Are Methane Emissions Driving Us To A 3°C World?

February – 2021

The Al-Attiyah Foundation

The Al-Attiyah Foundation is proudly supported by:

INTRODUCTION

ARE METHANE EMISSIONS DRIVING US TO A 3°C WORLD?

The United Nations Environment Programme suggests that the world is on track for an average temperature rise of 3°c, with CoVid-19 likely to result in just a 0.01°c reduction in global warming by 2050. NASA announced that Earth's global average surface temperature in 2020 tied with 2016 as the warmest year on record. This has been driven by rising greenhouse gas emissions, methane being the second most important. What are the main sources of methane emissions and what is their impact on climate? What technologies and approaches are being introduced to measure and reduce methane emissions? And how are international policy and regulation evolving?

Energy Industry Report

This research paper is part of a 12-month series published by The Al-Attiyah Foundation every year. Each in-depth research paper focuses on a prevalent energy topic that is of interest to The Foundation's members and partners. The 12 technical papers are distributed in hard copy to members, partners, and universities, as well as made available online to all Foundation members.

EXECUTIVE SUMMARY

- Global methane (CH_4) emissions rose by approximately 10% since 2000, with atmospheric concentrations of the gas reaching 1,890 parts per billion (ppb) as of October 2020 from pre-industrial levels of 722 ppb.
- The current anthropogenic methane emissions trajectory is estimated to be between the two warmest IPCC-AR5 scenarios (i.e., RCP8.5 and RCP6.0), corresponding to a temperature rise above 3°c by end of the century.
- Methane is a powerful greenhouse gas (GHG) with a global warming potential (GWP) 28-36 times that of CO_2 over 100 years.
- The IEA estimates 72 Mt of methane was emitted into the atmosphere from oil and gas operations in 2020, the largest emitters being Russia, the US, Iran and Turkmenistan.
- Numerous options exist to reduce methane from oil production. The IEA cites options which could lead to 75% reductions in emissions.
- The European Union is planning to apply binding standards for natural gas to limit methane emissions, with implications for international producers that do not comply.
- China is a major emitter of methane from coal mines. China aimed to recover 13.2 Mt of methane in 2020, but its mitigation policies were not very successful.
- The Joe Biden administration is restoring and tightening Obama-era regulations on methane, though US industry opinion remains divided.

IMPLICATIONS FOR MAJOR OIL AND GAS PRODUCERS

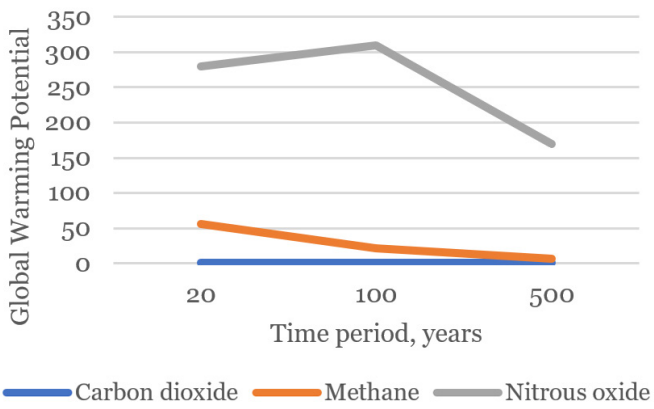
- Methane emissions affect the role and perception of natural gas as a transition fuel, and might lead countries to oppose the development of gas projects, including pipelines, LNG terminals and gas-fired power plants.
- Methane abatement offers a value-adding or at least a low-cost GHG reduction option, as about 40-50% of fossil fuel-related methane emissions could be eliminated at zero or negative cost.
- Tackling methane emissions would help safeguard the industry's future societal acceptance and license to operate. This is essential for oil and gas exporters to retain market access to Europe, and other customers that are likely to impose stricter standards in future.
- Corporate environmental, social and governance indicators, and mandatory financial reporting, will increasingly require rigorous and consistent methodologies for measuring and disclosing GHG emissions, including methane. Oil and gas companies should engage and lead to ensure such standards are accurate, practical and verifiable.
- There are industry-led alliances and partnerships, within the oil and gas sector, seeking to reduce leaks, including recently the Oil and Gas Methane Partnership 2.0. Working collaboratively with other sectors to reduce methane emissions from other sources, such as coal and agriculture, will enable more progress.

- Gas exporting companies that move decisively on reducing leakage could market their product as having lower greenhouse emissions, giving them a competitive advantage.

CLIMATE CHANGE IMPLICATIONS OF METHANE EMISSIONS

Over the past two decades, global methane (CH_4) emissions rose by approximately 10%, leading to record-high atmospheric concentrations of this potent greenhouse gas. Although its atmospheric lifetime of 12 years is much shorter than that of carbon dioxide (CO_2), the gas is so powerful that it traps heat 28-36 times more effectively than CO_2 over a 100-year period, and is responsible for about 23% of climate change in the 20th century (Figure 1). Over a 20-year period, the global warming potential of 1 tonne of CH_4 is similar to that of 85 tonnes of CO_2, according to the Intergovernmental Panel on Climate Change (IPCC).

Figure 1 Relative global warming potential of methane and other gases, per tonne[i]

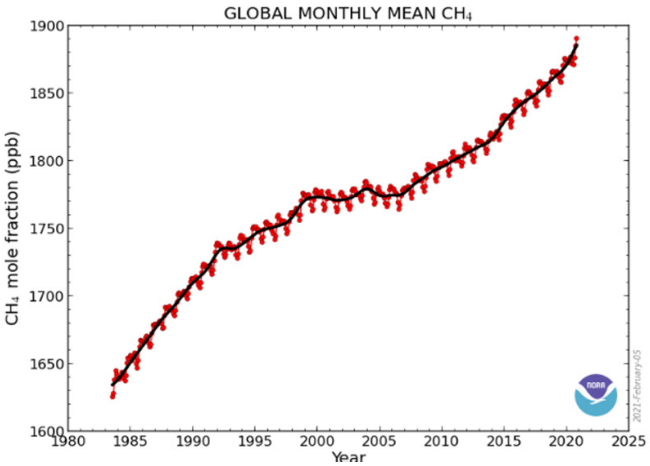


CLIMATE CHANGE IMPLICATIONS OF METHANE EMISSIONS

Combined with CO_2 and other GHGs, methane could warm Earth's atmosphere by 3-4°c before the end of this century[ii]. It is also culpable for ground-level formation of ozone, an air pollutant with harmful effects on human health. While methane does not cause direct harm to human health or crop production, tropospheric ozone (O_3) is responsible for about 1 million premature respiratory deaths globally, and is also a greenhouse gas.

From 2000-06, average annual emissions increased by around 50 million tonnes (Mt), driven mainly by agriculture and natural gas production. In 2017, the latest year in which comprehensive data was available, global annual CH_4 emissions reached a record-high of 596 Mt, according to the Global Carbon Project[iii]. Atmospheric concentrations of the gas reached 1,890 parts per billion (ppb) as of October 2020 (Figure 2).

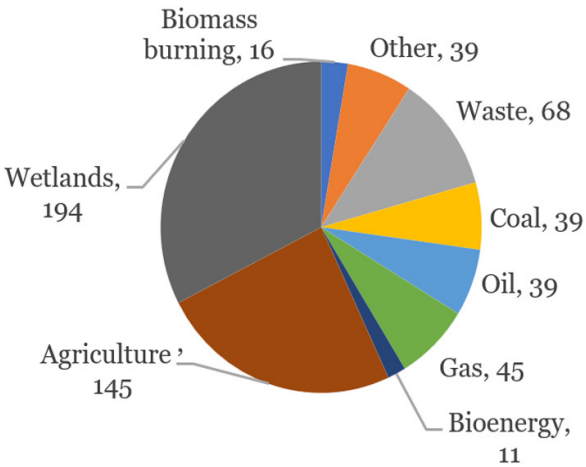
Figure 2 Atmospheric methane concentration[iv]

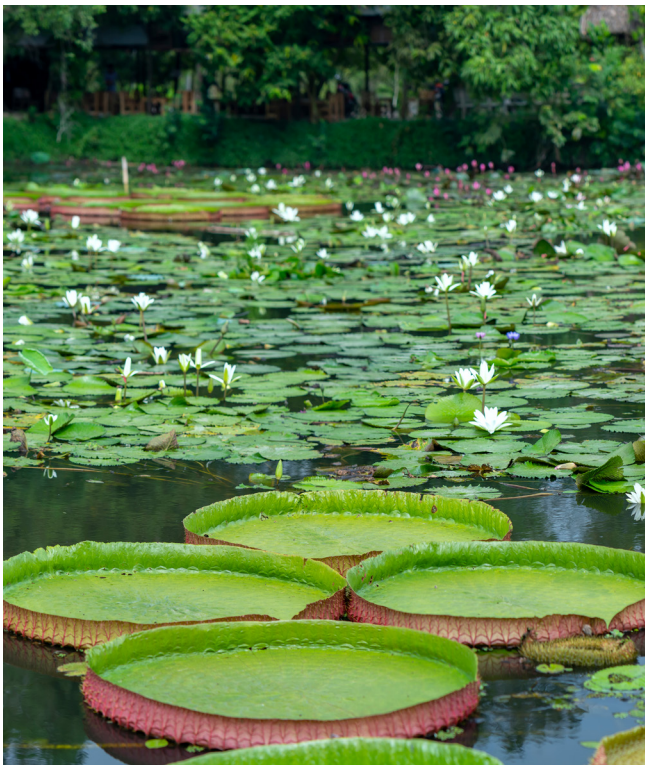


The current anthropogenic methane emissions trajectory is estimated to be between the two warmest IPCC-AR5 scenarios (i.e., RCP8.5 and RCP6.0), corresponding to a temperature rise above 3°c by end of the century[v].

About 30% of methane emissions are from wetlands, including lakes, rivers and ponds, while 20% is emitted from agriculture, mainly rice cultivation, livestock, and waste management. Coal, oil and gas production account for an additional 30% of CH_4 emissions, with the remainder from natural minor sources like wildfires, biomass burning, permafrost, termites, geological sources, hydrates, dams and the ocean[vi] (Figure 3).

Figure 3 Sources of methane emissions (Mt/year)[vii]





Scientists have found no proof that emissions from wetlands or other natural sources have increased from the 2000-06 average. Meanwhile, emissions from agriculture, led primarily by the increasing red meat consumption in certain regions, rose by around 12% to 227 Mt in 2017, while emissions from natural gas fields and leaking pipelines contributed 108 Mt in 2017, up 17%.

International Energy Agency (IEA) estimates for 2019 show a slight rise in methane emissions from fossil fuels compared to 2018 levels. It seems likely that CH_4 emissions would have fallen in 2020 given the slump in economic activity, hence, fossil fuel combustion, due to the Covid-19 pandemic. However, emissions will rise again as economies rebound, unless further action is taken.

The IEA estimated that some 72 Mt of methane was emitted from oil and gas operations in 2020, with the largest emitters being Russia, the US, Iran and Turkmenistan. The pandemic-induced decline in oil and gas prices could mean that companies would pay less attention to reducing their CH_4 emissions[viii]. Low natural gas prices may also lead to increases in gas flaring/venting, exacerbated by regulatory oversight in certain regions.

A study published on Earth System Science Data, led by the Global Carbon Project and the Laboratoire des Sciences du Climat et de l'Environnement in France, assessed the global methane sources and sinks to the atmosphere for 2000-17. Two methods were used for the measurement - a 'bottom-up' approach by surveying specific regions and sectors and a 'top-down' method by measuring atmospheric methane via plane or satellite. The combination of both these methods is required, to provide

fine granularity on sources and timing of emissions and to cover remote locations. Figure 4 shows the European Copernicus satellite's view of methane, with high concentrations over China likely linked to rice cultivation.

The budget indicates that global CH_4 emissions rose by 9% (about 50 million tonnes) between 2000-17 (Figure 5). Increasing emissions from both the agriculture and waste sector and the fossil fuels sector are likely the driving force, highlighting the need for stronger mitigation in both sectors.

Figure 4 Satellite sensing of methane (ppb)[ix]

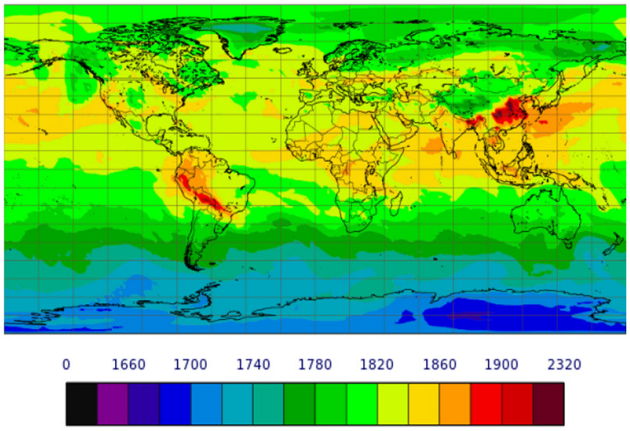
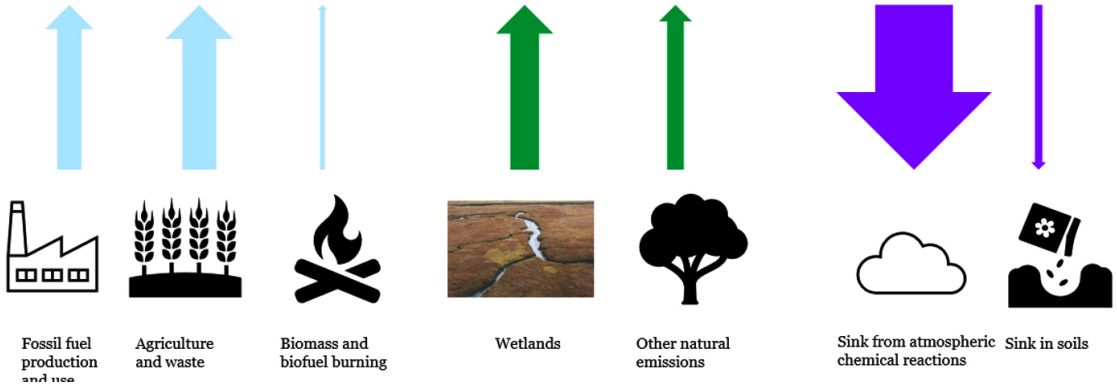


Figure 5 Global methane budget 2008-17[x]

				Total emissions			Increase in atmosphere			Total sinks
Top-down	111 (81-131)	217 (207-240)	30 (22-36)	576 (550-594)	181 (159-200)	37 (21-50)	13 (0-49)	-518 (474-532)	-38 (27-45)	556 (501-574)
Bottom-up	128 (113-154)	206 (191-223)	30 (26-40)	737 (595-880)	149 (102-182)	222 (143-306)	>100	-595 (489-749)	-30 (11-49)	625 (500-798)



TECHNOLOGIES AND APPROACHES TO ADDRESS CH_4 EMISSIONS

According to the IEA, around three-quarters of fossil fuel-related methane emissions could be reduced with technology that exists today at zero net cost. Curbing methane leakage from the oil and gas industry by 90% would eliminate 0.2°c from the forecasted increase in Earth's average temperature by 2050. A 75% reduction of fossil fuel-generated methane emissions could prevent up to 6 $GtCO_2e$ emissions yearly – almost 10% of the planet's 2019 GHG emissions[xi]. Emissions can also be cut in the other major sectors (agriculture and waste).

Technologies that prevent vented and fugitive emissions are well-known, but incentivizing their deployment via voluntary or regulatory means remains a challenge. The IEA cites a number of options, which if deployed across the oil and gas value chain would lead to a 75% total emissions mitigation. These include:

- Early replacement of devices;
- Replace pumps with electrical ones, powered by solar or other generators to eliminate emissions;
- Change gas-driven devices to electrically-driven zero-bleed technologies;
- Replace compressor seals or rods;
- Install vapour recovery units;
- Conduct blowdown capture;
- Install portable flares at oil and gas production sites;
- Install plunger lifts to extract liquids more efficiently, while limiting methane leakage;
- Deploy new methane-reducing catalysts;
- Use microturbines, mini-CNG, mini-GTL or mini-LNG facilities at remote locations to avoid venting during transportation; and
- Conduct reduced emission or green completions[xii].

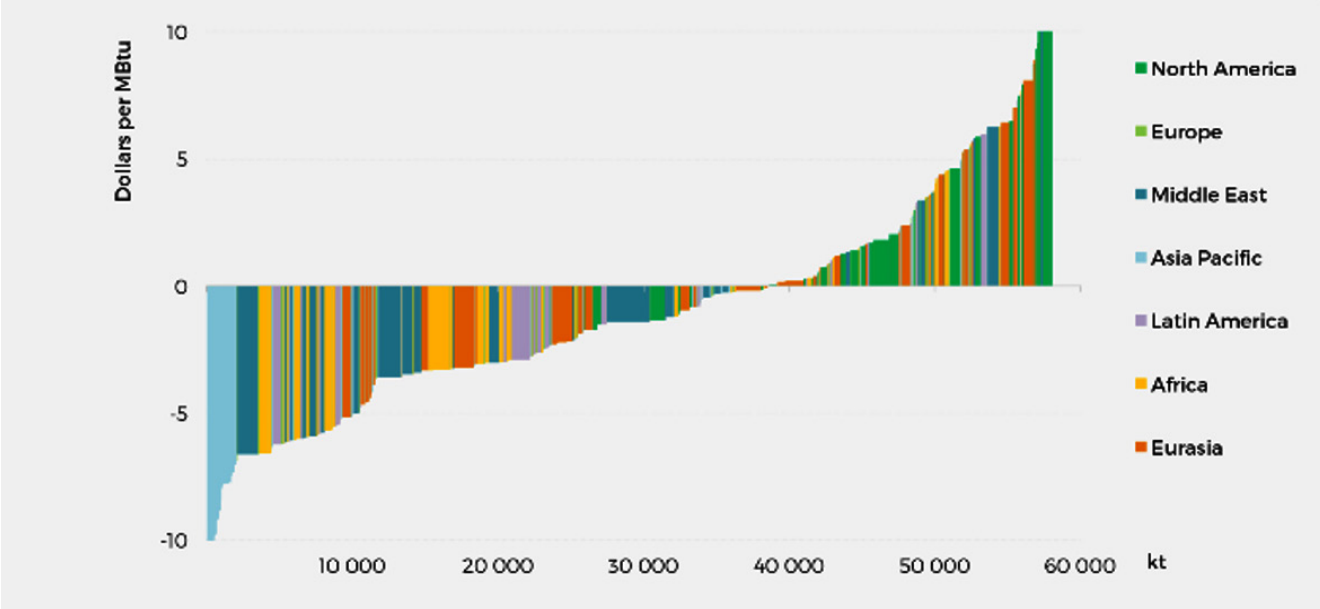
TECHNOLOGIES AND APPROACHES TO ADDRESS CH_4 EMISSIONS

Most leakage in the oil and gas industry is due to malfunctioning equipment or poor operational practices. It can therefore be cut at low or even negative cost. Super-emitters are caused by a variety of factors, including operational error (leaving storage hatches open), malfunctions (valves stuck open), and mechanical failure (loose connections, leaking compressor seals). Routine maintenance and operational awareness can solve many of these problems.

Flaring unwanted gas is preferable to venting, which releases methane directly, but flares do not combust completely[xiii]. Better flare maintenance could have a major impact, along with eliminating routine flaring entirely, by developing gas processing, on-site use, or connections to collection pipelines.

The IEA has estimated that about 40-50% of the possible 75% methane emissions reduction in the oil and gas industry, could be done at zero or negative cost, i.e., the value of the gas saved would more than pay for the measures taken (Figure 6).

Figure 6 Marginal abatement cost for methane[xiv]



The negative cost opportunities are spread across primarily Asia, Africa, Middle East and Latin America.

Downstream methane leakage can also be problematic if the industry is trying to expand its markets. For instance, LNG has been promoted as a shipping fuel. However, leakage rates ("slip"), from about 0.7% at high engine loads, to 2.3-3.6% at lower loads[xv], are high and undermine the climate benefit of LNG compared to fuel oil or marine gasoil. However, modern low-pressure, four-stroke dual-fuel engines have slip of 0.28% which can be realistically reduced to 0.1%[xvi].

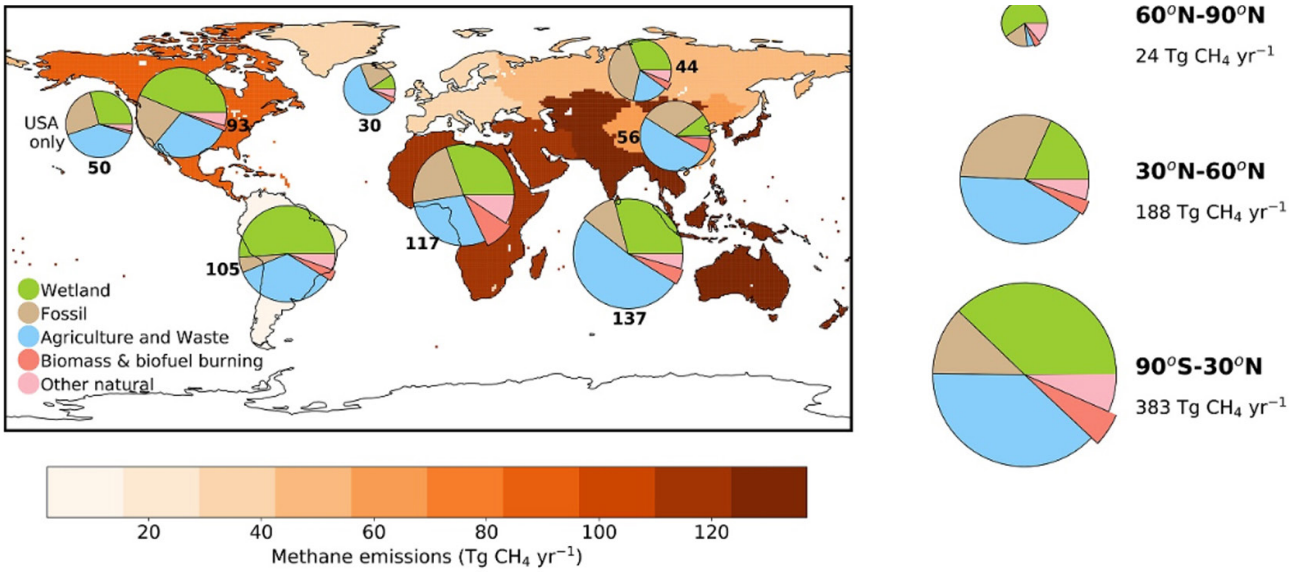
Reducing methane emissions from agriculture and waste relies on relatively simple techniques. However, it is a more complicated policy issue than reducing oil and gas emissions, because of the very large number of individual farmers, the different techniques, crops and climatic conditions, and the challenge of measurement. Unlike a gas company, which can at least sell the methane it captures, a farmer does not benefit directly from reducing emissions.

The table outlines certain approaches currently being employed across the world to reduce methane emissions in the agriculture and waste management sectors.

Agriculture	• Improve manure management and animal feed quality • Apply intermittent aeration of continuously flooded rice paddies • Improve animal health and husbandry by combining herd and health management, nutrition and feeding management strategies • Introduce selective breeding to reduce emission intensity and increase production • Promote farm-scale anaerobic digestion to control methane emissions from livestock • Cover anaerobic lagoons and collect and transmit lagoon-generated biogas to a dedicated point for transmission to plants • Adopt guidelines on healthy dietary choices, including supplements that reduce methane generation by ruminants
Waste management	• Reduce waste generation at source through education, fees, improved refrigeration and preservation • Extract CH4 from landfills using wells and a vacuum system, which collects gas to be combusted in a flare or utilised for energy[xvii] • Separate and treat biodegradable municipal waste, and turn it into compost or bioenergy • Upgrade wastewater treatment with gas recovery and overflow control • Improve anaerobic digestion of solid and liquid waste by food industry • Anaerobic sludge digestion (new construction or retrofit of existing aerobic treatment systems) • Upgrade primary waste-water treatment • Divert organic waste

POLICIES AND EFFORTS TO REDUCE CH_4 EMISSIONS

Figure 7 Methane emissions by region, source category and latitude based on top-down inversion models[xviii]



Policy and regulations to reduce CH_4 emissions differ from one region to another, and so does their effectiveness and enforcement.

The European Union plans to apply binding standards for natural gas to limit methane emissions, in line with its net-zero carbon strategy by 2050. The EU Methane Strategy was published in October 2020 and outlines a clearer roadmap than previous versions, with legislative proposals planned over the course of 2021. The EU is focussing on low-cost initiatives such as detection and repair and the elimination of gas flaring. According to the strategy, oil and gas companies will be required to monitor and report methane emissions and repair leaks, while venting and flaring would be banned. The strategy also includes engagement with producer countries on best practices for emissions reduction.

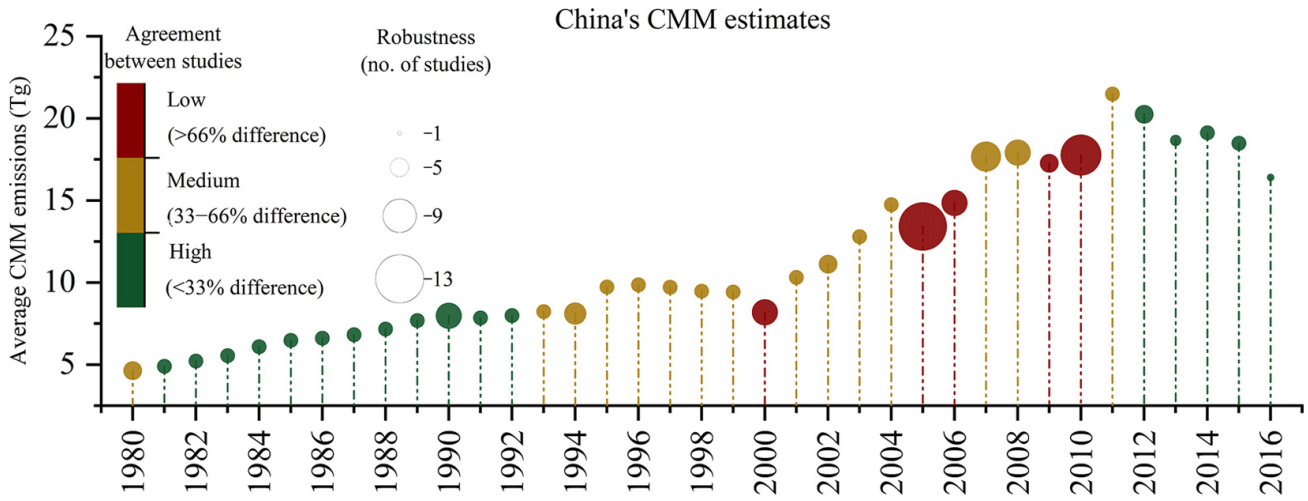
These announcements pushed many gas buyers to reconsider gas supply agreements. In November, France's multinational utility Engie company halted talks over a potential long-term gas supply agreement with US LNG developer NextDecade, following pressure from the French government and environmentalist groups which oppose the LNG from shale gas[xix].

The Environmental Defence Fund recently observed some remarkable shifts in gas buying behaviour, with customers beginning to ask pertinent questions about the origin of the gas they are purchasing.

Although campaigners welcomed EU's plans to tackle imported emissions, green EU lawmakers critisize the lack of legislation on agriculture, where most CH_4 emissions come from livestock farming.

In the US, where CH_4 accounted for 10% of the country's GHG emissions in 2018, the newly elected President Biden has called on the EPA to review the action of President Trump to roll the Obama administration's New Source Performance Standards, set in 2016 to control methane emissions from the energy sector[xx].

Figure 8 China's coal mining methane emissions estimates[xxiv]



On February 26, President Biden restored the Obama-era calculation on the economic cost of GHGs, with a 5% discounted carbon price of US$ 51/tCO_2e to be used in government decision-making and budgeting by September, with a final number expected to be announced by January 2022. Using a GWP of about 29, the price of US$ 1,500/tCH_4 is set for methane emissions[xxi]. This discounted price has been criticised as too low, even though it is more than 25 times higher than the US$55/t$CH_4$ set by Trump[xxii].

Although President Biden's campaign to restore methane regulations is a step forward, the new administration would need at least some industry support to reinstate the Obama era performance standards. It should be noted that the oil majors including, BP, Chevron, Shell and ExxonMobil all opposed Trump's decision to loosen the regulations in the first place. Since these companies have set targets to cut their emissions, they expected all other companies to be compelled to do their part. However, the American Petroleum Institute, the largest industry group, and numerous smaller companies supported Trump's loosening of methane regulations.

POLICIES AND EFFORTS TO REDUCE CH_4 EMISSIONS

In China, more than 40% of methane is emitted during upstream gas and oil operations and coal production[xxiii]. Coal mine methane emissions, alone, rose from 4.64 Mt in 1980 to 21.48 Mt in 2012, before falling moderately to 16.41 Mt in 2016 (Figure 8). Recent data found that China's overall methane emissions increased 1.1 Mtpa between 2010-15, accounting for up to a quarter of the increase in global emissions over that period.

The country has laid out ambitious plans to pursue mitigation and emissions reduction options. In its 12th five-year plan, China set out policies for 2011-15 aimed at recovering and use of 5.6 Mt of methane from coal mining. The target for 2020, was 13.2 Mt of methane.

However, satellite data shows that these policies have so far proved unsuccessful in curbing CH_4 emissions from the mining sector.

Most coal mines are situated in remote mountainous areas, which are rarely connected to natural gas infrastructure networks[xxv].

Methane abatement would be supportive of the country's aims to peak its GHG emissions by 2030, and to increase the share of gas in primary energy while reducing that of coal. The 14th five-year plan, which will be approved this month (March 2021), emphasised natural gas' role in the transition towards a carbon-neutral China by 2060. However, this will require reducing methane leaks from the gas system as its use increases.

China National Petroleum Corporation (CNPC), the country's largest oil and gas producer, has announced plans to deepen its methane emissions cuts, setting a more ambitious pledge in line with the country's net-zero target by 2060.

There are also some methane reduction policy initiatives, driven by industry-led methane alliances and partnerships. For example:

- The Climate & Clean Air Coalition's Oil and Gas Methane Partnership, which was officially launched at the UN Secretary General's Climate Summit in New York in 2014. Already, 62 companies with assets in five continents representing 30% of the world's oil and gas production has joined the partnership. Technical partners include the Environmental Defence Fund, EPA's Natural Gas Star program, the Global Methane Initiative and the World Bank's Global Gas Flaring Reduction Initiative[xxvi].
- The Oil and Gas Climate Initiative (OGCI[xxvii]), that groups thirteen major international oil companies, has made methane reduction a priority[xxvii], and invested heavily in monitoring the gas, and providing low-leakage valves and control systems.
- The ONE[xxix] Future Coalition, a group of 37 gas companies aims to reduce leakage in the US's natural gas industry to 1% or less. It has strong representation from US-focussed independent companies, including EQT, the largest American gas producer, as well as mid-stream and gas utility companies. The coalition has surpassed it 1% goal for all 3 years of reporting.
- ExxonMobil and Chevron, joined by Equinor, Cheniere, and Pioneer Natural Resources, have formed the Collaboratory for Advancing Methane Science, focussing on research into leak reduction[xxx].
- The Global Methane Initiative[xxxi] was launched in 2004 as an international private-public initiative on methane abatement, which provides technical support on methane recovery and use. Partner countries include major oil and gas producers Russia, the US, Saudi Arabia, Nigeria, Norway, China, Australia and others.
- The Methane Guiding Principles[xxxii] is a collaboratively developed approach from industry and civil society, to measure and report methane emissions in a standardised way, and commit members to continuous reductions in leakage. Members include Qatar Petroleum, the large Western oil companies, Gazprom, Novatek, Rosneft and others.

However, some of the world's major gas producing companies are absent from these initiatives, choosing instead to pursue their own individual initiatives. The examples of notable absentees are Lukoil, Sinopec, Sonatrach, and ADNOC.

CONCLUSIONS

The potent heat-trapping gas, methane, if not captured and used, greatly diminishes the credentials of natural gas as a clean energy source, as compared to low-carbon sources, including renewables and nuclear.

For this, the oil and gas industry sector has to tackle the various economic, environmental and reputational aspects of methane leakage, if it is to see continued growth in gas usage through the 2030s. Oil and gas companies and major exporting countries would be well-advised to engage and lead on developing standards, to ensure they are accurate, practical, rigorous and verifiable[xxiii].

There are several coalitions and partnerships working on the problem of methane in the oil and gas sector. These collaborations need to be extended to other sectors to work cooperatively on methane emissions from other sources, such as coal and agriculture.

Low methane leakage is relatively easy to achieve, compared to deeper decarbonisation by the industry. New monitoring technologies, including drones and satellites, better completion, production and pipeline systems, and improved gas commercialisation options, offer substantial savings on emissions. Companies targeting carbon-neutrality, including most of the European majors, and leading gas exporting countries, will find cutting methane one of the key near-term steps for improving their greenhouse gas footprint and safeguarding their markets.

APPENDIX

i. UN Framework Convention on Climate Change, https://unfccc.int/process/transparency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-unfccc/global-warming-potentials
ii. https://www.nbcnews.com/science/environment/soaring-methane-emissions-threaten-put-climate-change-goals-out-reach-n1233831
iii. https://www.nature.com/articles/d41586-020-02116-8
iv. https://www.esrl.noaa.gov/gmd/ccgg/trends_ch4
v. Future Earth https://futureearth.org/2020/07/15/global-methane-emissions-have-risen-nearly-10-percent-over-last-20-years/
vi. NASA https://svs.gsfc.nasa.gov/4799
vii. The International Energy Agency https://www.iea.org/reports/methane-tracker-2020
viii. The International Energy Agency https://www.iea.org/articles/global-methane-emissions-from-oil-and-gas
ix. https://atmosphere.copernicus.eu/charts/cams/methane-fore-casts?facets=undefined&time=2021030500,3,2021030503&projection=classical_global&layer_name=composition_ch4_totalcolumn
x. Global Carbon Project https://www.globalcarbonproject.org/methanebudget/index.htm
xi. https://www.ccacoalition.org/es/node/3788
xii. The International Energy Agency https://www.iea.org/reports/methane-tracker-2020/methane-abatement-options
xiii. https://capterio.com/insights/2019-10-4-flarings-billion-tonne-methane-secret-an-under-estimated-opportunity-for-decarbonization-and-revenue-generation-in-oil-amp-gas-a-thought-piece-by-capterio
xiv. The International Energy Agency https://www.iea.org/newsroom/news/2017/october/commentary-the-environmental-case-for-natural-gas.html
xv. https://ec.europa.eu/environment/integration/research/newsalert/pdf/methane_emissions_from_lng_powered_ships_higher_than_current_marine_fuel_oils_444na4_en.pdf
xvi. https://www.wartsila.com/media/news/06-04-2020-cutting-greenhouse-gas-emissions-from-lng-engines
xvii. https://www.globalmethane.org/documents/gmi-mitigation-factsheet.pdf
xviii. Carbon Brief Co. https://www.carbonbrief.org/scientists-concerned-by-record-high-global-methane-emissions
xix. https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/022421-eu-should-include-methane-performance-standard-in-emissions-legislation-shell
xx. https://insideclimatenews.org/news/21012021/biden-executive-orders-climate-change/
xxi. https://www.politico.com/news/2021/02/26/biden-carbon-price-climate-change-471787
xxii. https://www.scientificamerican.com/article/epa-revises-the-social-cost-of-a-potent-greenhouse-gas/
xxiii. https://www.reuters.com/article/us-china-cnpc-carbon-idINKBN2430P7
xxiv. https://www.sciencedirect.com/science/article/abs/pii/S0048969720318088#f0025
xxv. Carbon Brief https://www.carbonbrief.org/chinas-methane-emissions-rise-despite-tougher-laws-satellite-data-shows
xxvi. Climate & Clean Air Coalition https://www.ccacoalition.org/es/node/3788
xxvii. A consortium of 12 world's leading energy firms with the objective to accelerate the industry response to climate change
xxviii. Oil and Gas Climate Initiative, https://oilandgasclimateinitiative.com/climate-investments/#our-portfolio
xxix. https://onefuture.us/our-members/
xxx. https://methanecollaboratory.com/
xxxi. https://globalmethane.org/downloads/GMI%20Fact%20Sheet.pdf
xxxii. https://methaneguidingprinciples.org/methane-guiding-principles/
xxxiii. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/11/Methane-Emissions-from-Natural-Gas-and-LNG-Imports-an-increasingly-urgent-issue-for-the-future-of-gas-in-Europe-NG-165.pdf


2030 PROJECTED
CO_2 CONCENTRATION
CURRENT CO_2
CONCENTRATION
OPTIMUM CO_2
CONCENTRATION
460
440
420
400
380
360
340

OUR PARTNERS

The Al-Attiyah Foundation collaborates with its partners on various projects and research within the themes of energy and sustainable development.

UIP-ICP
ULUSLARARASI İŞBİRLİĞİ PLATFORMU
INTERNATIONAL COOPERATION PLATFORM
İSTANBUL

World Petroleum Council

MITSUI & CO.

مؤسسة قطر
Qatar Foundation
Unlocking human potential لإطلاق قدرات الإنسان

KAHRAMAA
المؤسسة العامة القطرية للكهرباء والماء
Qatar General Electricity & Water Corporation

NATIONAL COUNCIL ON U.S.-ARAB RELATIONS

ISAG
Istituto di Alti Studi in Geopolitica e Scienze Ausiliarie

مجلس قطر للمباني الخضراء
QATAR GREEN BUILDING COUNCIL

جامعة حمد بن خليفة
HAMAD BIN KHALIFA UNIVERSITY

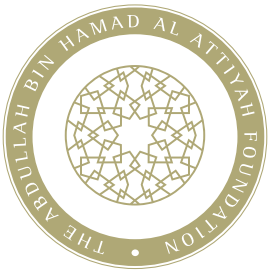
United Nations Global Compact

جامعة قطر
QATAR UNIVERSITY

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

GORD
المنظمة الخليجية للبحث والتطوير
Gulf Organisation for Research & Development

GULF TIMES



Barzan Tower, 4th Floor, West Bay, PO Box 1916 - Doha, Qatar

Tel: +(974) 4042 8000, Fax: +(974) 4042 8099
www.abhafoundation.org

AlAttiyahFndn
The Al-Attiyah Foundation