility's ability to monetise gas savings; a net negative abatement cost indicating a favorable return on investment. Gas producing assets generally have a positive business case because captured methane can be added to sales, while oil assets often lack the infrastructure to handle additional gas volumes, making monetisation difficult. A **methane management roadmap,** as depicted in **Figure** 12, has been proposed to initiate methane management in ASEAN, aimed at promoting the adoption of best practices across the region.

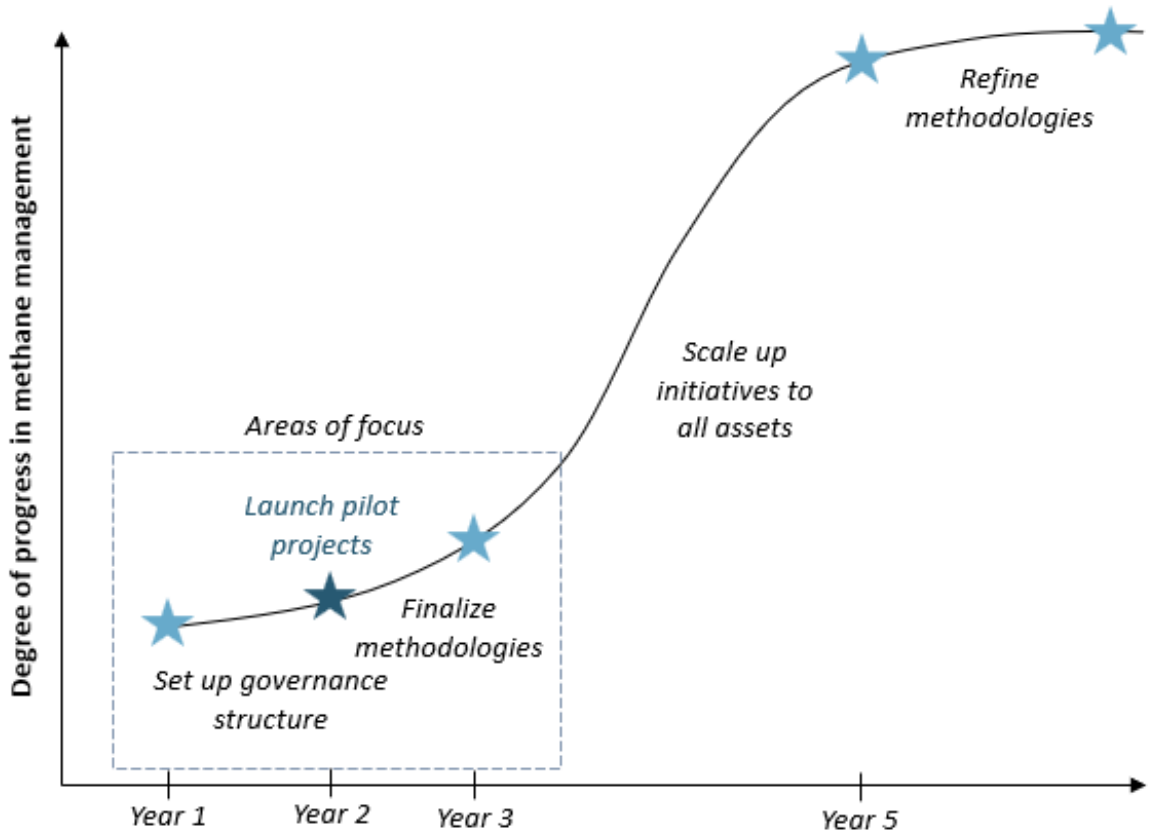


Figure 12. Overview of ASEAN Methane Management Roadmap

Source: Rystad Energy research and analysis.

The program is expected to begin by establishing a governance structure with a steering committee from key ASEAN Member States and a charter outlining roles and decision-making processes. This will facilitate the selection of pilot project sites to test methane measurement tools and identify effective monitoring and abatement methods for regional implementation. Next, findings could be synthesised through data analysis, MRV methodology testing, and the development of best practice guidelines, which may be shared in capacity-building workshops. During the scale-up phase, initiatives will expand to include all regional assets and integrate methane management into regulatory frameworks. Regular reviews could be conducted to refine methodologies and strategies as needed.

Conclusion

The roadmap and underlying analysis reveal several key insights, summarised below.

Methane emissions originating from oil and gas operations in the ASEAN region are critical to handle, given the high GWP over a 20-year period. Effective implementation of monitoring and abatement efforts to address the approximately 0.32 Mt of methane in the region could generate up to **US$87 million in gas sales**

The overall methane management landscape in ASEAN has significant potential to grow, and it is important to maintain the momentum of the past few years. Participation in the GMP, OGMP 2.0, and the COP28 Oil and Gas Decarbonization Charter are **key initial steps that put much-needed emphasis on the issue of methane emissions.** An ASEAN-wide adoption of the OGDC 0.2 percent intensity target would be a significant next step. The commitments of the largest emitters in the region make this a highly achievable target.

The ASEAN region faces several challenges in methane management, including limited regulatory focus. To address these issues, there is a need for **increased awareness, improved stakeholder coordination**, and the establishment of **clear incentives** for methane abatement and reporting.

Leak detection, reporting, and certification are essential initiatives for driving emission reduction in the region. Effective monitoring is vital for identifying leak sources, and appropriate detection methods need to be utilised. A standardised reporting framework is expected to enhance transparency around emissions reporting, while a certification program could offer recognition and financial incentives for the region's emission reduction efforts.

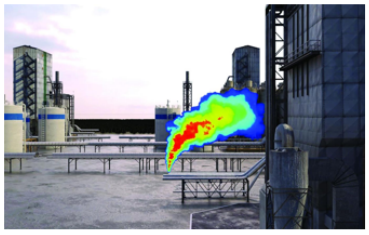
There are a variety of tools available to operators looking to achieve emission reduction. Most addressable methane emissions in the region could be abated at a net negative cost. Key technologies include LDAR, installation of VRU, and flaring-related methods, which together have the potential to address over three-fifths of the region's emissions. By forming a baseline through methane monitoring and verification, a toolkit of technologies could be tailored to key sites' emission profiles, maximising their impact through scalable and sustainable abatement projects.

The proposed methane management roadmap is expected to initiate and sustain the adoption of best practices across the region. The roadmap establishes a governance framework, and is crucial to promoting the development and implementation of effective methane monitoring and abatement strategies across ASEAN Member States.

Appendix

Case studies for the implementation of Monitoring and Abatement solutions for methane emissions:

Case study 1:



Corporation	ConocoPhillips
Project initiation	2018-2022

Case description	
ConocoPhillips uses various LDAR tools to detect and fix methane leaks. In 2022, the company completed about **9,200 handheld OGI surveys** and **3,400 aerial surveys** in the Permian and Eagle Ford basins. They prioritize projects that significantly reduce GHG emissions with a break-even cost under **$60/tonne CO2eq**.	
Airborne systems	**Airplane sensors** can detect smaller leaks, but ConocoPhillips's experience indicates that their effectiveness at pinpointing exact locations can be diminished in areas where other facilities are in close proximity. **Drone-mounted technology** has proven effective in detecting and locating the source of leaks due to their low-altitude capabilities.
Satellite-based detection	**Satellite-based detection** is another option for large-scale leak detection, but ConocoPhillips has found it less effective in areas with closely spaced facilities and for identifying small to medium leaks.
Optical gas imaging camera inspections	While airborne technologies are effective at detecting leaks, personnel must follow up with **handheld OGI cameras** to pinpoint the exact location and equipment involved. ConocoPhillips then performs repairs and verifies successful mitigation.
Continuous monitoring systems (Metal oxide-based Sensors)	Three to six **strategically placed sensors** optimize effectiveness in varying wind conditions. An automated system analyzes elevated methane levels by factoring in equipment location, distance, wind speed, and direction to identify likely emission sources. Metal oxide-based sensors used are considered simple and cost-effective.

Figure 13. Overview of Leak Detection and Repair Campaign at ConocoPhillips' facilities

Note: CO_2eq = carbon dioxide equivalent; GHG = greenhouse gas; LDAR = leak detection and repair; OGI = optical gas imaging.
Source: Rystad Energy research and analysis, ConocoPhillips

Case study 2:

Corporation	ConocoPhillips
Project initiation	2016

Case description	
ConocoPhillips has implemented **Vapor Recovery Units** for multiple of their US based facilities that captures vapors from crude oil storage tanks and produced water tanks through a closed-loop system. Being the largest methane emitting region in the US, the Permian Basin is a focus area for the company.	
Greenfield VRU	ConocoPhillips is installing **Vapor Recovery Units at new facilities** to capture and sell gas from 3-phase separators. The company is also utilizing mobile VRUs which convert flare gas into compressed natural gas (CNG). The produced CNG can then be used to power drilling or completion operations.
Brownfield VRU	In 2022, the company completed several projects in **Permian and Bakken** to retrofit Vapor Recovery Units on **existing brownfield sites** to capture tank emissions and reduce flaring. These projects have the potential to reduce the company's flaring by half in the Bakken basin, which is the equivalent of removing approximately **100 kt of CO2e per year**.
Cost estimate	ConocoPhillips' facility at Baker in the state of Montana **installed 9 VRUs** that captures vapors from crude oil storage tanks and produced water tanks. These 9 VRUs had a total capital cost of around 0.7 Million USD. The captured gas generates a revenue of approximately 250,000 USD per month leading to a quick payback on the investment.

Figure 14. Overview of implementation of Vapour Recovery Units (VRU) at ConocoPhillips' facilities

Note: CO_2e = carbon dioxide equivalent; kt = kiloton; VRU = vapor recovery unit.
Source: Rystad Energy research and analysis, ConocoPhillips

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