Curtailing Methane Emissions from Fossil Fuel Operations

Pathways to a 75% cut by 2030

International Energy Agency

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Abstract

Tackling methane emissions from fossil fuel operations represents one of the best near-term opportunities for limiting the worse effects of climate change because of its short-lived nature in the atmosphere and the large scope for cost-effective abatement, particularly in the oil and gas sector. This report explores practical measures that governments and companies can take to secure a 75% reduction in methane emissions from fossil fuel operations as envisioned in the IEA's Net Zero by 2050 Roadmap.

Building on the estimates of emissions and abatement options in the IEA Methane Tracker and our Regulatory Roadmap and Toolkit, we quantify the potential impact of a range of measures, including policy and regulatory action, voluntary industry initiatives and improvements in transparency of emissions data. By identifying the different measures and approaches that can limit methane emissions, this analysis aims to provide insights and guidance for decision-makers in the lead-up to COP26 and beyond.

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Executive summary

Methane has contributed to around 30% of the global rise in temperatures to date, and curbing these emissions is the most effective means available for limiting global warming in the near term. Emissions from fossil fuel operations present a major opportunity in this respect, since the pathways to reduction are both clear and cost-effective. Fossil fuel operations generated close to 120 Mt of methane in 2020 – nearly one-third of all methane emissions from human activity. The scope for reducing these emissions is enormous. This is particularly true in the oil and gas sector, where it is possible to avoid more than 70% of current emissions with existing technology, and where around 45% could be avoided at no net cost.

Reducing fossil fuel demand alone will not do the job quickly or effectively enough, which means early and concerted abatement efforts by governments and industry are essential. Under the IEA's Net Zero Emissions by 2050 Scenario, methane emissions from fossil fuel operations would need to fall by around 75% between 2020 and 2030. Only about one-third of this decrease is the result of reduced consumption of fossil fuels, principally coal. Most of the decline comes from the rapid deployment of measures and technologies to eliminate avoidable methane emissions by 2030.

A number of countries have already shown leadership through ambitious policy commitments on methane. Some have included methane alongside other greenhouse gases as part of their national net zero pledges, while others have set dedicated targets like the new Global Methane Pledge, led by the European Union and the United States. Cutting methane emissions from fossil fuel operations can, and should, play a central role in national efforts to meet these goals.

In this analysis, we identify the practical steps that can be taken by countries and companies to secure a 75% reduction in emissions from fossil fuel operations. Building on the estimates of emissions and abatement options in the IEA Methane Tracker, we quantify the potential impact of a range of measures, including policy and regulatory action, voluntary industry initiatives, and improvements in the transparency of emissions data. By identifying the different measures and approaches, this analysis aims to provide insights and guidance for decision makers in the lead-up to COP26 and beyond. This is a crucial decade for action. It is vital that immediate steps be taken to cut emissions of both methane and CO_2 to keep a 1.5 °C stabilisation in global average temperatures within reach.

Tried and tested approaches exist for lowering methane emissions from oil and gas, and efforts to improve data quality are ongoing. A set of well-established policy tools have already been deployed in multiple jurisdictions to drive down emissions. These include leak detection and repair requirements, technology standards and bans on non-emergency flaring and venting. Still further reductions can be achieved with the help of more accurate and reliable data on emissions and abatement opportunities – but this will require robust measurement and reporting mechanisms. If all countries that have already committed to reducing methane emissions were to adopt these policies, we estimate methane emissions from global fossil fuel operations could be cut by nearly 15%.

Countries that have already committed to methane reduction can take steps to encourage their trading partners to step up abatement efforts. The committed countries will need to work together to expand their coalition through a mix of diplomatic action, incentives, technical and institutional support, and trade measures. If committed countries were to leverage their buying power, they could reduce the emissions associated with their imports of oil and gas, leading to a further reduction of more than 10%.

The oil and gas industry has a critical role to play as a complement to government action, particularly where regulatory capacity is limited. A growing number of companies are actively working to reduce methane emissions from their own operations, encourage sound policies and regulations, and provide more transparent data. These companies can quickly address emissions across their own operations and help spread best practices across the industry by extending their efforts to ventures where they are non-operating partners. This would accelerate many of the abatement actions targeted by governments and could deliver a further reduction in global emissions of almost 10%.

Better and more transparent data about the sources of methane emissions puts added pressure on countries and companies to act. Measurement-based emissions reporting helps governments to regulate more effectively. It also allows consumers and investors to identify top performers and to work with companies on setting and achieving emissions reductions goals. Advances in monitoring technologies, notably from satellites, are a key development in this area. As the technology improves and data processing becomes more agile, early-warning systems that pinpoint methane leaks will become increasingly viable. Such powerful tools can facilitate timely action, especially in countries where oversight systems are weak.

When it comes to coal, the most effective way to lower emissions is to focus on lowering demand. But encouraging better management of methane leaks in existing and abandoned mines is also important. Under the Net Zero Emissions by 2050 Scenario, the global supply of coal falls by more than half by 2030, which would significantly reduce total methane emissions from fossil fuel operations. If all the countries with commitments on methane were to follow this path, total emissions would decline by more than 10%. A further 5% of emissions could be avoided in the near term if mine operators took steps to utilise more of their methane and to limit emissions from their abandoned sites.

A broader coalition is needed to address methane emissions. At present, around 40% of methane from fossil fuel operations originates in countries where strong commitments to reduce emissions have already been made. So even if these countries were to deploy every strategy listed above to tackle the methane emissions within their borders, it would still not deliver a 75% reduction by 2030. Although recent policies and technological advances are reasons for optimism, the time has come for all countries and operators to tackle the issue head on.

1. Introduction

Summary

- Tackling methane emissions from fossil fuel operations represents one of the best near-term opportunities for limiting the worst effects of climate change. This is due to methane's short atmospheric lifetime and the relatively low cost of abatement, particularly in the oil and gas sector. Based on average natural gas prices from 2017-2021, we estimate that almost 45% of methane emissions from oil and gas operations can be avoided by taking steps with no net cost.
- Under the IEA's Net Zero Emissions by 2050 Scenario, total methane emissions from all fossil fuel operations fall by around 75% between 2020 and 2030. To achieve this goal, a concerted effort will be necessary to implement all available abatement measures, while minimising fossil fuel use.
- A number of countries have already stepped forward with ambitious commitments to lower methane emissions. Several companies and industry groups have also made similar announcements. Yet even if fully implemented, these commitments will not deliver cuts sufficient to meet global climate goals.
- To achieve the necessary reductions, countries with strong commitments must take comprehensive action to regulate methane within their borders. Well-established abatement policies combined with robust, measurement-based reporting mechanisms can help.
- In parallel, this group must build a larger coalition of engaged actors to address emissions beyond their borders. This will require a mix of diplomatic encouragement, trade measures and incentives, technical and institutional support, and enhanced transparency.

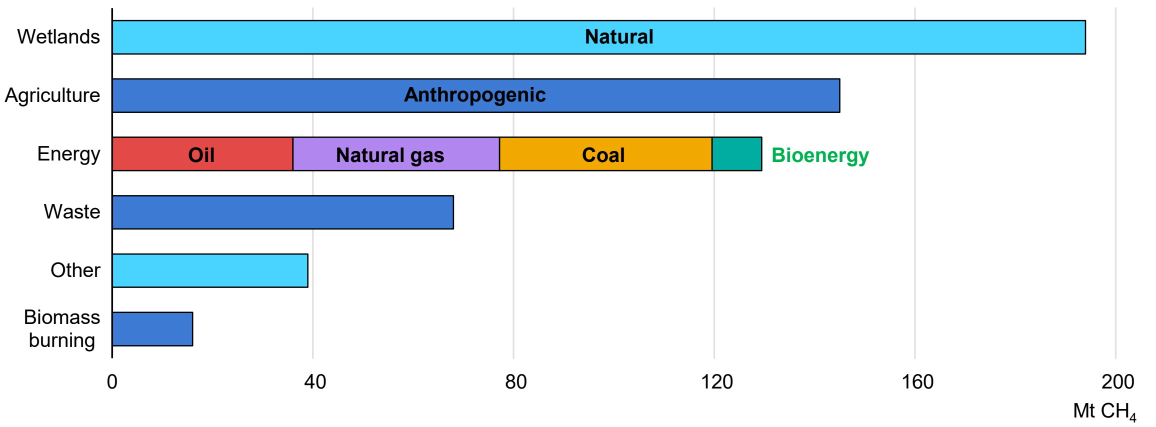
Tackling methane emissions is one of the most significant opportunities available for limiting the near-term effects of climate change. Reducing methane has a major and immediate climate benefit because it has a much shorter atmospheric lifetime than CO_2 (around 12 years compared with centuries for CO_2), and it absorbs much more energy while it remains in the atmosphere: Over a 20-year timeframe, methane absorbs more than 80 times the energy of a comparable volume of carbon dioxide., compared to about 30 times over a 100-year timeframe.

In its most recent report, the IPCC 6th Assessment Report Working Group I highlighted the importance of strong, rapid and sustained reductions in methane emissions. The UN Environment Programme and Climate and Clean Air Coalition's Global Methane Assessment concluded that a concerted effort to reduce 45% of all anthropogenic methane emissions by 2030 could avoid nearly 0.3 °C of global warming by the 2040s and reduce environmental and health impacts from air pollution. Action on methane will be particularly important in the period to 2030 because sharp cuts in methane can deliver a net cooling effect within a relatively short period. This could help to keep the door open to a 1.5 °C stabilisation in global average temperatures, while the world pursues reductions in CO_2.

Methane emissions from fossil fuel operations should be the first priority

Methane from fossil fuel operations represents nearly one-third of human-caused emissions. These emissions represent one of the best near-term opportunities for climate action because the pathways for reducing them are known and understood. Further, compared to action on agriculture and waste, a larger proportion of the abatement options come at a low cost.

Figure 1.1 Sources of methane emissions



Note: Energy sector emissions are for 2020 and based on the latest estimates from the Methane Tracker and the World Energy Outlook. Non-energy sector emissions are taken from the Global Methane Budget for the year 2017, with natural sources relying on top-down median estimates, and other anthropogenic sources relying on bottom-up median estimates.

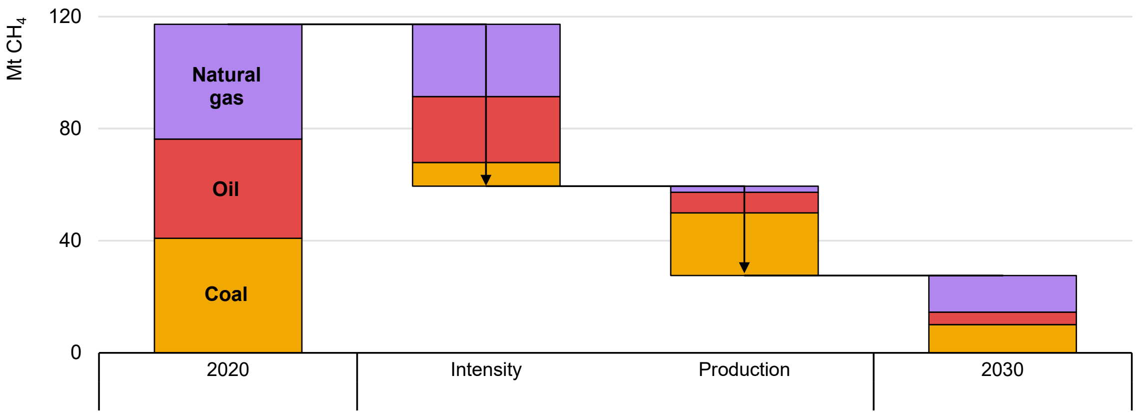
Reducing methane from oil and gas operations is particularly promising because more than 70% of emissions can be abated with existing technologies. In addition, the cost of mitigation is often lower than the market value of the gas that is captured. Based on average natural gas prices from 2017-2021, we estimate that almost 45% of oil and gas methane emissions can be avoided with measures that would come at no net cost. While new investments to abate the remaining emissions would total about USD 13 billion, those costs would be more than offset by revenues from the sale of captured methane.

The abatement opportunities for coal are more costly, due to the low concentration and dispersed nature of methane sources. Nonetheless, significant opportunities remain to reduce emissions in the near term using existing technology (alongside reductions achieved through lower consumption). Thermal coal, which is used for power generation, must be replaced by competitive, low carbon alternatives, such as renewables. As for the coking coal used in steel production, there is no immediate cost-effective substitute. However, it is often produced in deep mines where more options exist for mitigation. As such, its production can decline gradually while keeping emissions to a minimum.

A concerted effort is essential: Cutting fossil fuel use will not deliver methane abatement fast enough

To deliver sufficient cuts in emissions, the volume of methane released per unit of oil, gas or coal produced must fall significantly. Focusing on production and use of these fuels alone will not be enough, even with the dramatic reductions foreseen in the IEA Net Zero Emissions by 2050 Scenario. (This scenario provides a 50% chance of limiting the global temperature rise to 1.5 °C.)

Figure 1.2 Reductions in methane emissions from coal, oil and natural gas in the Net Zero Emissions by 2050 Scenario



Under the Net Zero Scenario, **total methane emissions from fossil fuels fall by around 75% from 2020 levels by 2030**. About one-third of this drop results from overall reduction in fossil fuel consumption. Most of it depends on the accelerated deployment of mitigation measures and technologies leading to the elimination of all technically avoidable methane emissions by 2030.

Methane abatement efforts will be important across all fossil fuels. Coal consumption drops by a larger amount than oil and gas over this period, but the emissions intensity of coal also falls significantly. By 2030, emissions intensities for coal production fall by almost 45% under the Net Zero Scenario, while intensities for oil and gas supply fall by more than 70%.

Momentum to tackle methane emissions is building, from countries as well as companies

A number of governments have made early public commitments to reduce methane emissions from fossil fuel operations. The exact form and language of these commitments varies: Some set explicit methane reduction targets backed by credible regulations, while others simply include methane within a broader net zero pledge or nationally determined action plan.

Most recently, the European Union, the United States, and several other countries announced a pledge to reduce global methane emissions by at least 30 percent from 2020 levels by 2030 while also improving methods for quantifying methane emissions. Although this pledge applies to all methane emissions from human activity, it notes that the greatest potential for mitigation by 2030 is in the energy sector.

Although many countries have adopted high-level targets such as the Global Methane Pledge, specific progress on implementation varies greatly. Canada, Mexico, Norway and the United States have already adopted regulations specifically designed to reduce emissions from oil and gas operations. However, even among the countries leading the charge on methane, there are significant gaps and opportunities to accelerate action.

Several countries have also announced their intention to strengthen or develop new regulations. The United States is working to revise and expand existing regulations, and the European Union is set to announce new legislation on methane under its 2020 Methane Strategy. Meanwhile, countries like the People’s Republic of China (“China” hereafter) and Côte d’Ivoire have said they will prioritise the reduction of short-lived climate pollutants like methane.

Table 1.1 Policy commitments and actions on methane emissions from fossil fuel operations in selected countries

Country or region	Targets/action on methane
Argentina	• Supports the Global Methane Pledge (2021) • Pledge to reach net zero by 2050 includes all greenhouse gases (2020) • Legislation under consideration to regulate oil and gas methane (2020)
Canada	• Pledge to reach net zero by 2050 includes all greenhouse gases (2021) • Federal regulations on oil and gas methane (2018) • 40-45% reduction target for oil and gas methane by 2025 (2016)
China	• Most recent five-year plan commits to increase regulation of methane, and other non-CO_2 gases (2020) • Pledge to reach net zero by 2060 includes all greenhouse gases (2020)
Côte d'Ivoire	• Short-Lived Climate Pollutant Action Plan targets a reduction of 50% by 2030 of avoidable fugitive emissions from oil and gas operations (2020) • Global Methane Alliance reduction target of at least 45% by 2025 and 60-75% by 2030 (2019)
European Union	• Supports the Global Methane Pledge (2021) • EU Methane Strategy to reduce methane emissions (2020) • Pledge to reach net zero by 2050 includes all greenhouse gases (2018)
Korea	• Pledge to reach net zero by 2050 includes all greenhouse gases (2019)
Japan	• Supports the Global Methane Pledge (2021) • Pledge to reach net zero by 2050 includes all greenhouse gases (2020)
Mexico	• Supports the Global Methane Pledge (2021) • Regulations for control of methane from hydrocarbons sector (2018) • 40-45% reduction target for oil and gas methane by 2025 (2016)
Norway	• Pledge to reach net-zero by 2030 includes all greenhouse gases (2016) • Longstanding regulations to limit emissions from oil and gas industry
Nigeria	• 60% reduction target for fugitive oil and gas methane by 2031 (2021) • Global Methane Alliance reduction target of at least 45% by 2025 and 60-75% by 2030 (2019) • Short-Lived Climate Pollutant Action Plan targets a 50% reduction in methane leakage and fugitive emissions by 2030 (2018)
United Kingdom	• Supports the Global Methane Pledge (2021) • Pledge to reach net zero by 2050 includes all greenhouse gases (2016)
United States	• Supports the Global Methane Pledge (2021) • Pledge to reach net zero by 2050 includes all greenhouse gases (2021) • Executive Order committing to update methane regulations in the oil and gas sector (2021) • 40-45% reduction target for oil and gas methane by 2025 (2016) • Federal regulations on new oil and gas sources (2016)

Progress in methane abatement from coal mines has been slower. Still, some leading coal producing countries have begun encouraging the re-use of methane recovered from mining operations. In China, for example, a 2020 notice on environmental impact assessments for coal developments requires improvements in the utilisation rate of coal mine methane. Meanwhile, in the United States, coal mine methane reduction projects are eligible for compliance offsets, or credits, that are tradable on carbon markets.

Meanwhile, a growing number of energy companies have pledged publicly to reduce their methane emissions through initiatives such as the Methane Guiding Principles (MGP), the Oil and Gas Climate Initiative (OGCI) and the Oil and Gas Methane Partnership 2.0 (OGMP 2.0). This group includes major producers in the private sector as well as state-owned oil and gas companies. Companies joining these initiatives commit to reducing methane leaks and flaring volumes over time and to advocating for sound methane policy and regulation.

In addition to these undertakings, energy companies are gradually becoming more transparent about their emissions. In 2020, through the OGMP 2.0, more than 70 oil and gas companies committed to a reporting standard that will increase the accuracy and amount of data that is gathered on methane emissions over time. While this standard is currently voluntary, the European Union is exploring a mandate based on the OGMP 2.0 Framework in upcoming methane legislation.

Meanwhile, new tools that facilitate emissions detection and support abatement action are becoming more readily available. It is now possible to observe significant emissions events from a handheld device, as well as from aircraft or satellites. Satellite detection has improved particularly rapidly. The first detection from space occurred in 2016, and only five years later, there are now new reports of major leaks being detected nearly every week. Continuous monitoring devices are also enabling real-time, on-site detection at oil and gas facilities. While useful to companies seeking to better understand their own emissions, these technologies can also be deployed to enhance transparency and put pressure on emissions abatement laggards.

Box 1.1 Global Methane Pledge

In advance of the UN Climate Change Conference (COP26), the European Union and the United States announced the Global Methane Pledge, an initiative that aims to build momentum for reducing methane emissions. By signing the pledge, countries commit to a collective goal of reducing global methane emissions by at least 30% from 2020 levels by 2030, while also improving methods for quantifying emissions. As of the end of September 2021, eight additional countries have joined: Argentina, Ghana, Indonesia, Iraq, Italy, Japan, Mexico and the United Kingdom.

This pledge covers all sources of methane, including emissions from agriculture, waste and the energy sector. But reductions in methane from fossil fuel operations would be a promising area to target first: Not only would these cover a large portion of emissions, but big cuts can be achieved cheaply with existing technology.

Based on recent submissions to the UNFCCC, supplemented by our own estimates, we estimate that the pledge signatories would reduce their anthropogenic methane emissions by well over 20% if they were to combine all technically available oil and gas abatement opportunities with strong policy action to reduce methane leaks from coal production. Still, this would only reduce total methane emissions from human activity by about 5%.

If the world achieved the 75% cut in methane from fossil fuel operations envisioned by the Net Zero Emissions Scenario, this would lower total human-caused methane emissions by around 25%. So while it is clear that such action can go a long way toward reducing emissions, membership in the pledge coalition must expand and methane management in other sectors must improve in order to reach a 30% decline.

The world is not yet on track to deliver deep cuts in methane emissions from fossil fuel operations

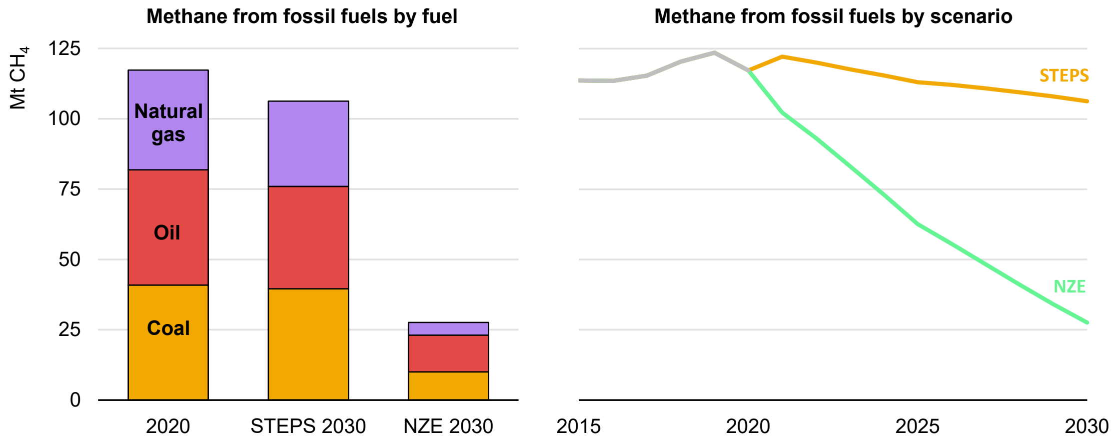
Under the Stated Policies Scenario – the IEA's baseline scenario, which reflects the impact of policies in place as well as those that have been announced – total methane emissions from fossil fuel operations fall by less than 10% between 2020 and 2030. This is well short of what is needed to meet global climate goals, as reflected in our climate-driven scenarios.

The Net Zero Scenario assumes total methane emissions from fossil fuels will fall by about 90 Mt between 2020 and 2030 – a 2.7 gigatonne of carbon-dioxide equivalent (Gt CO_2-eq) reduction in greenhouse gas (GHG) emissions.[1] To put this in perspective: The reduction in energy-related CO_2 emissions in the Net Zero

[1] One tonne of methane is considered to be equivalent to 30 tonnes of CO_2 based on the 100-year global warming potential (IPCC, 2021). See IEA (2017) for a more detailed discussion on relating emissions of methane to CO_2.

Scenario is around 12 Gt in 2030 from the 2020 level. That means methane reduction represents a further 22% reduction in energy related GHG emissions.

Figure 1.3 Methane emissions from fossil fuels and outlook by scenario



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Note: STEPS = Stated Policies Scenario; NZE = Net Zero Emissions by 2050 Scenario.

While it is encouraging that many of the largest producers and consumers of fossil fuels have committed to reducing methane, a step change in effort will be needed in order to close the gap between what current policies and practices are expected to deliver and what is needed to meet climate goals. Though many existing commitments are ambitious, they often lack specificity. Even if all countries follow through on their existing pledges and commitments, most will fall short of delivering their share of the 75% cut needed globally from fossil fuel operations. The same can be said of voluntary commitments from industry, which are well below what is needed under the Net Zero Emissions Scenario.

Countries that have already made strong commitments need to act quickly on domestic emissions…

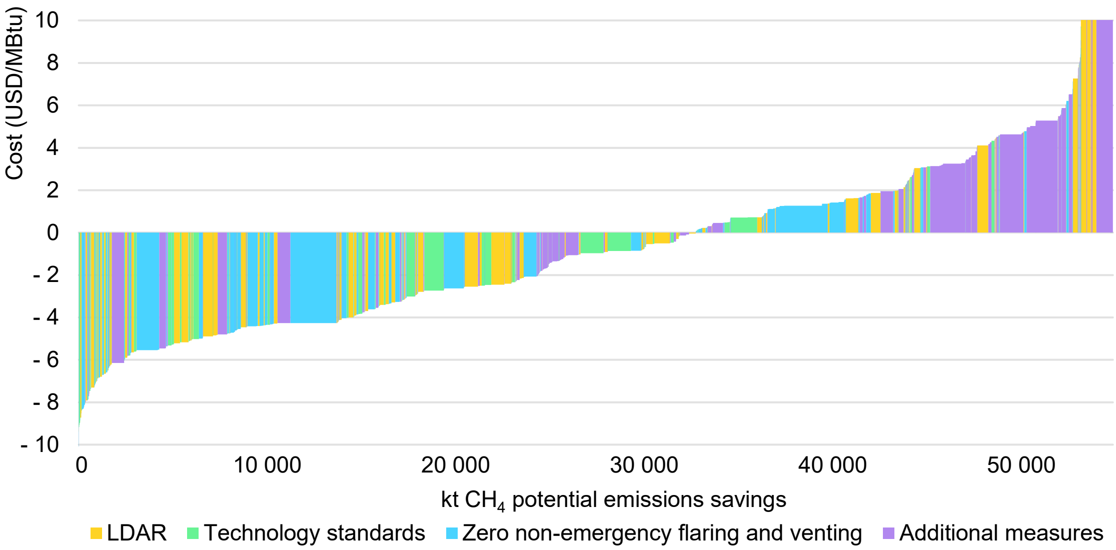
Despite the fact that affordable technologies exist to tackle a large percentage of methane emissions, they remain stubbornly high – even in countries that have already committed to early mitigation measures. More decisive action is therefore required to encourage companies to invest in abatement and to improve emissions data collection. In this regard, policy and regulatory action, along with measures to ensure compliance, will be essential.

As detailed in our Methane Regulatory Roadmap and Toolkit, numerous means are available to countries seeking to reduce emissions. These approaches include traditional command-and-control regulations, performance-based instruments, economic or market-based measures and information reporting requirements.

These tools deliver results. Leak detection and repair requirements, as well as straightforward technology standards and bans on non-emergency flaring and venting, are just some of the approaches that have proven effective in different jurisdictions around the world. Such well-established policies can be scaled up to fight other sources of methane emissions. Moreover, they work at the low-end of the abatement cost curve, where the value of recovered gas may fully or partially offset the cost of abatement.

Beyond these tried and tested policies, the introduction of performance standards, financial incentives or emissions taxes can also create incentives for companies to embrace abatement measures. But such approaches depend on access to reliable emissions data, which – for now – makes them unsuitable in many jurisdictions. Thus there is a clear need to develop systems for measurement-based reporting more broadly, so that countries can better understand and regulate the emissions within their borders.

Figure 1.4 Worldwide methane abatement cost curve by policy option, 2020

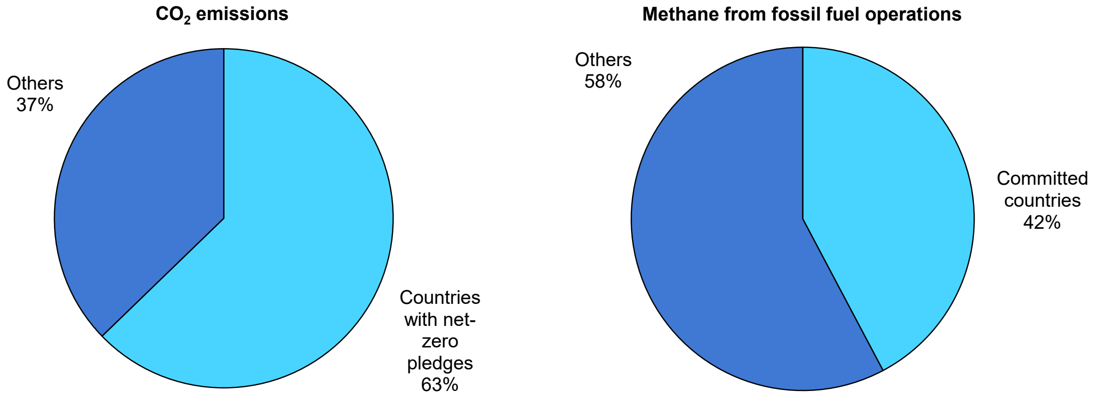


Note: Policies in this marginal abatement cost curve are tied to specific abatement measures in the IEA oil and gas methane emissions model. Gas prices are regional average levels seen from 2017 to 2021.

…and they need to encourage others to join the effort

In the context of energy-related CO_2 emissions, countries with net zero pledges are responsible for well over 60% of global emissions. The picture for methane is quite different: The committed countries are responsible for only about 40% of emissions from fossil fuel operations. It is therefore critical for this coalition to expand its reach through greater collaboration, encouragement, incentives and information-sharing initiatives.

Figure 1.5 Energy-related CO_2 emissions from countries with net zero pledges and fossil fuel methane emissions from countries with strong commitments on methane



Note: Countries with strong methane commitments are listed in Table 1.1.

Among countries lacking strong commitments on methane, progress toward emission reduction varies. While some have taken no formal policy action, a number of countries, including Australia and the Russian Federation ("Russia" hereafter), have recognised the importance of cutting methane emissions and introduced measures aimed at boosting reductions. Others, such as Colombia and Iraq, are in the initial stages of developing new regulations on methane. These efforts have so far had limited impact, but they are nonetheless encouraging.

Elsewhere, big energy importers like the European Union and Japan could leverage their positions to encourage emissions cuts across the value chain of the fuel destined for their markets. Importers could, for example, create incentives for better measurement and reporting of upstream emissions. Alternatively, they could allow oil and gas with lower emissions intensity to be priced at a premium – or limit market access for fuels with higher emissions intensity.

Alongside policy changes, voluntary action by companies may also play a role in driving reductions. Committed companies can encourage their peers to join methane reduction initiatives like OGCI, OGMP 2.0, and MGP, and promote best practices on methane management to their partners in non-operated joint ventures.

Governments can further support company efforts by helping to improve transparency about the state of emissions. Explicit recognition of standards like the OGMP 2.0 Framework, or support for initiatives like the International Methane Emissions Observatory (IMEO) could encourage more companies to join. Promotion of methane detection and quantification technologies – including continuous monitoring systems, aircraft- and satellite-based tools –can heighten emissions awareness and speed responses to leaks. As technology improves, these technologies could even support remote early warning systems based on satellite detection.

By adopting these types of complementary measures, countries that have already committed to methane reduction at home can help lower emissions beyond their borders. In the remainder of this report, we will explore the potential of such parallel efforts and discuss ways that governments and companies can work together to drive down emissions.

Methodology and approach

The aim of this report is to present a non-prescriptive, high-level identification of the different measures and approaches that could deliver a 75% reduction in methane emissions from fossil fuel operations by 2030. We consider a range of action that includes policy and regulation, voluntary industry initiatives, as well as tools to improve the quality and availability of information about methane emissions. All the data used here are IEA estimates and projections. For oil and gas, they come from the IEA Methane Tracker 2021 and the World Energy Model.

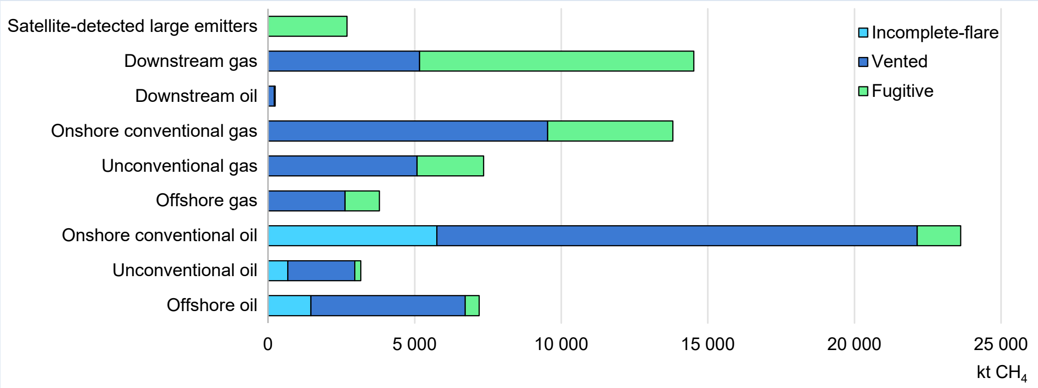
Box 1.2 IEA Methane Tracker

The IEA produces and publishes country-level estimates for oil and gas methane emissions and abatement options as part of our IEA Methane Tracker. These estimates are updated on a regular basis and rely on the most up-to-date data on oil and gas production volumes, country- and production-specific emissions intensities, as well as measurement campaigns and large emissions events detected by satellites. This is our best attempt to reconcile existing information and produce a consistent set of country-level estimates. We welcome all contributions based on measurement campaigns and robust data sources that can support further refinements to our estimates.

Abatement potentials and costs are derived using a bottom-up approach that estimates the source of leaks within countries and the range of potential options to limit these. Abatement measures cover a wide range of equipment and operational options, each with country-specific capital and operating costs. In situations where leaks can be avoided and the methane sold to end-use customers, this can provide a positive revenue source to offset some of the costs of deploying an abatement option. Prices for any methane that can be sold are based on estimated well-head prices within each country, with credit obtained for selling the gas applied regardless of what contractual arrangements between different companies may be required to lead to this result.

Further details on the methods used to derive our methane emissions estimates and abatement options is provided in the World Energy Model documentation.

Oil and gas methane emissions by source, 2020



Policy and regulatory interventions will play a critical role in ensuring that companies have incentives to undertake abatement action. For actions related to methane from oil and gas operations, we have identified a group of countries that have announced ambitious policy commitments in this area – Argentina, Canada, China, Côte d'Ivoire, the European Union, Korea, Japan, Mexico, Norway, Nigeria, the United Kingdom, and the United States. We then assess the measures these countries could adopt to maximise the technically feasible abatements at the domestic level, as well as the steps they can take to tackle emissions associated with imported fossil fuels.

We have evaluated the impact of **regulations** on methane emissions from **oil and gas operations** by considering which abatements these would trigger, building from the IEA's marginal abatement cost curve (MACC) from the Methane Tracker. For regulatory measures that require specific actions (e.g. leak detection and repair requirements), estimates are derived from the abatement potential tied to those specific actions in the Methane Tracker MACC. For regulations based on performance or market-based instruments, we assume that companies would take the lowest net-cost options available first. At the international level, we explore a range of trade and policy options, including diplomatic action and transparency standards, which have potential to affect emissions linked to imported oil and gas.

In the context of **voluntary industry action**, we have identified a group of oil and gas companies that have made public commitments to reduce methane leaks over time, to advocate for sound policy and regulation and to provide greater transparency about their emissions. We include within this group all companies that have joined MGP, OGCI, OGMP 2.0, and the China Oil and Gas Methane Alliance. We assess the emissions reductions these companies could drive if they undertook all technically feasible abatements within their own operations and sought to spread best practices to their non-operated joint ventures.

We also explore the potential of **transparency initiatives** to spur action on methane. Measurement and reporting systems can help improve the understanding of emissions, enabling more targeted action and encouraging more stakeholders to engage on methane management. We discuss how instruments such as satellite monitoring can facilitate methane abatement and ensure that governments, companies and other stakeholders have reliable data on which to base their decisions and direct their climate efforts.

The estimates for **coal mine methane** described in this report are derived from mine-specific emissions intensities for all major coal producing countries – including the United States, China and India. They are based on reported data and country-level estimates from satellite-based measurements or, for mines in countries for which there are no reliable direct estimates, on coal quality (e.g. the ash content or fixed carbon content of coal produced by individual mines), mine depth and regulatory oversight.

The remainder of this report is structured as follows:

- **Chapter 2** explores the potential for countries committed to early action on methane to reduce methane from oil and gas operations using a range of policy and regulatory tools.
- **Chapter 3** discusses what additional reductions could be achieved from oil and gas operations outside the countries that have committed to early action through a combination of different levers, including diplomatic encouragement, policy actions on imported oil and gas, voluntary action by companies, and improvements in transparency.
- **Chapter 4** considers potential pathways to lowering methane emissions associated with coal production, including through reductions in coal use, improvements in utilisation of coal mine methane and mitigation of leaks from abandoned mines.

2. Domestic policies to mitigate oil and gas methane

Summary

- Virtually all countries have potential to reduce emissions from oil and natural gas within their borders significantly. We estimate that the countries committed to early action emitted about 22 Mt CH_4 from oil and gas operations in 2020, of which more than 70% is technically possible to abate.
- To achieve all technically feasible reductions, the committed countries will need policies that are supported by accurate and reliable data on emissions and abatement opportunities. But given the current data quality, these types of measures are not yet viable in most jurisdictions.
- In the meantime, a mix of well-established policy tools already deployed in multiple jurisdictions could – if adopted by all committed countries – cut methane emissions from oil and gas operations in half (to 11 Mt CH_4).
- With the support of robust measurement, reporting and verification, additional measures exist to complement the reductions from established policy tools. This can further reduce domestic emissions by more than 4 Mt CH_4.
- Combined, these actions could reduce global oil and gas methane emissions by 20%.

Policy action aimed at domestic oil and gas can deliver quick methane reductions

IEA analysis indicates that virtually all countries have significant abatement potential within their borders – both for emissions from oil operations and from natural gas. This is the case even for countries that are net fuel importers, since downstream operations account for more than 20% of global oil and gas methane emissions. Countries committed to early action on methane emit about 22 Mt CH_4, of which more than 70% is technically possible to abate.

Several of these countries have adopted regulations to address methane emissions from oil and gas. Still, there is room to strengthen and broaden these regimes to fill coverage gaps and further reduce domestic emissions. For example, some rules apply only to new fuel sources, meaning that existing sources can escape abatement requirements. Moreover, some regulatory regimes exclude certain industry segments, such as LNG or downstream emissions. And often, many of the largest emitters are exempted, even within regulated sectors.

At the same time, there is a need for higher quality data on emissions to better understand where the opportunities for abatement lie, and to measure the effectiveness of regulations. While some measures can work effectively using existing information, others will require more robust, measurement-based reporting. For this reason, committed countries need to improve measurement, verification and reporting. Meanwhile, it is important that regulations be clear and straightforward in order to speed emissions reduction and lay the groundwork for stronger action in future years.

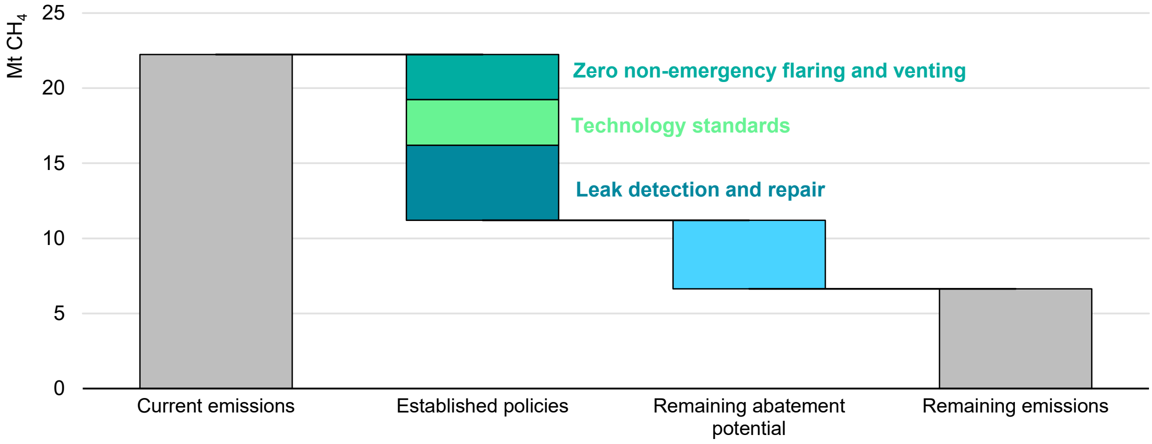
Policies with well-established precedents can mitigate half of domestic emissions

Different types of regulatory measures can be applied to methane. Certain policies have well-established precedents, as they have already been applied in multiple settings. These measures have proven to be both effective and relatively straightforward to administer. Policies in this category have the added benefit of not requiring very advanced tools to verify compliance, although some basic quantification and reporting mechanism is generally necessary. The measures in this category also tend to fall on the lower end of the abatement cost curve – and tend therefore to be the most cost-effective overall.

These **established policies** include leak detection and repair requirements, equipment mandates for sources known to emit significant volumes of methane, and measures designed to limit non-emergency flaring and venting. So far, these policies have been implemented mostly through prescriptive, command-and-control regulations. In principle, these same reductions could also be achieved through policies that incorporate performance- or market-based standards which allow companies to choose the compliance mechanism they find most cost-effective. But given the current state of emissions data, these types of measures will not be viable in most jurisdictions without significant investments to improve monitoring, reporting and verification. In the meantime, the established policies can deliver quick wins while countries work to put more robust monitoring mechanisms in place.

If these established policies were adopted and enforced in all countries that have committed to early action on methane, more than 11 Mt CH_4 of emissions could be avoided – roughly half of their combined oil and gas methane emissions.

Figure 2.1 Reductions from policy measures in countries committed to action on methane



Leak detection and repair programmes are the main tool for addressing fugitive emissions from leaking components and malfunctioning equipment. The reduction potential of leak detection and repair programmes depends on their scope as well as the frequency of inspections and the inspection methods used. Current techniques often involve an on-the-ground inspection with optical gas imaging cameras, but new and emerging technologies – including continuous monitoring sensors, aircraft, drones and satellites – can significantly reduce the cost of detecting fugitive sources when combined with on-site surveys. The more frequently inspections take place, the sooner leaks can be detected and abated – but costs increase with frequency. For the purposes of this assessment, we assume on-site inspections take place once per quarter. We estimate quarterly leak detection and repair reduces fugitive emissions by about two-thirds – or about 5 Mt CH_4.

Technology standards are designed to reduce emissions associated with the normal operation of certain equipment, such as compressors or pneumatic devices. There are a range of technologies that can perform the same function as these components, but with lower – or even zero – emissions. Regulations that set limits on emissions from certain types of equipment or that require their replacement with emission-free alternatives can significantly reduce methane. For the purposes of this analysis, this category includes mandates for installation of well-known technologies at new facilities or the replacement of higher-emitting components with these lower-emitting alternatives at existing projects. Adopting these measures in the committed countries would lead to a reduction of around 3 Mt CH_4 of methane.

Policies designed to achieve **zero non-emergency flaring and venting** can reduce methane emissions by as much as 3 Mt CH_4. Alternatives to flaring include transferring methane offsite via pipeline; capturing it for re-use on site; or compressing captured gas for transfer to processing facilities by truck. Clamping down on flaring can also sometimes create perverse incentives to vent – an even worse outcome from an emissions perspective. This underscores the importance of an integrated approach to flaring and venting policy.

Another area often overlooked by regulators is the combustion efficiency of flaring systems. When properly designed, maintained and operated, a flare should emit a minimal amount of methane. But malfunctions, as well as changes in weather or production conditions, can sometimes allow higher amounts of gas to escape. Occasionally, a flare may be totally extinguished, resulting in direct venting to the atmosphere of gas that should be combusted. New IEA analysis, included in the World Energy Outlook 2021, estimates that, in 2020, flares leaked on average around 8% of the natural gas and natural gas liquids that should have been combusted – more than double previous estimates. Incomplete combustion from flares accounted for about 10% of total oil and gas methane emissions, 95% of which was avoidable.

Regulations must be backed by adequate **enforcement measures** to ensure that companies follow the rules. For the purposes of this assessment, we have assumed a high degree of compliance with the established policies, but it bears repeating that without a concerted effort to ensure compliance, even straightforward regulations may not achieve the desired result. This may be a particular challenge for countries that do not already have a well-developed regulatory capacity on oil and gas methane. That said, it may still be possible to adapt existing monitoring systems to improve methane tracking. For example, most countries already compile a national inventory of greenhouse gases. This can serve as a starting point for enhancing methane monitoring and compliance mechanisms.

These established policies do not usually require site- or source-level emissions measurements to function. Instead, they typically require companies to self-report on any equipment they install or replace, as well as activities such as blowdowns or well completions. Better data can nonetheless help regulators verify and validate reported emissions reductions and track progress towards long-term emissions goals. It is also useful for baseline assessment and planning.

Box 2.1 Policy glossary – Established policies

Leak detection and repair. This refers to policies that require companies to establish programs for locating and repairing fugitive leaks. These policies often specify the method and equipment required for leak detection, the frequency of detection campaigns, which facilities must undertake the inspections, and a requirement to fix leaks within a certain timeframe. Within the IEA methane emissions model, this corresponds to both upstream and downstream abatement options. The model assumes that leak detection and repair will apply to all facilities and may be applied at different frequencies. This assessment assumes quarterly inspections, as this frequency is common among current requirements.

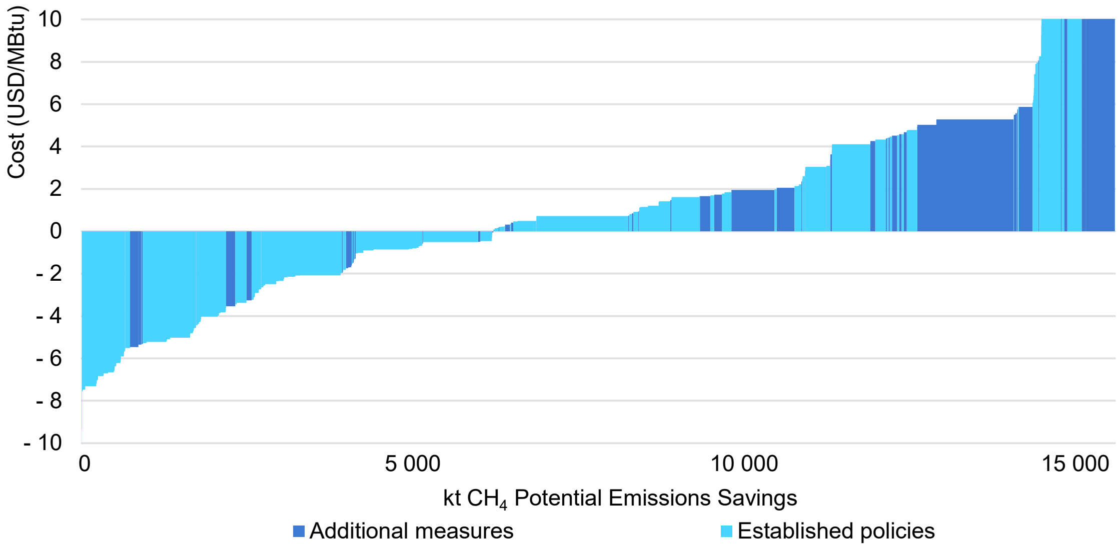
Technology standards. This refers to policies that set specific guidelines for equipment, technologies or procedures. Generally, such requirements mandate that certain equipment be replaced by a lower-emitting alternative. Within the methane model, this corresponds to the following abatement options: replace compressor seal or rod; early replacement of devices; replace with instrument air systems; and replace pumps.

Zero non-emergency flaring and venting. This refers to policies that either prohibit all non-emergency flaring and venting or those that mandate specific processes and procedures which result in less flaring and venting. Within the methane model, this corresponds to the following abatement options: install plunger; install flares; blowdown capture; and vapour recovery units.

Other types of regulations and more robust measurement systems will still be needed to maximise abatement

Broader adoption of these established policies would be a big step forward, but still falls short of ensuring that all technically feasible abatement measures are realised. Robust measurement-based monitoring regimes combined with additional regulations will be needed. Meanwhile, better emissions data can help companies to tailor abatement measures to their operations and can encourage them to develop and deploy innovative technologies.

Figure 2.2 Methane abatement cost curve for policies in committed countries, 2020



In some cases, established policies can be extended or expanded to drive abatement beyond what existing precedents require. As noted above, quarterly leak detection and repair could lead to a significant reduction in emissions, but more frequent monitoring could yield further reductions. In other cases, regulations could mandate newer technologies that, although proven, have not yet been widely adopted.

Enhanced technology standards targeting these technologies may be more complicated to administer than those included within the established policies. These technologies may be context-specific and require detailed knowledge of local industry conditions to determine when they are applicable. For example, in certain situations, it may be possible to move from "low bleed" pneumatic controllers to "zero bleed" technologies that utilise electricity. However, regulators would need detailed information about power availability at specific sites before requiring the use of electric pneumatic controllers.

Other policy options can help drive emissions reductions without prescribing or mandating specific solutions. **Performance standards** leave it up to companies to select the abatement measures most suitable for their operations. The standards, which usually grow stricter over time, focus only on outcomes – i.e. total emissions into the atmosphere. Such standards can be applied at all levels, from individual pieces of equipment to entire facilities. Since companies typically have better information than regulators about local conditions, they are more likely to identify the most cost-effective solutions.

Market-based mechanisms create incentives for companies to take actions that scale with the level of the incentive or tax. **Emissions pricing** imposes a cost on emitting methane that creates an incentive for companies to take abatement action beyond the minimum required. By contrast, loans at preferential rates, grants and other **financial incentives** for methane abatement can help companies to overcome investment barriers or encourage action. Such policies have been used to remediate orphan wells and spur investments that reduce emissions at upstream oil and gas sites.

Performance standards and market-based mechanisms generally cannot function without **robust monitoring, reporting and verification regimes** based on site- or source-level measurements. Both regulators and companies need to have high confidence in the actual performance of regulated sources and equipment, as well as in the potential of abatement actions to affect that performance. Similarly, methane taxes and fees only encourage emissions abatement if companies can be sure that it will reduce their tax bills. Given the current quality of emissions data, however, this kind of approach is not yet viable in most jurisdictions. Hence the need for near-term efforts to improve monitoring, reporting and verification regimes and enable these types of regulation in the future.

Box 2.2 Policy glossary – Additional measures

Within the IEA methane emissions model, additional measures correspond to the following abatement options: replace with electric motor; monthly leak detection and repair; daily leak detection and repair; other. These actions can be driven by a combination of different policies.

Enhanced technology standards. Countries that have adopted prescriptive standards have tended to focus on widely used and proven technologies. But similar requirements can also be applied to more recently developed equipment, technologies or procedures.

Performance standards. These instruments set minimum standards for performance without dictating how those goals should be achieved. Standards can be applied on a wide scale, targeting the performance of entire facilities or even individual pieces of equipment.

Emissions pricing. A charge or tax applied to methane emissions. Depending on the kind of data available, taxes can be assessed on an entity's overall emissions, or on a calculation of the emissions intensity at individual sites or basins. Another approach is to issue tradable emissions permits, which can either target specific, short-lived pollutants or be included within a broader carbon trading scheme.

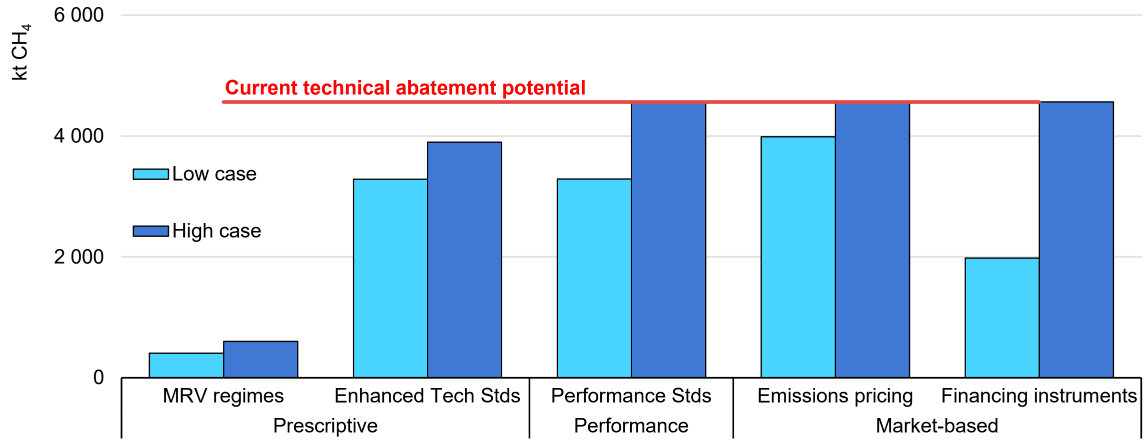
Financing instruments. Governments can use different mechanisms to provide a financial incentive for companies to lower methane emissions. This could include loans, grants, and direct funding tied to specific abatement action. These instruments are flexible and may be applied through existing fiscal systems (e.g. royalties relief) or take the form of targeted loan or grant programs.

Monitoring, reporting and verification regimes. A robust regime based on source-level measurements is necessary for most of these supplementary measures to function. Unlike quantifications based on generic emissions factors, a monitoring, reporting and verification regime that can support performance standards or emissions taxes needs to be based on reliable measurements that can differentiate emissions coming from different sources and industry sites.

Additional measures can deliver a further 20% reduction to committed countries' domestic emissions

We estimate that a combination of these additional measures, stringently applied, could result in full adoption of the technically feasible abatements among committed countries. This would lead to a further 20% reduction (close to 5 Mt CH_4) in their combined domestic emissions – far beyond what could be achieved through established policies alone. For the oil and gas sectors of these countries, meeting that threshold would represent a reduction of about 70% of domestic methane emissions.

Figure 2.3 Reductions from selected policies in committed countries



Note: These measures are assessed based on the abatement potential remaining after established policies have been implemented. The low and high cases assess different levels of stringency and implementation: For MRV regimes, this includes all abatement measures with a slightly negative cost (low) or no net-cost (high); for enhanced technology standards, this means mandating the replacement of gas-powered devices with electric alternatives (low) and the use of other technologies (e.g. use of micro turbines or mini-LNG facilities) (high); for performance standards, the range reflects an intensity standard of 3.0 $ktCH_4$/Mtoe of oil and gas (low) and 2.5 $ktCH_4$/Mtoe (high); for emissions taxes, the related tax levels would be USD 10/t CO_2-eq (low) and USD 40/t CO_2-eq (high); for financing instruments, this reflects a budget of about USD 120 million (low) and USD 1.2 billion (high).

Each of the policies in this category can lead to different degrees of emissions reduction, depending on the stringency of the requirements and how they are implemented. These measures provide added reinforcement to ensure that targeted reductions are achieved, particularly in jurisdictions where there have historically been gaps in enforcement.

Performance- and market-based policies could, in principle, be used to drive all current technical abatement options, including those that are also addressed by established policies. But given the urgent need for action on methane, for this analysis we assume all countries will implement the established policies first, in parallel with actions to improve monitoring, reporting and verification.

The additional measures detailed here will require a strong regulatory and policy framework to ensure that targeted reductions are achieved. Given that established policies already cover the cheapest abatement options, most of the remaining options are more expensive. Adopting a monitoring regime without enhancing requirements is unlikely to yield significant new emissions reductions, since most companies will have already taken the abatement actions that have no net cost.

Enhanced technology standards can spur more sizeable reductions, since they mandate abatement action regardless of the potential cost. Still, they will fall short of reaching full abatement potential. This is because many technologies are context specific, and a regulation would need to be highly detailed to cover all situations. In our analysis, enhanced technology standards could drive reductions of 3-4 Mt CH_4, depending on which standards are applied.

Performance-based emissions intensity standards, on the other hand, do have the potential to reach all technically feasible abatement – if they are stringent enough. Strict intensity standards could even force the shutdown of certain oil and gas operations where methane is especially difficult to abate. In our analysis, potential reductions could range between 3-5 Mt CH_4.

Finally, market-based instruments can also be calibrated so that all technically feasible abatement potential is fully achieved. A relatively low emissions tax of USD 10 per tonne of CO_2-equivalent would be enough to drive over 85% of feasible reductions, while a tax of USD 40 per tonne of CO_2-equivalent would ensure that virtually all of the available reductions were realised. Alternatively, positive financial incentives could help to mobilise additional funds to support abatement action. In total, about USD 1.2 billion in credits and other incentives would suffice to cover the entire net costs of these additional abatement measures.

3. International supply chains for oil and gas

Summary

- A broader coalition of engaged stakeholders is needed to bring down methane emissions. The committed countries will need to bring other actors on board through a mix of diplomatic action, incentives, technical and institutional support, and trade measures.
- If countries with methane commitments adopt policies aimed at internationally traded oil and gas – such as measurement-based reporting standards, price premiums for oil and gas with a lower emissions intensity or emission- intensity requirements – they could drive a further reduction of about 14 Mt CH_4. Any efforts in this area must be paired with technical and institutional support to enhance regulatory capacity and mitigate distributional impacts.
- In parallel, voluntary action by companies can play an important role in driving reductions that go beyond government requirements, particularly where regulatory capacity is limited. If companies currently engaged with methane initiatives apply all available reduction measures to their operated assets as well as their non-operated joint ventures, they could lower emissions by over 30 Mt CH_4. That includes roughly 9 Mt CH_4 that could not be addressed by measures aimed at internationally traded oil and gas.
- Even if all committed actors were to pursue the methane abatement measures within their reach, around 16 Mt CH_4 of total abatement potential would remain unexplored. Increasing transparency through industry standards and advanced monitoring systems based on satellite data and other emerging technologies can help to close this gap.

A broader coalition is needed to bring down methane emissions

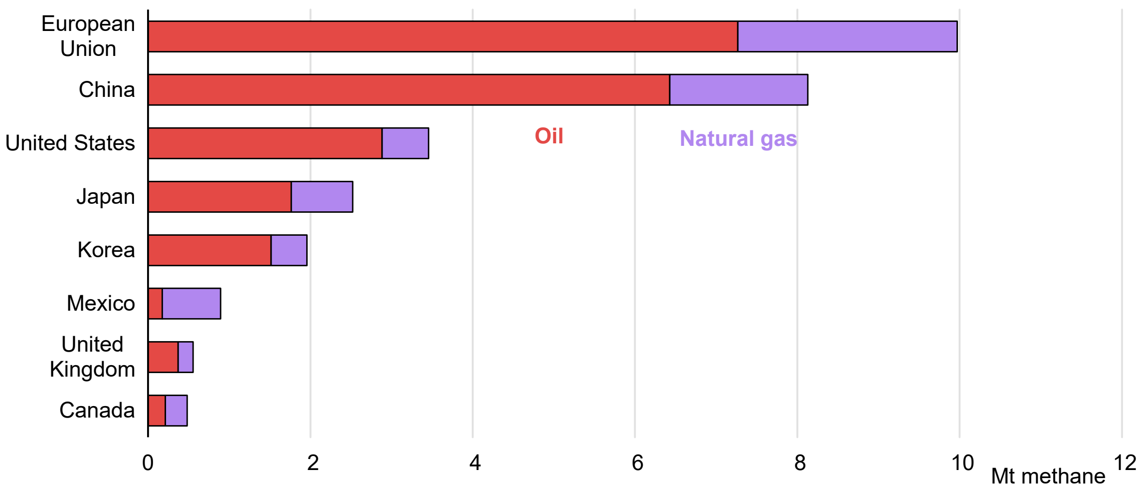
If all countries that have committed to early action on methane exploit every technically feasible abatement option within their borders, this would only reduce current global oil and gas methane emissions by about 20%. This is because the biggest sources of methane emissions – as well as most of the technical abatement potential – are to be found in other countries, including major emitters like Russia and Iran. In order to reach the 75% global drop envisaged in climate-driven scenarios by 2030, it will be necessary to expand the coalition of committed actors.

There are multiple, complementary pathways that can help to grow this coalition. Certain countries will take the initiative to step up abatement on their own, in the knowledge that this is a very cost-effective way to limit near-term warming. Committed countries can encourage such steps through a mix of diplomatic action, political or economic incentives, technical and institutional support, as well as trade measures. In parallel, voluntary action by companies, through initiatives such as MGP, OGCI and OGMP 2.0, can play a critical role. Lastly, increasing transparency about emissions can entice new actors to join the abatement effort, improve their capacity to act and strengthen related incentives.

Major importers can leverage their buying power to encourage additional reductions upstream

More than 40% of the oil and gas produced in countries without methane commitments is exported for use in countries that do have such commitments. Most of this is tied to oil trade, where 55% of this production winds up in committed countries. For natural gas, the figure is less than 25%. Several major importers have strong commitments on methane, including the European Union and Japan. If they were to provide strong incentives to their energy suppliers to mitigate emissions, they could drive emissions reductions outside of their jurisdictions.

Figure 3.1 Methane emissions associated with imported oil and gas to selected committed countries, 2020

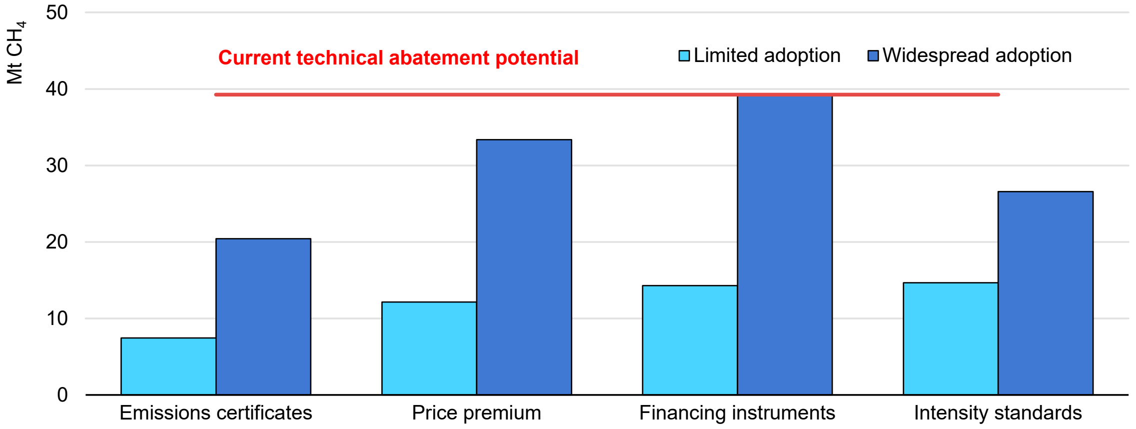


Policy instruments could provide incentives for better measurement and drive reductions

There are several policy tools that importing countries could use to create incentives for methane abatement beyond their borders. These can include purely voluntary measures – encouraging better measurement and reporting of emissions, for example – market access conditions such as minimum emissions intensity standards, or border adjustment taxes. They can also involve cooperation to establish methane regulatory equivalence with exporting countries by defining a set of minimum requirements (e.g. measurement and reporting requirements, technology standards, or a ban on non-emergency flaring and venting).

We estimate results for a set of policy options tied to a limited or a widespread adoption of each measure. The former assumes that abatement measures would only be implemented on fuel flows destined for markets committed to deep methane reductions, while the latter considers these would have a broader effect on the entire oil and gas supply chain.

Figure 3.2 Indicative reductions from international measures on oil and gas destined for countries committed to action on methane emissions



Note: Only emissions in countries that have not yet committed to deep cuts in methane emissions from oil and gas operations are considered in this analysis. Limited adoption scales the abatement potential to oil and gas flows destined to committed countries, whereas widespread adoption shows estimates for all oil and gas activity in countries without commitments. This assessment is based on the following assumptions: emissions certificates drive all abatement measures with a slightly negative net cost; a price premium reflects a value of USD 5/t CO_2-eq; financing instruments would require a budget of close to USD 720 million for the limited adoption case and USD 2 billion for the widespread adoption case; intensity standards restrict market access to oil and gas with an intensity of over 3.0 kt CH_4/Mtoe, which in the case of widespread adoption would drive most measures associated with the established policies.

Emissions certificates, which attest the amount of emissions tied to a specific volume of oil or gas, are starting to appear in trade arrangements. Certification standards contribute to transparency about emissions data while helping to resolve information barriers and raise awareness of existing opportunities to lower emissions. A more complete understanding of the emissions associated with a specific flow of oil or gas can enable the producer to identify cost-effective abatement solutions. Although generally expected to be voluntary, in some contexts emissions certificates could become a condition for market access. If this were to encourage exporters to adopt most of the abatement measures that come at no net cost, it would lead to a reduction of about 7 Mt in methane emissions, even in the case of limited adoption.

A standard for emissions – or an equivalent transparency standard – could also support a **price premium for oil and gas with a lower emissions intensity**. If producers who can demonstrate that their emissions are below a specific benchmark can charge a higher price for their products, this can provide a strong incentive for abatement. There is some risk that a premium might lead certain producers to divert "cleaner" oil and gas streams to these markets rather than encourage new abatement, but over time, a price premium is likely to lead companies to invest in methane reduction. A price premium of USD 3 per million MBtu – which would drive the adoption of all measures with a low cost (below USD 5/t CO_2-eq) – could lead to an estimated reduction of nearly 12 Mt of methane.

Countries may also establish other types of **financing instruments**, such as allowing companies that invest in abatements to earn tradeable credits, or funding abatement measures directly. This type of financing could be particularly effective for addressing emissions from abandoned or orphan wells, where recovered gas may not be marketable. We estimate that less than USD 720 million would suffice to finance abatements related to imports, resulting in 14 Mt of emissions reduction.

As knowledge of, and confidence in, emissions estimates improves, countries may consider setting **minimum intensity standards**, which effectively exclude any oil or gas from a source or producer that does not meet a target emissions intensity. If average emission intensities at the basin or national level are used as benchmarks, individual producers must be able to gain access to the market by demonstrating a lower intensity for this kind of policy to transmit incentives effectively. If a moderately stringent intensity standard were applied to all imports by committed countries, this could lead to a cut in methane emissions of about 15 Mt.

While measures like these could theoretically reach all emissions, those that restrict market access – including minimum intensity standards and alternatives such as border adjustment mechanisms – may face particular hurdles. They require robust measurement, reporting, and verification schemes that go beyond current industry practice. Furthermore, measures that restrict access to markets could trigger trade disputes and protracted negotiations. At the same time, these policies can potentially impact energy security if there is a limited amount of compliant supply. There may also be significant distributional impacts if instruments like border mechanisms limit the marketability of oil and gas from certain destinations. For these and other reasons explored below, countries need to do more than simply place requirements on imported oil and gas.

Box 3.1 Policy glossary – Trade-related measures

Emissions certificates. A requirement that all imported fuels provide a certification of associated methane emissions. There are several ongoing efforts to improve the methodology for estimating emissions from imported gas, including certification of LNG cargoes and setting facility-specific intensities, which could support future certification standards. A transparency mechanism could also support a price premium for oil and gas with a lower emissions intensity.

Financing instruments. Governments can provide financial incentives for methane abatement. These include preferential loans, price premiums for oil and gas with a lower methane footprint, mechanisms for companies with lower-than-average emissions to generate tradeable credits, auction mechanisms and direct financing for abatement efforts. Such instruments are flexible and may be applied through existing fiscal systems, emissions trading schemes or targeted financing programs.

Minimum intensity standards. This involves limiting imports to fuels with an emissions intensity below a given threshold. Volumes of oil and gas that do not meet the standard may be excluded from the market or subject to a tax or other restrictions. If implementation included robust measurement-based emissions certification, individual producers would have incentives to reduce their emissions.

Border adjustment mechanisms. A limited number of jurisdictions levy taxes on methane or include it within emissions trading schemes. A border adjustment mechanism enables countries to require importers to either pay an equivalent tax or demonstrate that a similar level of tax was applied in a third country – thus "equalising" the tax rate that applies to domestically produced and imported gas.

International co-operation is needed to improve regulatory capacity and to mitigate distributional impacts

A concerted diplomatic effort to encourage other countries to join in strong methane commitments can be a powerful tool to bring new countries on board. The Global Methane Pledge announced in September 2021 is notable in that several of the countries that expressed their support had previously not made any significant commitment on methane, including Ghana, Indonesia, and Iraq. This kind of diplomatic action can be particularly effective when key trading partners collaborate to set joint targets. In 2016, the United States and Canada joined with Mexico to announce a joint commitment to reduce oil and gas methane by 40-45% by 2025. Although its continuing significance is unclear in the face of more recent developments, it is noteworthy that all three governments announced new or updated regulations on methane in the years following their announcement.

Diplomatic efforts may also be paired with technical and institutional support to enhance their impact. Exporting countries may face challenges related to current regulatory and institutional capacity. In some countries, the regulatory system that addresses methane – including licensing regimes, safety regulations and environmental regulations – is not yet fully developed. Compliance and enforcement may also present a major challenge in certain countries, particularly where regulators do not have experience enforcing similar regulations or the resources to do so. As the first movers on oil and gas methane abatement, the committed countries have gained experience from developing and implementing regulations targeted at the sector. This experience can be valuable to other countries as they embark on their regulatory journey.

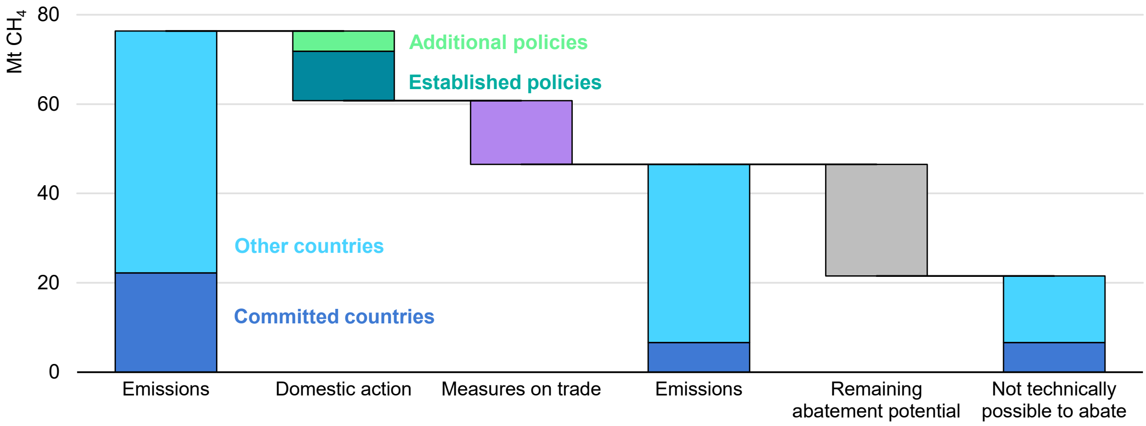
The committed countries should also invest in building abatement capability in these countries, through mechanisms such as direct funding, technical assistance to companies and operators, and regulatory capacity for governments. Efforts such as the Methane Guiding Principles best practice guides and the UN Environment Programme–CCAC Global Methane Alliance training programme are good examples of these forms of assistance, but more work is needed to increase capacity in producer countries and mitigate distributional impacts. The financing community can play a role by supporting investments in methane reduction, and the developed economies can direct funding for abatement efforts or infrastructure projects that enable gas use and tackle the harmful practices of flaring and venting.

Countries will also need to carefully consider the distributional impacts when designing international measures that may affect trade flows. Different instruments may operate based on a similar market dynamic – price premiums and border adjustment mechanisms, for example, function by putting a price on methane – but distribute costs differently. This could provide additional justification for privileging policies that provide financing for abatement actions in developing economies over those that simply exclude poor performers from the market. This could have the added benefit of enabling important elements of just transitions, including infrastructure investments to ensure gas is not wasted and potentially dealing with legacy sources (e.g. orphaned wells).

A mix of incentives, diplomatic encouragement and institutional support could lead to major reductions

If countries committed to methane reductions were to adopt a mix of the efforts described above, they could encourage exporters and create incentives to undertake abatement action while simultaneously improving the accuracy of data about emissions from their trading partners. Depending on how exporters prioritise emissions reductions, the estimated total reduction could range from close to 15 Mt if they limit abatement action only to oil and gas destined for committed countries, to almost 40 Mt if they seek to reduce methane across all their production, regardless of its final destination. Reductions at the low end of this range would represent a drop of almost 20% in total oil and gas methane emissions.

Figure 3.3 Potential oil and gas methane reductions from domestic and international actions implemented by committed countries



Note: Measures on trade reflect abatement measures applied to oil and gas production destined for committed countries.

Company action can deliver reductions in countries that have not yet committed to action on methane

In parallel with action by governments, industry has an important role to play in driving rapid cuts and leading abatement efforts. In certain countries, companies may be able to move more quickly on emissions than governments, particularly where regulatory capacity is limited.

A number of oil and gas companies have already set targets to limit emissions, or to reduce the emissions intensity of their production, and there are many voluntary, industry-led initiatives seeking to reduce emissions with varying levels of ambition. In particular, companies involved in the Methane Guiding Principles (MGP), the Oil and Gas Climate Initiative (OGCI), the Oil and Gas Methane Partnership 2.0 and the China Oil and Gas Methane Alliance have all committed to reducing their emissions intensity over time, to advocate for sound methane policy and regulation and to be more transparent about their emissions.

Each of these initiatives brings together a slightly different group of companies, and they include members from countries across the methane commitment spectrum. Together, the operated assets of these companies represent about 50% of all global oil and gas production.

Box 3.2 Selected voluntary industry initiatives on methane

The **Methane Guiding Principles (MGP)** established in 2017 is a multi-stakeholder collaborative platform incorporating more than 20 companies as well as intergovernmental organisations (including the IEA), academia and civil society. The principles aim to advance understanding and best practices for reducing methane emissions, and to develop and implement methane policies and regulations.

The **Oil and Gas Climate Initiative (OGCI),** made up of 12 major international oil and gas companies, aims to improve methane data collection and to develop and deploy cost-effective methane management technologies. In 2021, OGCI members updated their target for reducing the average methane intensity of their aggregated upstream gas and oil operations to well below 0.2% by 2025 (from the 0.30% baseline in 2017).

The **Oil & Gas Methane Partnership 2.0 (OGMP 2.0)** is an initiative of the Climate and Clean Air Coalition led by the UN Environment Programme (UNEP) that provides protocols for companies to survey and address emissions, as well as a platform for them to demonstrate results. It includes representatives from governments, the UNEP and the Environmental Defense Fund, and more than 70 companies from across the oil and gas value chain. These companies, representing about 30% of global oil and gas production, have agreed to report emissions from both operated and non-operated assets at an increasing level of accuracy and granularity.

The **China Oil and Gas Methane Alliance** aims to build a platform for cooperation, sharing technical experience, improving methane emissions control, and engaging with climate governance. It groups seven members from the Chinese oil and gas industry, including companies from both the upstream and downstream segments.

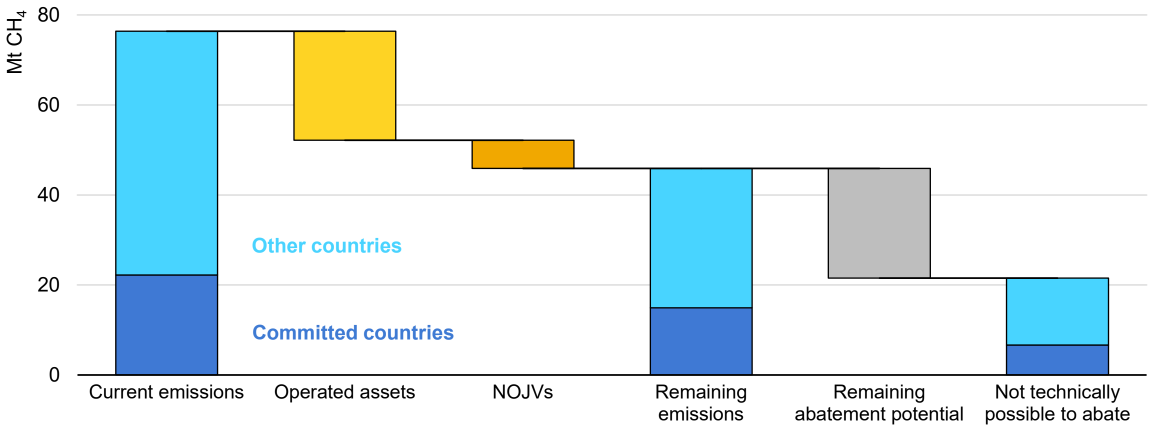
We estimate that if all companies participating in one of these four initiatives were to pursue all technically feasible abatement measures across their operated assets, they could reduce methane emissions by about 24 Mt CH_4. Broadening those efforts to include non-operated joint ventures[1] would lead to a further drop of about 6 Mt in methane emissions. All in all, if committed companies implement all abatement measures within their reach, they can deliver a total reduction of over 30 Mt.

Many of these reductions could also be accomplished by other means – including policy measures from committed countries, financial incentives, or government action in other countries. However, companies are often closer to the problem at hand, have the required technical capabilities, and can act more quickly to improve methane management. Given the urgency of the climate crisis and the extent of existing methane sources, it is important to pursue parallel avenues to ensure that all abatement opportunities are rapidly addressed.

Critically, more than 75% of the reductions that could be achieved by companies participating in methane initiatives would have to come from assets in countries that do not have strong commitments on methane. These could tackle 9 Mt of emissions that we estimate would not be reduced by any of the other measures discussed above. In other words, strong action by these companies can lead to emissions reductions beyond what the committed countries can reach on their own.

[1] Non-operated joint ventures (NOJVs) include any projects in which a company has more than 1% equity ownership and is not the operator.

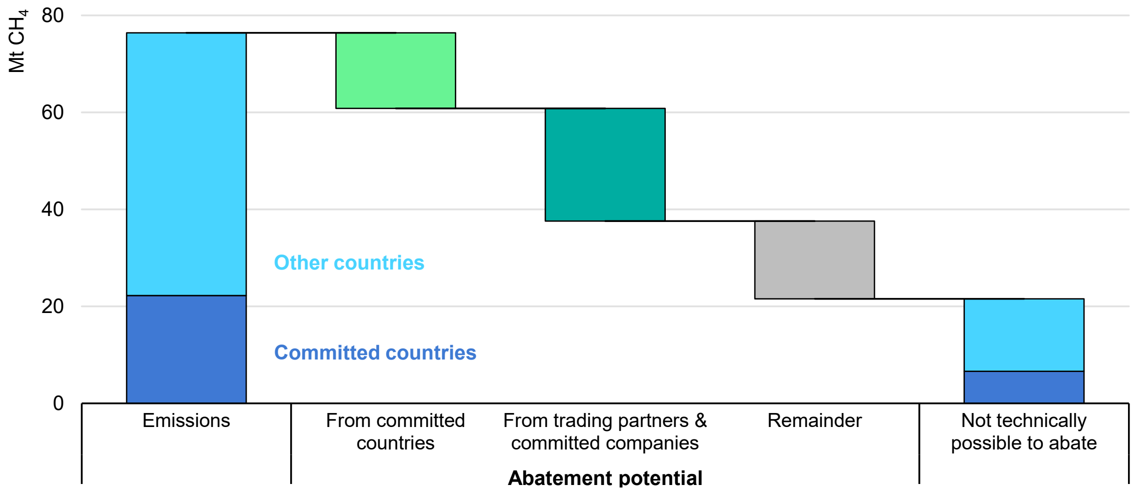
Figure 3.4 Potential methane reductions from voluntary company action



Increasing transparency can put pressure on countries and companies to address remaining emissions

Even if the existing coalition of committed countries and companies succeed in implementing all the abatement measures discussed above, there would still be 16 Mt of technically achievable abatement potential left untapped – close to 30% of the total. In essence, this is because there is a significant portion of emissions coming either from countries without strong abatement policies, from projects that do not involve companies participating in methane reduction initiatives, or which are otherwise not associated with oil and gas flows to committed countries. Closing this gap will require the engagement of many stakeholders, be it through diplomatic efforts, raising awareness or investment decisions.

Figure 3.5 Overview of abatement potential over which committed countries and companies have direct or indirect influence



Note: Total reductions associated with action by committed countries and companies are taken into account. To avoid double-counting, we assume that company and government action overlap. Thus, potential reductions in other countries associated with trade measures (over 14 Mt) are non-additional to company action (about 23 Mt). Similarly, company action in committed countries (about 7 Mt) is included within the effects of domestic policies (close to 16 Mt).

Alongside efforts to bring new countries and companies on board, there are complementary mechanisms that can help to close this 16 Mt gap of remaining abatement potential. Transparency standards can help to improve the understanding of emissions, the comparability of estimates and potentially lead to the engagement of other actors. The OGMP 2.0 Framework has seen rapid growth in participation over the past year, in part due to the engagement of the European Union following the announcement of its Methane Strategy. Explicit recognition or incorporation of reporting standards in regulations can motivate their uptake. As better measurement and transparency practices proliferate, this can improve the overall understanding of emissions and help companies and countries identify abatement options.

Monitoring, reporting and verification regimes are a centrepiece of methane abatement strategies and will be key in driving further emissions reductions. We estimate that a global standard based on robust measurement could potentially lead to a reduction in methane emissions of close to 25 Mt if applied across the entire oil and gas industry. This would effectively remove barriers that prevent companies from addressing leaks and emissions that they are unaware of, allowing them to take advantage of the vast extent of cost-effective abatement opportunities (provided companies are able to prioritise capital for abatement and that infrastructure barriers can be addressed).

More importantly, a functional and reliable monitoring, reporting and verification regime is a prerequisite for many policy tools that can drive deeper cuts in emissions in an efficient manner, including market-based instruments, performance standards and trade measures. Furthermore, it can facilitate the work of regulators in verifying compliance and in tracking progress against reduction targets, while enabling the financial community to engage with the industry.

The improvement of satellite technology is a key development in this area. Better and more accessible data can enable further methane reductions, both in committed countries and other jurisdictions. However, current satellite technology has important limitations – including that they are impaired by cloud coverage and do not provide reliable measures in equatorial, offshore, and northern regions. Thus, a monitoring, reporting and verification regime should rely on a suite of measurement tools, building from the growing pool of available technologies that includes drone-based and other aerial surveys, ground-based surveys and continuous monitoring devices. These can support the detection of ongoing emissions events, verify the success of repair measures and facilitate enforcement actions.

Current technology already enables regional characterisation and quantification of emissions and the detection of large leaks: In 2020 alone, close to 500 events were identified by Kayrros, a data analytics company, based on publicly available satellite data. Upcoming high resolution, high sensitivity satellites will advance detection thresholds, methane quantification capabilities, raise public awareness and support regulatory oversight. As technology improves and data processing becomes more agile, early warning systems that pinpoint methane leaks will be increasingly viable and can constitute a major tool in facilitating timely action.

To establish such a system, governments, oil and gas companies and satellite data providers need to work together to establish a network of contacts that would allow rapid communication of leaks to those on the ground best able to address them. We estimate that around 2 Mt of methane associated with large emissions events could be reduced using today's instruments and capabilities. This amount is poised to grow over time, as satellite detection matures and new instruments come online.

In the coming years, the emissions intensity of fossil fuels will define how big a role they will play in the energy transition. Improved transparency, whether in the form of satellite detection and quantification, improved industry standards or other monitoring, reporting and verification tools and platforms, can bring additional pressure to bear on producers to address emissions. Until recently, large emitters were able to shield themselves from scrutiny by simply not measuring or reporting their emissions. However, as visibility of these emissions increases due to the multiplication of measurement instruments and related data is more readily available, public awareness will grow. This can help with the assessment of regional levels of methane emissions and uncover diffuse sources of leaks, such as marginal wells, and empower communities to push for stricter policies from their governments and demand stronger action from oil and gas operators.

In the Net Zero Emissions Scenario, oil and natural gas continue to comprise a large part of the overall energy mix out to 2030, so investment in existing fields will remain necessary throughout this period. Banks, investors and financiers can ensure that this happens alongside comprehensive methane reduction measures. While many of these actors recognise the importance of tackling methane emissions, the lack of data has been a barrier to action. Robust monitoring, reporting and verification systems can help them to identify good performers, work with companies on setting short-term targets for emissions reductions and reward methane abatement by lowering the costs of capital. Oil and gas companies are already facing tougher scrutiny of their methane footprints, which can make access to capital more difficult and affect their environmental, social and governance ratings. There is still a long road ahead for oil and gas methane reduction efforts, but with sufficient political will and corporate engagement, it might just be enough to keep climate goals within reach.

Box 3.3 Leveraging data to drive deep reductions in methane emissions from fossil fuel operations – International Methane Emissions Observatory

With the multiplication of methane emissions data and reporting initiatives, there is a growing need for the evaluation and reconciliation of data. Robust and transparent datasets can help companies, governments and investors work together to track methane abatement efforts and better manage these emissions.

The International Methane Emissions Observatory (IMEO), established by the UN Environment Programme with support from the European Union and in partnership with the IEA, is an initiative that uses an innovative data approach to spur methane emissions reduction globally. IMEO collects data from various sources, including company reporting through the OGMP 2.0, direct measurements from peer-reviewed studies, satellite observations, and national inventories. These data will be integrated and reconciled according to a hierarchy of tiers, providing a systematic way to evaluate their integrity, transparency, and relevance. The final product will be a comprehensive public dataset detailing methane emissions levels and sources from fossil fuel activities around the world.

Through the OGMP 2.0, IMEO works with companies in the oil and gas industry to improve the accuracy and granularity of methane emissions reporting. This approach improves the quality of the data and allows for a better understanding of emissions sources, therefore allowing prioritisation of mitigation actions. IMEO also works with the scientific community to close the knowledge gap on the location and magnitude of methane emissions by funding direct measurement studies which provide robust, publicly available data.

While data is the foundation of IMEO's approach, its theory of change relies on connecting empirically verified data with action on transparency, science, and policy. IMEO supports the ecosystem of partners and institutions working on methane emissions reduction and helps them to scale up their activities to the levels needed to avoid the worst impacts of climate change.

4. Coal

Summary

- Tackling methane is more challenging in the coal sector than in oil and gas operations, but it is still a major opportunity for climate action. There are significant opportunities to reduce emissions in the near term based on existing technology, and reductions in consumption can play a major role in bringing down methane emissions.
- In our pathway to a 75% cut in methane emissions from fossil fuel operations, coal sector emissions fall by 31 Mt CH_4. Most of this decline comes from a drastic fall in coal use, which drops by 55% from 2020 to 2030 in our Net Zero by 2050 Scenario. The decrease in supply is particularly stark for coal used for power generation, which falls by close to 60% by 2030 as coal-fired power plants are replaced with renewable generation. We estimate that if all committed countries take action to reduce demand in line with Net Zero Scenario, this will lead to a reduction of almost 15 Mt CH_4.
- Actions to minimise leaks in coal mines need to happen in parallel with measures to reduce consumption. Overall, the deployment of technologies that capture gas from coal sites yields a decrease in the methane intensity of coal supplies of almost 45% in the Net Zero Scenario by 2030, leading to a decline of over 8 Mt CH_4. Close to 70% of this reduction – or 6 Mt CH_4 – comes from committed countries. For coking coal, the drop in intensity is even starker, standing at close to 50%.
- Abandoned mines present a growing challenge, both for methane emissions and land use. Well-managed mine closures are an essential part of just transitions as they can ensure emissions reductions and mitigate impacts on communities.

Tackling methane is more challenging in the coal sector than in oil and gas operations, but it is still a major opportunity for climate action

Coal seams naturally contain methane, referred to as coal mine methane, which can be released during or after mining operations in various ways, including:

- Seepage of methane from coal seams exposed in surface or open pit mines.

- Degasification and ventilation systems that are used to extract and dilute methane found in underground coal mines to create safe working conditions and avoid explosions.
- Post-mining activities such as processing, storage and transport when quantities of methane still trapped in the matrix of the coal seep out.
- Abandoned mines, since there may still be large volumes of coal remaining in a mine even after operations have ended and the methane contained in this coal may continue to escape into the atmosphere.

An important factor associated with coal mine methane emissions is the depth and age of the mines. Deeper coal seams tend to contain more methane than shallower seams, while older seams have higher methane content than younger seams. Therefore, in the absence of any mitigation measures, methane emissions tend to be higher for underground mines than for surface mines. On the other hand, it is easier to capture methane from underground mines, which means there are more options for mitigating related emissions.

Mitigating coal mine methane is often challenging because the methane concentration of emissions is typically very low and can fluctuate in quality and quantity. The lower the concentration of methane, the more technically and economically difficult it is to abate. The same applies to methane emitted during the mining process. For example, air from the ventilation and degasification systems of underground mines (called ventilation air methane) contains less than 1% methane. Furthermore, the lack of gas infrastructure or nearby consumers can hinder the sale of recovered methane. In the absence of a viable recovery project, methane can either be destroyed by thermal oxidisation or flared. However, there are few projects globally that have installed the equipment necessary to do this, with safety concerns and a lack supporting regulatory frameworks, including an unclear ownership structure of coal mine methane, cited as reasons for the lack of progress.

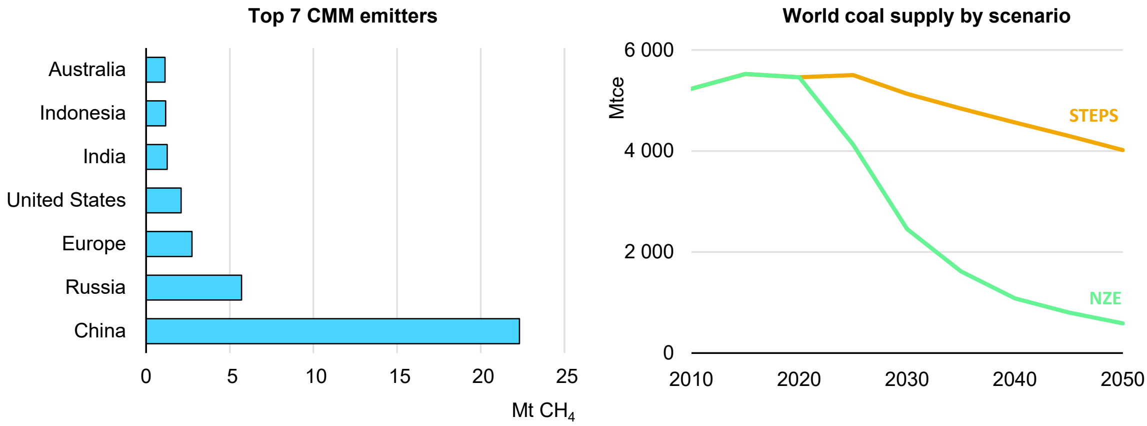
Nonetheless, significant opportunities remain to reduce emissions in the near term based on existing technology, alongside reductions in consumption that bring a corresponding decrease in methane emissions. Considering its high-carbon and methane footprint, there is not much space for it outside some hard-to-substitute uses. Steam coal, which is used for power generation, should be quickly replaced by low-carbon competitive alternatives, such as renewables. Meanwhile, coking coal, which is used for steel production, is produced in deep mines where more mitigation options exist and has no immediate cost-effective substitute; thus, its production can gradually fall while associated methane emissions are kept to a minimum.

A drastic fall in coal consumption is the main driver of coal-related methane reductions in the Net Zero Emissions Scenario

Transitioning away from coal use brings a series of benefits, including lower air pollution and CO_2 emissions. In the Net Zero Scenario, coal-related methane emissions fall by close to 31 Mt. The major driver of this drop is a drastic fall in coal use: supply drops by 55% from 2020 to 2030 and by almost 90% until 2050. This decline is responsible for over 70% of the reduction in coal mine methane, a drop of about 22 Mt. The remaining reduction of over 8 Mt results from better management of methane leaks in existing operations.

About two-thirds of this 31 Mt reduction comes from committed countries. If committed countries were to take action to reduce demand in line with Net Zero Scenario, this would lead to a reduction of around 15 Mt, with China alone being responsible for over 10 Mt. However, China's current climate pledge is to reach a peak in emissions by 2030, suggesting that most of the cuts in methane from coal supply would only occur after that.

Figure 4.1 Top coal mine methane emitters and total coal supply by scenario



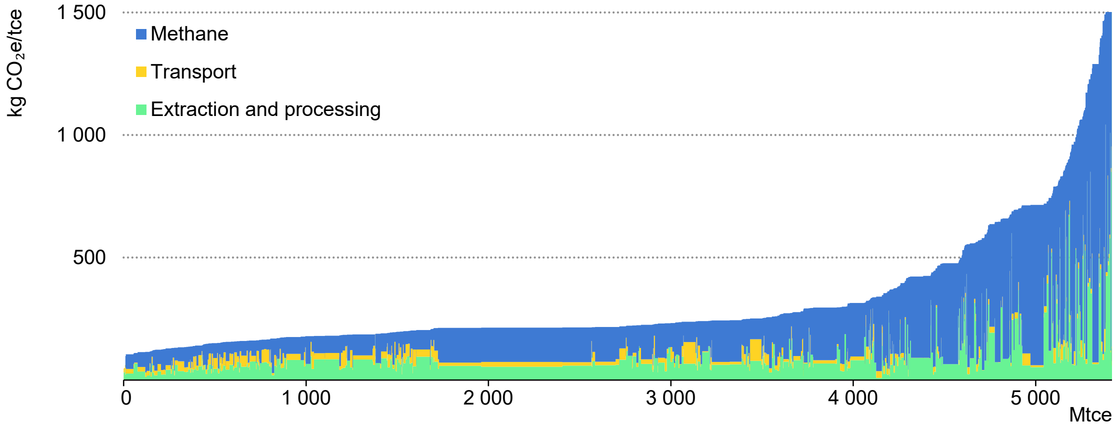
The largest share of the decline in coal mine methane comes from a transformation in the power sector as coal-fired power plants are rapidly replaced by renewables in the Net Zero Scenario. As a result, the supply of steam coal falls by close to 60% by 2030. This leads to a reduction of about 15 Mt in coal-related methane emissions.

Other sectors, such as the steel industry, still lack viable large-scale alternatives to coal use – which means that some level of coal production will remain necessary for now. Indeed, the outlook for coking coal is less drastic than for steam coal. In the Net Zero Scenario, coking coal supply drops by less than 30% from 2020 to 2030, which means its share of total coal production will grow from about 17% to 27%. As the energy sector transitions from coal-fired power generation and industries develop viable alternatives to its use, policies have an important role to play in limiting its climate impacts.

From a climate perspective, it matters which coal operations carry on and which are retired

As with oil and gas, there is a wide variation in the methane intensity of coal production. The worst-performing coal emits as much as 100 times more methane than the best performing. This means that as coal production drops in the coming years, the impact on methane emissions will depend to a large extent on which coal assets are taken offline. For example, retiring the worst-performing quartile of production would remove well over 20 Mt of methane, but retiring the best-performing quartile would only remove about 3 Mt.

Figure 4.2 Indirect CO_2 and methane emissions from global coal supply, 2018



Source: World Energy Outlook, 2019.

From a climate perspective, the methane intensity of a given coal mine should certainly be considered when deciding which assets should continue to produce. Furthermore, the potential of emissions to continue after the end of operations should also be considered, with a need for measures to ensure these are kept to a minimum. Moreover, without government intervention, there may not be an incentive for private companies to act on methane leaks given the general absence of measurements and the limitations of current emissions reporting.

Policies and measures can lower methane leaks from coal operations by around 45%

The Net Zero Emissions Scenario anticipates a reduction of around 45% in the methane intensity of coal supply from 2020 to 2030, leading to a decline of over 8 Mt in related emissions. Close to 70% of this reduction – or 6 Mt – comes from committed countries. For coking coal, the drop in intensity is even starker, standing at close to 50%. This abatement potential can be reached through policies and measures that require the capture of coal mine methane. There are a number of low-cost alternatives for coal mine methane mitigation, and adequate planning can facilitate timely and effective action on coal supply chains. Furthermore, technological development is increasing the potential of methane reduction in this area and facilitating the detection of related leaks.

Figure 4.3 Large-scale coal-related methane leaks detected by satellite from 2019-2021

Note: Shows large methane emissions sources detected in areas of coal operations between 2019 and 2021.
Source: Kayrros analysis based on modified Copernicus data.

Higher concentration sources of methane can be captured if measures are planned prior to the start-up of mining operations. Degasification wells and drainage boreholes can capture methane in coal reservoirs, reducing the potential of leaks during production. This gas can then be used for small-scale power generation or, if concentrations are high enough, injected into a local gas grid. Where concentrations are low and there is no demand for gas in the area, methane can be combusted to reduce its climate impacts, either through open flares or enclosed combustion systems.

For mines that are already in operation, ventilation air methane is often already captured and can be directed to processes such as blending or oxidation to make it usable as an energy source (e.g. for heating mine facilities or drying coal). Thermal or catalytic oxidation technologies are technically feasible at low CH_4 concentrations, between 0.25% and 1.25%, and can reduce methane emissions from most facilities by more than 50%.

Active policies and regulatory regimes are needed to create incentives or require mine operators to install coal mine methane abatement technologies. Many of the regulatory approaches already discussed could be applied to the coal sector, including requirements to apply best available technologies, intensity standards or monitoring and reporting obligations. Permitting processes can also play a role in reducing coal mine methane by requiring any new mines or mine expansions to develop plans to handle methane emissions before operations commence. This includes the application of drainage technologies and the development of capacity to support gas use, such as pipelines networks, gas-powered electricity generation or auxiliary and monitoring equipment.

Some regulations have already been issued to address coal mine methane. In China, the main emitter of coal mine methane, a 2020 notice on environmental impact assessments for coal developments requires improvements in the utilisation rate of coal mine methane: It stipulates the need to use it where concentrations are above 8% and encourages utilisation if concentrations are below that level. In the United States, another large coal producer, there are carbon markets that enable the creation and use of compliance offsets through coal mine methane reduction projects.

Mine closure policies can ensure abandoned mines do not keep leaking methane and support just transitions

Currently abandoned mines account for a limited share of coal-related emissions as most mines are still operational. However, this is poised to change in the coming years, with a recent study indicating that abandoned mine methane emissions could nearly double from 2020 to 2040. In climate-driven scenarios, mine closures need to occur at faster rates, increasing the importance of considering the emissions from this source.

Mine flooding is the most effective way to reduce methane emissions from abandoned coal mines as it stabilises the hydrostatic pressure on the coal seams, leaving only residual emissions. In cases where flooding is not technically feasible due to site conditions, mines can be sealed, with drainage systems directing the emerging gas to use – similarly to what can be done before mines start operations. Regulations on mine closure and specific policies for legacy sites can ensure these measures are broadly applied.

Permitting systems often require the elaboration of closure plans as part of the approval process for mining activities. Post-mining land use planning is thus incorporated into project design and follow-up, including measures to minimise disturbance, establish stable non-contaminated landforms (including limiting methane leaks), ensure progressive rehabilitation and enable subsequent use. Regulators need to have enforcement powers over company commitments to ensure these plans are carried through, which might require assuring financial securities.

Successful mine closure is favoured when it is considered in the various phases of a mining development's life cycle, from feasibility studies to project design throughout operations and decommissioning. This involves: continuous planning efforts; progressive allocation of financial resources, asset review and divestment evaluations; and implementation of closure, including remediation and monitoring, until agreed-upon completion criteria are met. Best practice recognises that the mining sector is a temporary user of land and that sites should be returned to a state that enables the sustainable development of present and future generations.

In this context, some areas will need assistance to transition from the coal industry as their economies currently rely heavily on the revenues from this activity. Development finance institutions can provide blended finance and technical support to ensure a just transition. The World Bank, for example, is supporting long-term transitions for coal regions through institutional governance reforms, assistance to communities and repurposing of land and assets. Further incentives or direct public action will be necessary to address abandoned mines that no longer have a legal entity responsible for them. It is possible that such sites might also be significant sources of methane emissions and will need to be flooded or sealed to reduce related climate impacts.

Annex

Abbreviations and acronyms

CCAC	Climate and Clean Air Coalition
CH_4	methane
COP26	Conference of the Parties 2026
CO_2	carbon dioxide
CO_2-eq	carbon-dioxide equivalent
ESG	Environmental, social and governance
GHG	greenhouse gas
Gt	gigatonnes (1 tonne x 10^9)
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IMEO	International Methane Emissions Observatory
kg	kilogramme (1,000 kg = 1 tonne)
kt	kilotonnes (1 tonne x 10^3)
LNG	liquefied natural gas
MACC	marginal abatement cost curve
MBtu	million British thermal units
MGP	Methane Guiding Principles
Mt	million tonnes (1 tonne x 10^6)
Mtce	million tonnes of coal equivalent
Mtoe	million tonnes of oil equivalent
OGCI	Oil and Gas Climate Initiative
OGMP	Oil and Gas Methane Partnership
STEPS	Stated Policies Scenario
t	tonne
tce	tonnes of coal equivalent
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar

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