The Imperative of Cutting Methane from Fossil Fuels

An assessment of the benefits for the climate and health

International Energy Agency

This report was prepared by the International Energy Agency (IEA) with contributions from the United Nations Environment Programme (UNEP) and UNEP-Convened Climate and Clean Air Coalition (CCAC).

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Source: IEA.
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Executive summary

- Rapid cuts in methane emissions from fossil fuels through targeted abatement measures – alongside deep cuts in carbon dioxide (CO2) emissions – are essential to achieve global climate targets. Without targeted action on methane, even with deep reductions in fossil fuel use, the increase in the global average surface temperature will likely exceed 1.6 °C by 2050.
- More than 75% of methane emissions from oil and gas operations and half of emissions from coal today can be abated with existing technology, often at low cost. The oil and gas sector has the greatest share of ready-to-implement and cost-effective technical opportunities to reduce methane emissions. Cuts in methane emissions from fossil fuel operations will likely need to provide half of the reduction in total methane emissions from human activities needed to 2030 to limit warming to 1.5 °C.
- Achieving net zero emissions will require a significant reduction in fossil fuel use. In the IEA's Net Zero Emissions by 2050 (NZE) Scenario, the sharp decline in fossil fuel demand means that no new conventional long lead time oil and gas projects are approved for development after 2023, and there are no new coal mines or coal mine lifetime extensions.
- Reductions in fossil fuel use alone – even in the NZE Scenario – do not achieve deep enough cuts in methane emissions to reach levels consistent with limiting warming to 1.5 °C with no or low overshoot.. Additional, targeted actions to tackle methane emissions from fossil fuel production and use are essential to limit the risk of crossing irreversible climate tipping points.
- Under pathways that factor in much higher fossil fuel use, targeted deployment of methane mitigation solutions would avoid roughly 0.1 °C warming in 2050, an impact comparable to immediately eliminating all CO_2 emissions from the world's heavy industry.
- Immediate, targeted methane abatement in the fossil fuel sector can prevent nearly 1 million premature deaths due to ozone exposure, 90 million tonnes of crop losses due to ozone and climate changes, and about 85 billion hours of lost labour due to heat exposure by 2050, providing roughly USD 260 billion in direct economic benefits.
- Appropriate regulatory frameworks are needed, as is a dramatic ramp-up in investment in mitigating methane emissions from fossil fuel production. Total spending required to deploy all available methane mitigation strategies in the oil and gas sector through 2030 is less than 2% of the net income earned by this industry in 2022. Most measures can and should be financed by the industry itself, but a number of low- and middle-income countries may face barriers to accessing capital for some interventions, which may not be implemented without concessional financing.

Immediate reductions in methane emissions are needed to limit warming to 1.5 °C

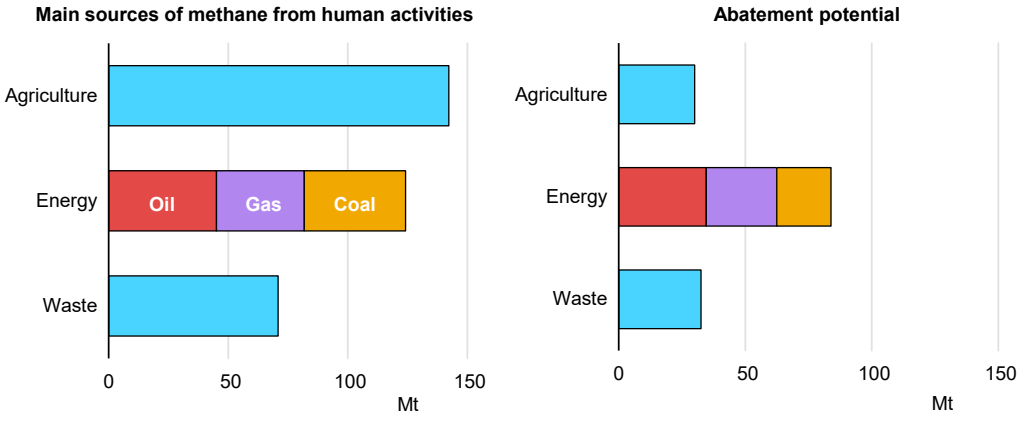
Methane is a powerful climate pollutant. It is responsible for around 30% of the rise in global temperatures since the Industrial Revolution and is the second largest contributor to global warming after CO_2. Methane has a much shorter atmospheric lifetime – around 12 years compared with centuries for CO_2 – but it is a much more potent greenhouse gas, absorbing significantly more energy while it lingers in the atmosphere.[1]

The most recent comprehensive assessment suggests that annual global methane emissions are around 580 million tonnes (Mt). This includes emissions from natural sources (around 40% of the total) and from human activity (around 60% of the total), the latter of which is known as anthropogenic emissions. Fossil fuel operations are the second largest contributor to anthropogenic methane emissions, having emitted around 120 million tonnes (Mt) in 2022. Coal, oil and natural gas were each responsible for close to 40 Mt.

A major reduction in global methane emissions is needed to limit the increase in average temperatures to 1.5 °C. Under current trajectories, total anthropogenic methane emissions could rise by up to 13% between 2020 and 2030; in scenarios that limit warming to 1.5 °C, they fall by 30% to 60% over this timeframe.

The fossil fuel sector likely holds the largest potential for rapid and low-cost reductions in methane emissions. We estimate that more than 80 Mt of annual methane emissions from fossil fuels can be avoided by 2030 using existing technologies, often at low – or even negative – cost.

Main sources of methane emissions and current abatement potential



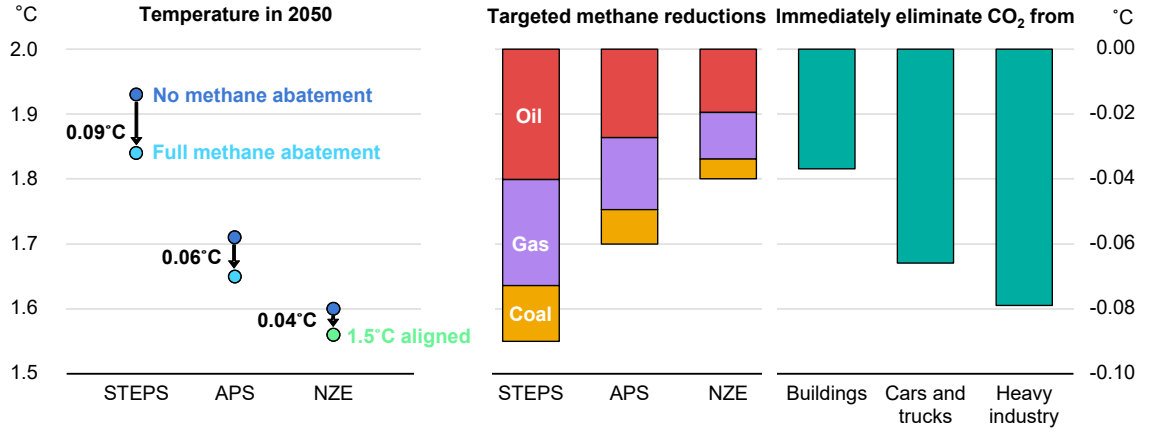
Notes: Methane emissions and abatement potential for oil, gas and coal is based on the IEA's Global Methane Tracker. Abatement potential for agriculture and waste it is based on the Global Methane Assessment. Emissions from bioenergy and from biomass burning, each totalling around 10 Mt per year, are not shown.

[1] There are various ways to combine these factors to estimate the effect on global warming. The most common is the global warming potential (GWP). This can be used to express a tonne of a greenhouse-gas emitted in CO_2 equivalent terms to provide a single measure of total greenhouse-gas emissions (in CO_2-equivalent). The GWP for methane of fossil origin is 82.5 when considering its impact over a 20-year timeframe and 30 when considering its impact over a 100-year timeframe (IPCC, 2021). We take one tonne of methane to be equivalent to 30 tonnes of CO_2.

This work considers fossil fuel demand projections from the IEA's Stated Policies Scenario (STEPS), Announced Pledges Scenario (APS) and Net Zero Emissions by 2050 Scenario (NZE). It assesses possible pathways for methane emissions given changes in fossil fuel use, including a pathway with no explicit efforts to curtail methane emissions, and a pathway with full adoption of all methane mitigation options available to the fossil fuel industry.

The results indicate the sharp reductions in fossil fuel use in the NZE Scenario are not sufficient by themselves to drive down methane emissions at the necessary pace and scale to avoid the worst effects of climate change. Alongside action to reduce CO_2 emissions, deploying targeted methane mitigation measures across fossil fuel operations is essential to limit warming to 1.5 °C with no or low overshoot. A slower decline in fossil fuel use, as modelled in the STEPS and APS, means the temperature rise will far exceed 1.5°C before mid-century. Targeted methane mitigation can help lower the temperature rise by up to 0.1 °C in 2050.

Temperature differences in 2050 due to fossil fuel methane mitigation and comparable outcomes from CO_2 reductions



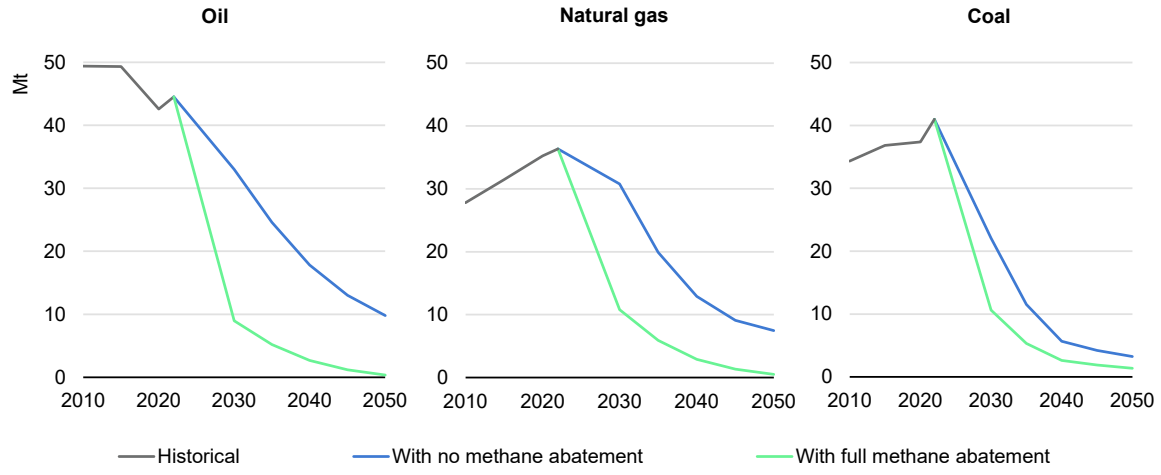
Notes: Shows temperature differences in 2050 under the STEPS, APS and NZE trajectories of fossil fuel demand between a case that deploys all available fossil fuel methane abatement measures and a case where no methane abatement measures are adopted. Temperature differences are estimated using the Model for the Assessment of Greenhouse Gas Induced Climate Change ("MAGICC") version 7.5.3 developed and maintained by Climate Resource. MAGICC was widely used in the Intergovernmental Panel on Climate Change Sixth Assessment Report. Temperature increases are the median estimate.

Fossil fuel demand reductions alone will not cut methane emissions fast enough to limit warming to 1.5 °C

The IEA's NZE Scenario limits the global average surface temperature rise to 1.5 °C while achieving universal access to modern energy by 2030. It is a demand-led transition that relies on a huge scaling up of clean energy to drive down fossil fuel use and emissions while ensuring uninterrupted access to energy services. In this scenario, oil and natural gas demand fall by nearly 80% between 2022 and

2050, and coal demand by more than 90%. This would translate into a reduction of methane emissions from fossil fuels from around 120 Mt in 2022 to 85 Mt in 2030 and 20 Mt in 2050 (around 85% below 2022 levels) without any targeted methane reduction efforts, due to reduced fossil fuel production and consumption.

Methane emissions from fossil fuel operations in the NZE Scenario



Notes: "With no methane abatement" assumes constant methane emissions intensities of production, with changes in emissions following changes in fossil fuel demand.

The pace and scale of methane emissions reduction from the decline in fossil fuel use in the NZE Scenario is not sufficient to limit warming to 1.5 °C with no or low overshoot. Without targeted action to reduce methane emissions from fossil fuel operations, the rise in the global average surface temperature would exceed 1.6 °C in 2050. A higher maximum temperature rise increases the risk of climate damages and of crossing irreversible climate tipping points.

In the NZE Scenario, all available methane abatement technologies are deployed by 2030 across all fossil fuel production, processing and transport facilities. This means that by the end of the decade, all producers have an emissions intensity similar to those of the world's best operators today. Global methane emissions from fossil fuel operations fall to 30 Mt in 2030 and 2 Mt in 2050 (98% below 2022 levels). There are further reductions in the methane emissions intensity of fossil fuel supply after 2030 as technologies continue to improve.

Targeted action to abate methane in the NZE Scenario cuts methane emissions from fossil fuels in 2050 by a factor of ten. This reduces the temperature rise in 2050 by around 0.05 °C. This number may appear small but is huge in climate terms, with an effect comparable to immediately eliminating all CO_2 emissions from all of the world's buildings.

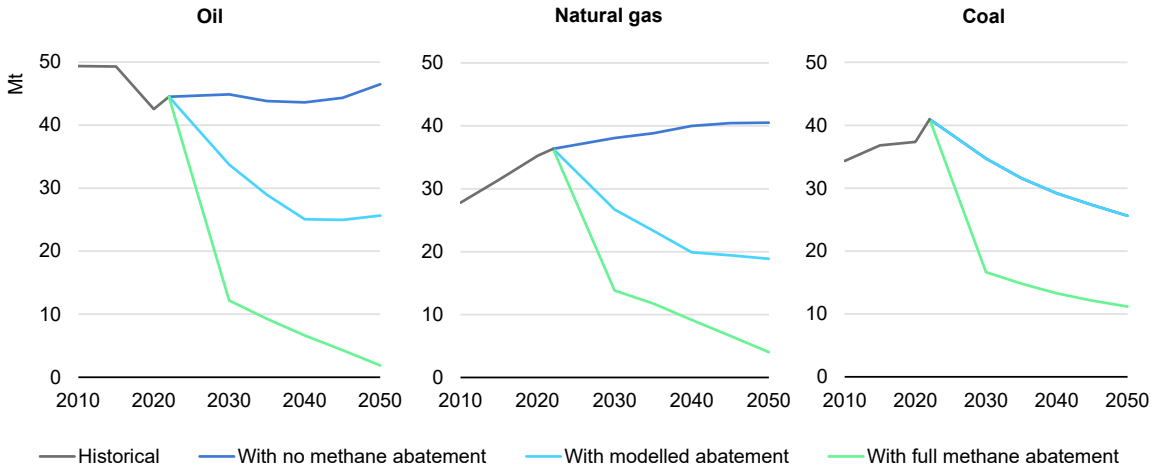
Targeted methane mitigation remains important even if fossil fuel demand does not fall as rapidly as needed

The IEA's STEPS is an outlook based on a detailed sector-by-sector review of energy and climate policies and measures currently in place or under development by governments. In this scenario, there is a peak in demand for natural gas, oil and coal this decade, but declines after these peaks are relatively modest.

If no targeted measures are taken to reduce methane emissions, the demand trajectory for fossil fuels in STEPS alone would imply methane emissions fall to around 115 Mt in 2050, only marginally below 2022 levels (120 Mt). Reductions would stem mainly from lower coal use, partially offset by slightly higher emissions from oil and natural gas supply in 2050 than in 2022.

In contrast, deploying all available measures to abate methane from fossil fuel operations under the STEPS trajectory for fossil fuel demand would cut related methane emissions by more than 60% in 2030 and by 85% in 2050 compared with the no-abatement case.

Methane emissions from fossil fuel operations in the STEPS



Notes: "With no methane abatement" assumes constant methane emissions intensities of production, with changes in emissions tied to changes in fossil fuel demand. There are no explicit efforts to reduce the methane emissions intensity of coal production in the Stated Policies Scenario.

Under the STEPS, methane emissions from fossil fuel operations fall to around 70 Mt in 2050 (40% below 2022 levels). This is because many governments have announced or put in place measures to cut methane emissions. Incorporating these measures into the STEPS helps to lower the methane emissions intensity of oil and gas use in this scenario (there are no explicit efforts to reduce the methane emissions intensity of coal production in the STEPS). For example, the United States' Inflation Reduction Act includes a charge on methane emitted by

oil and gas companies alongside USD 1.55 billion in financial and technical assistance. Nigeria has issued guidelines for emissions management in the upstream oil and gas sector to support the elimination of routine gas flaring by 2030, as well as a 60% reduction in the fugitive methane emissions that escape during the production and transport of oil and natural gas by 2031. There are also regulations in place that target venting and flaring in Algeria, Brazil and other jurisdictions.

Voluntary action by companies is also incorporated into the STEPS and the oil and gas industry is assumed to gradually implement methane abatement measures that can be deployed at no net cost. There are voluntary industry initiatives looking to reduce methane emissions – for example, the Oil and Gas Climate Initiative has launched the Aiming for Zero Methane Emissions Initiative, a call for the industry to treat methane emissions as seriously as it treats safety. The offshore oil and gas industry in the United Kingdom released a Methane Action Plan in 2021 to reduce emissions by 50% from 2018 levels and end routine flaring by 2030.

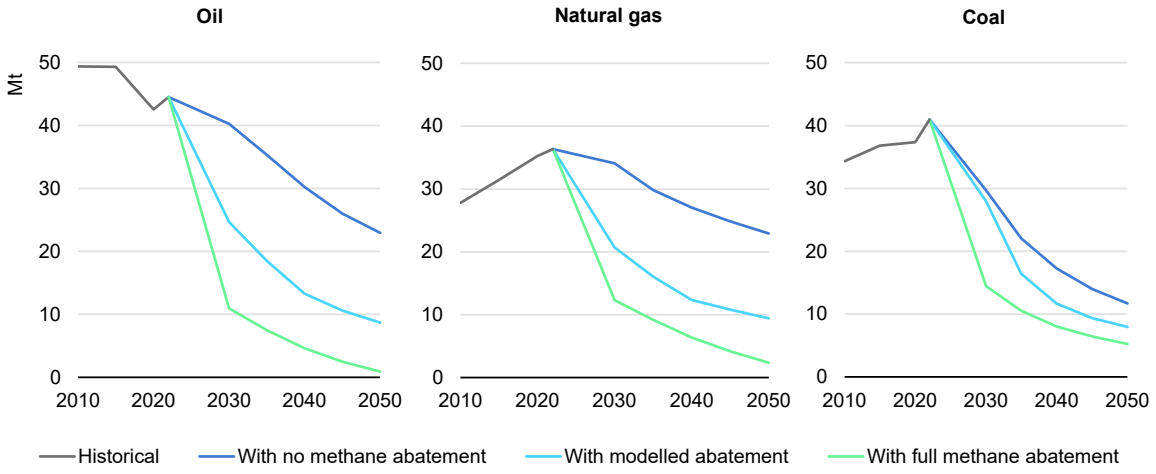
Net zero pledges would drive down methane emissions but more ambition and targeted action is needed

The IEA's APS assumes that governments will meet, in full and on time, all climate-related commitments they have announced, including longer-term net zero emissions targets. Pledges made by businesses and other stakeholders are also considered where they add to the ambition set out by governments.

In the APS, the achievement of announced climate pledges by governments leads to a strong decrease in fossil fuel use (a 55% reduction in aggregate between 2022 and 2050). Even without any explicit abatement efforts, methane emissions from fossil fuel use would fall to around 105 Mt in 2030 and 60 Mt in 2050 (just under half of the levels in 2022) exclusively due to declines in fossil energy consumption.

If all available abatement measures were to be fully deployed by 2030, this would cut methane emissions from fossil fuel operations to just under 40 Mt in 2030 and – with further technology improvements and deployment after 2030 – to less than 10 Mt in 2050. In other words, methane emissions from fossil fuel production would be 65% lower in 2030 and 85% lower in 2050 than in the case with no targeted abatement efforts.

Methane emissions from fossil fuel operations in the APS



The APS assumes countries with net zero greenhouse gas emissions targets deploy all available abatement measures well in advance of their announced target date. Endorsers of the Global Methane Pledge Energy Pathway are assumed to deploy all mitigation measures in the oil and gas sector by 2030 and participants in the Global Methane Pledge deploy all abatement measures with no net cost in the fossil fuel sector by 2030. Governments and companies that have endorsed the World Bank's Zero Routine Flaring by 2030 Initiative achieve this target, reducing flaring and associated methane emissions by around 95%. Other announced methane reduction plans, such as Qatar Energy's Sustainability Strategy, which has a methane intensity target of 0.2% by 2025, are also achieved in full and on time. These measures, alongside the reduction in fossil fuel use, mean methane emissions in the APS fall to just under 75 Mt in 2030 and to around 25 Mt in 2050 (nearly 80% below 2022 levels).

Targeted methane abatement could avoid up to 0.1 °C of warming in 2050 in higher fossil fuel demand scenarios

Under the STEPS trajectory of fossil fuel demand, deploying all available methane abatement measures in the fossil fuel industry would avoid nearly 0.1 °C of warming in 2050 compared with a scenario with no additional methane abatement. This has a comparable effect on the global temperature rise by mid-century to immediately eliminating all CO_2 emissions from the world's heavy industry.

The STEPS sees a continued rise in global average temperatures to around 1.9 °C in 2050 and 2.4 °C in 2100, and temperatures continue to climb thereafter. Deeper efforts to tackle methane emissions in the STEPS would mitigate some of this temperature increase and reduce climate impacts at that time. But without enhanced efforts to simultaneously cut CO_2 emissions, regardless of what happens with methane emissions, it will not be possible to achieve the world's climate goals.

In the APS, the global average temperature rises to around 1.7 °C in 2050 and 2100. The temperature difference between full methane abatement and no methane abatement under the APS trajectory of fossil fuel demand is just over 0.05 °C in 2050. Avoiding every fraction of a degree significantly cuts the risk of climate damages and exceeding climate tipping points. The APS gets close to achieving the goal of the Paris Agreement to limit the temperature rise to "well below 2 °C", but would still generate strong negative impacts for societies around the world.

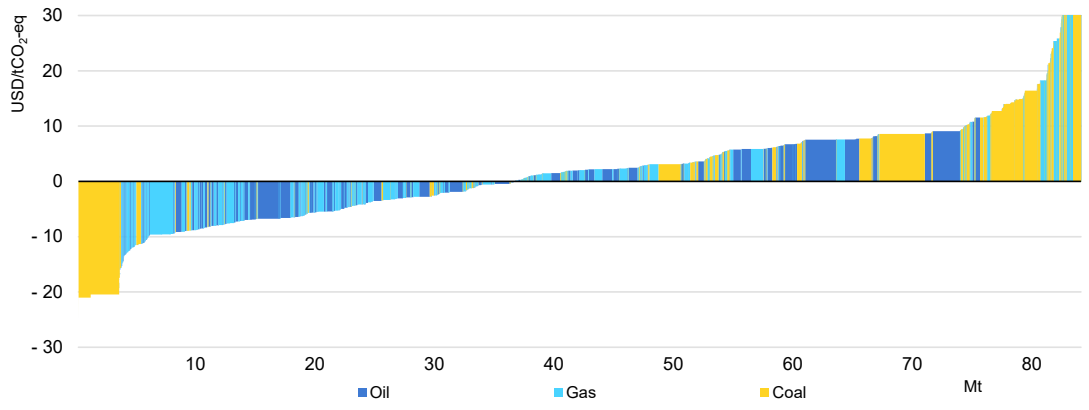
A large share of methane abatement measures can be deployed at low or no cost

Methane abatement in the oil and gas industry is one of the cheapest options to reduce greenhouse gas emissions anywhere in the economy. The technologies and measures to prevent emissions are well known and have already been deployed around the world. Key examples include leak detection and repair campaigns, installing emissions control devices, and replacing components that emit methane by design.

Captured methane emissions can often be sold, providing an additional revenue stream that can offset the upfront costs of abatement measures. Based on average natural gas prices from 2017 to 2021, we estimate that around 30% of the 120 Mt methane emissions from fossil fuel operations today could be avoided at no net cost (assuming an 8% rate of return over the lifetime of the measures). This is because the required outlays for abatement measures are less than the market value of the additional gas captured and sold.

While some measures require greater levels of upfront spending and may not result in additional gas sales, we estimate that it would be cost-effective to deploy nearly all fossil fuel methane abatement measures in the presence of an emissions price of about USD 20/tonne CO_2-equivalent.

Marginal abatement cost curve for methane from fossil fuel operations, 2022



Notes: One tonne of methane is considered to be equivalent to 30 tonnes CO_2 based on the 100-year global warming potential (IPCC, 2021).

Around USD 75 billion in spending is required to 2030 to deploy all methane abatement measures in the oil and gas sector in the NZE Scenario. This is less than 2% of the net income earned by the industry in 2022. The NZE Scenario sees lower natural gas prices than generally observed historically, but the value of the gas that would be saved and sold is still relatively large. Methane abatement would generate revenues of around USD 45 billion to 2030 from the sale of captured gas.

Of the total USD 75 billion spending to 2030, we estimate that about USD 15 billion to USD 20 billion may be more difficult to procure. This includes the spending required to cut emissions in low- and middle-income countries, especially those without strong methane reduction policies and regulations; at facilities owned and operated by national oil companies and smaller independent companies; and for measures that do not generate meaningful returns over their lifetimes. This is an appropriate area for focused international action.

There are also several opportunities to reduce coal mine methane emissions at a low cost. More than half of coal mine methane emitted globally today can be avoided with existing technologies, and more than 10% could be abated at no net cost (based on energy prices between 2017 and 2021 and an 8% required rate of return). Abatement options include capturing methane using degasification wells and drainage boreholes prior to the start of production at new coal seams (including new coal seams within existing mines). For underground mines already in operation, coal mine methane is often already pumped out through ventilation systems. This ventilation air methane can be captured and concentrated for use as an energy source – for example, to heat mine facilities or for coal drying. If utilisation is not an option, flares or thermal oxidisers can be used to reduce methane's climate impact.

An immediate and significant change in the pace and scale of methane reduction is needed to achieve international climate objectives. While industry efforts should play a role, government policy and regulation will be critical to removing or mitigating obstacles that prevent companies from getting started and going further. There are well-established policy approaches and options to reduce methane from oil and gas operations, while several jurisdictions are working to drive down emissions in the coal sector.

Cutting fossil methane emissions should play a central role in national policy efforts to meet climate goals

Tried and tested approaches exist for lowering methane emissions from the oil and gas industry, and efforts to improve data quality are ongoing. Policy tools include mandating leak detection and repair programmes, technology standards and bans on non-emergency flaring and venting. Further reductions can be

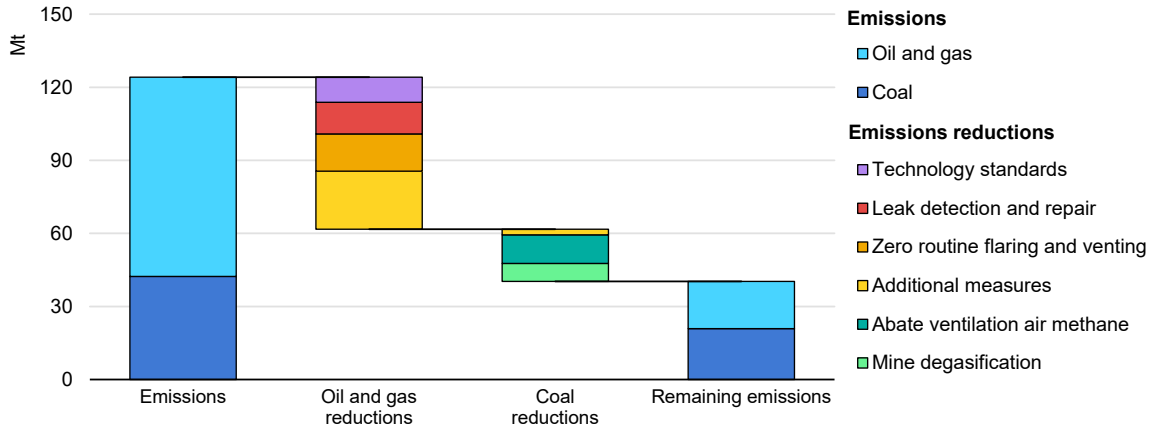
achieved with the help of more accurate and reliable data on emissions and abatement opportunities, including more robust measurement and reporting mechanisms.

Policy options are also available to tackle coal mine methane. Some countries have provided incentives to facilitate coal mine methane use as an energy source, for example, by introducing feed-in tariffs to encourage its utilisation for power generation. Other jurisdictions are using prescriptive requirements to curtail coal mine methane emissions, including by mandating its abatement in mines with high methane concentrations.

Countries that import fossil fuels can take steps to encourage their trading partners to step up abatement efforts through a mix of diplomatic action, incentives, technical and institutional support, and trade measures such as price premiums for low-emissions fuels, emissions intensity requirements for market access, and border adjustment mechanisms.

Improved and more transparent data about the sources of methane emissions would increase 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 work with companies to set and achieve emissions reduction goals.

Targeted abatement options available to cut methane emissions from fossil fuels in 2022



Methane abatement measures will deliver significant benefits for public health and food security

Methane is not only a potent greenhouse gas, but also a key precursor to ground-level ozone pollution. Taking immediate action to reduce methane emissions would therefore deliver important health, food security and economic benefits, in addition to helping limit dangerous climate feedback loops.

Based on the Climate and Clean Air Coalition's models and methodology developed for the Global Methane Assessment, methane abatement in the fossil fuel sector in the NZE Scenario would reduce ozone exposure worldwide, avoiding nearly 1 million premature deaths through 2050, which is equivalent to the current population of Amsterdam, Netherlands. Reduced ozone would also avoid nearly 3 million asthma-related emergency room visits and between 50 and 60 thousand hospital admissions for persons aged 65 and over. Reduced heat exposure would avert around 85 billion hours of lost labour, which is equivalent to 41 million full-time jobs.

The reduced ozone and the avoided climate change caused by reaching methane reduction targets would avert about 95 million tonnes of crop losses for wheat, rice, soy and maize (corn). These savings are equivalent to roughly 60% of the volume of wheat, rice, soy and maize produced in Africa in 2021.

The economic benefits of avoiding these labour and crop losses, as well as additional losses in forestry due to reduced ozone exposure, provide direct economic benefits valued at more than USD 260 billion between 2020 and 2050, in addition to significant health benefits.

Methane emissions reductions in APS and STEPS are smaller than in the NZE Scenario, resulting in lower cumulative benefits (see table below). However, achieving full methane abatement under APS and STEPS fossil fuel demand trajectories, as compared to no methane abatement, would provide larger additional benefits owing to the larger total mitigation potential. This could prevent 1.6-2.2 million premature deaths to 2050 as well as 5-7 million asthma-related emergency room visits, 100-140 thousand hospital admissions for persons aged 65 and over, 165-230 million tonnes of crop losses for wheat, rice, soy and maize, and around 150-210 billion hours of lost labour due to heat. Direct economic benefits in those two scenarios are valued at USD 450-650 billion.

As the health benefits are driven by ozone exposure, which responds immediately to methane abatement, they occur very quickly. For example, under the NZE Scenario, approximately 40% of the cumulative benefits to 2050 are realised by 2030 and about 80% by 2040.

Global cumulative health, agricultural and economic benefits of fossil fuel methane abatement to 2050

Scenario	Avoided premature deaths (thousands)	Avoided asthma-related emergency visits (millions)	Avoided elderly hospital admissions (thousands)	Avoided crop yield losses (billion tonnes)	Avoided labour losses (billion hours)	Economic gains (billion USD)
NZE	925	2.8	56	95	86	266
APS	910	2.77	55	93	85	261
STEPS	910	2.77	55	94	85	263

Notes: Health impacts are due to ozone exposure only; crop impacts are due to ozone, climate and carbon fertilisation; labour losses are due to heat. Economic benefits are from avoided crop and forestry losses and avoided labour losses only.

Source: CCAC based on the methodology of the Global Methane Assessment.

Some additional public health benefits could also be derived from reductions in emissions from air pollutants co-emitted during oil and gas extraction and production, such as nitric oxide and nitrogen dioxide, which are released primarily from flaring and other onsite combustion processes. One recent study concluded that air pollution from oil and gas extraction in 2016 in the United States caused approximately 7 500 premature deaths, 2 200 new asthma cases, and USD 77 billion in health damages (including the estimated value of avoided premature deaths).

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