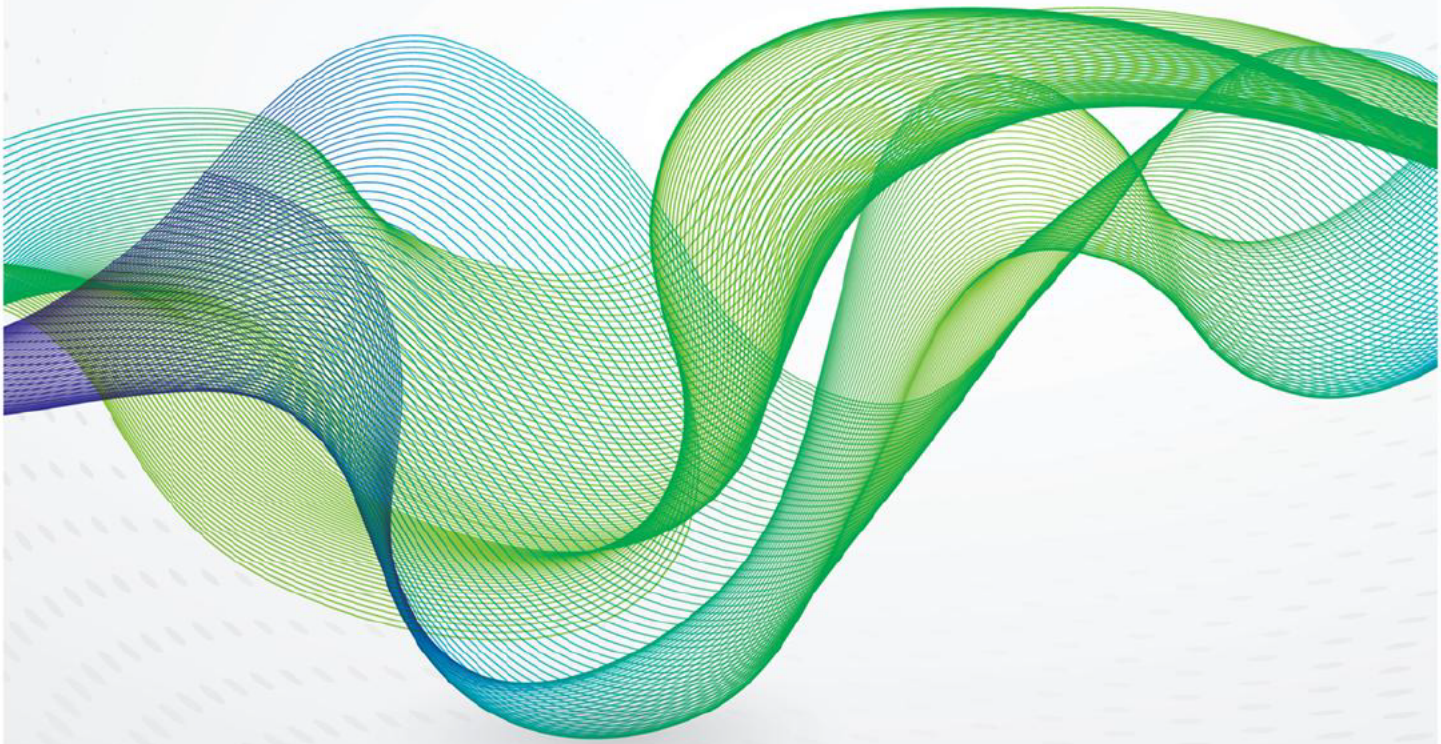
THE OXFORD INSTITUTE FOR ENERGY STUDIES

April 2025

Measurement Reporting and Verification of Methane Emissions from the Gas and Oil Sector and Consequences for LNG Trade:

a three year progress report



OIES Paper: ET 46

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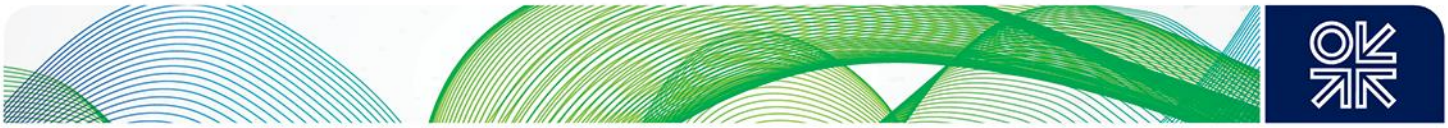

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ISBN 978-1-78467-271-3

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Acknowledgements

I would like to thank the following for helpful comments and suggestions: Bill Farren-Price, Bassam Fattouh, Christophe McGlade and Maria Olczak and Mostefa Ouki as well as John Elkins for excellent editorial suggestions. My thinking was significantly sharpened by those who attended the OIES Methane Emissions Workshop in March 2025. I am solely responsible for all errors, omissions and opinions expressed.

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1. Introduction and propositions

Greenhouse gas emissions from fossil energy have become an increasingly important issue in a world which, by general agreement, is not on track to meet net zero emissions and temperature reduction goals in the first half of this century.[1] At the start of 2022, OIES published a study by this author of measurement reporting and verification of methane emissions from natural gas and LNG trade.[2] That paper was based on two general propositions which are restated here:

- Any organization selling fossil fuels internationally (but in many countries also domestically) will need to make publicly available data on greenhouse gas (not just carbon dioxide) emissions from the supply chain of those fuels, but also methodologies showing how emissions were measured, how they are reported, whether an independent organization has verified the data and to what standard of accuracy.
- Failure to provide publicly available details of measurement, reporting and verification (MRV) will compromise the credibility of any published data and claims by governments or companies to be meeting targets, commitments or pledges. This is likely to speed up the phase-out of unabated fossil fuels, particularly in countries where there are substantial societal pressures to meet GHG reduction targets, with imported fossil fuels coming under particular scrutiny.

Since 2022 much has happened in terms of national and international governmental policies, pledges and agreements, as well as corporate initiatives, aimed at methane emissions reduction. The US Inflation Reduction Act and the European Union's Methane Regulation are substantial pieces of legislation. In North America increasing numbers of companies have joined initiatives to certify emissions from their oil and gas production.

There is general agreement that reduction of methane emissions from the fossil energy – oil, natural gas and coal – sector is one of the few measures which is cost-effective, relatively simple to achieve, and can make a substantial difference to the growth of atmospheric warming by mid-century.[3] While in many countries agriculture and waste are larger contributors to anthropogenic methane emissions than the energy sector, the number of energy companies and sites is significantly less than for other sectors, and substantial reductions are hence more manageable and achievable on a shorter time scale.

This paper provides an overview of progress on the measurement, reporting and verification of methane emissions from 2022-25 with a particular focus on the LNG sector, and considers how this sector may be impacted by regulation to be introduced in the period up to 2030, particularly in the European Union and the United States. While LNG accounts for a relatively small subset of fossil fuel emissions, the significant expansion of global LNG trade over the next five years means that it is attracting considerable attention. Methane emissions are the Achilles Heel of any claims for natural gas and LNG to be considered a transition or `bridge' fuel to a low or zero carbon future.

The paper updates legislative, regulatory and corporate initiatives since the 2022 study focusing on how much progress has been made over the three year period and the impact this may have on LNG trade. It is structured in ten sections, following this introduction:

- Section 2 examines the development of global methane emissions from oil and gas flaring, venting and leakage (fugitive) of methane.
- Section 3 looks at the limitations of sources, methodologies, metrics and verification of emissions.
- Section 4 examines intergovernmental methane initiatives.
- Section 5 deals with UN and corporate initiatives.

[1] UNFCCC (2023), UNEP (2024).
[2] Stern (2022).
[3] Estimates range from 0.1-0.3 degrees centigrade by 2050.

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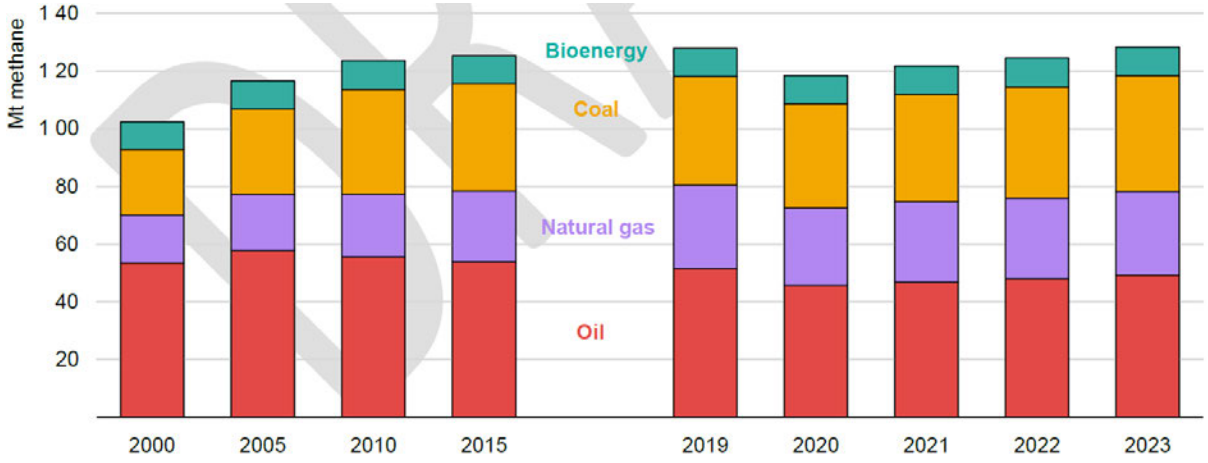
- US and EU methane legislation and regulation are the subject of Section 6.
- Corporate and government MRV and methane-related LNG initiatives are the subject of Section 7.
- Section 8 narrows the focus of the paper to emissions from the ten largest LNG exporters.
- Section 9 deals with transparency and confidentiality as major obstacles to progress in reducing methane emissions.
- Section 10 summarises and draws conclusions.

2. Global methane emissions from oil and gas

Global methane emissions have steadily increased since the industrial revolution. A 2024 study estimated that from the second half of the 19th century to 2019, methane emissions have been responsible for around 65% as much warming as carbon dioxide, and that from observed warming of 1.07 degrees centigrade from 2010-19, methane emissions accounted for 0.5 degrees.[4] Emissions have continued to increase steeply in the 2020s with two thirds attributable to anthropogenic sources.[5] Non-energy anthropogenic sources of methane emissions, principally agriculture and waste; and non-anthropogenic sources, principally tropical wetlands, are also major sources of emissions.[6] But some assessments have shown that in the period since the late 2000s, fossil fuel emissions have been a major (and perhaps the major) contributor to increasing emissions.[7]

The International Energy Agency's (IEA's) Methane Tracker estimated that out of 120Mt of energy-related emissions in 2023, oil accounted for 49Mt, coal for 40Mt, natural gas for 29Mt; bioenergy provided a further 10Mt. Figure 1 shows that after a continuous increase in the first two decades of the century there was a peak in 2019 followed by a sharp decline (presumably due to the Covid pandemic). But since 2020, there has been a slow but significant increase in energy-related emissions which have almost returned to 2019 levels.

Figure 1: Methane Emissions from Fossil Fuel and Bioenergy Production and Use 2000-2023 (Mt methane)



Source: IEA (2024a)

[4] Shindell et al (2024) citing the IPCC 6th Assessment Report.
[5] The increase in global methane emissions is shown in Global Monitoring Laboratory - Carbon Cycle Greenhouse Gases (noaa.gov). Jackson et al (2024) provides a more detailed breakdown of emissions by sector, region and country for the period up to 2020.
[6] Shindell et al (2024).
[7] Jackson et al (2024) summarise as follows: `Fossil fuel emissions [from 2000-2002 to 2018-2020]..rose an estimated 18-28%..Methane emissions from fossil fuel extraction and use are now comparable to direct methane emissions from cows and other ruminants globally…but emissions from agriculture and waste, including landfills, remain approximately twice those associated with fossil fuels'.

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The IEA's Net Zero Emissions by 2050 (NZE) Scenario – which sees the global energy sector achieving net zero emissions by mid-century, limiting the temperature rise to 1.5 °C, requires methane emissions from fossil fuel operations to fall by around 75% by 2030 from 2023 levels. And:

- if all methane policies and pledges made by countries and companies to date are implemented and achieved in full and on time, methane emissions from fossil fuels would decline by around 50% by 2030[8];
- around 40% of the 120 Mt of methane emissions from fossil fuels could be avoided at no net cost, based on average energy prices in 2023. The share is higher for oil and natural gas (50%) than for coal (15%).[9]

Table 1 breaks down global methane emissions from oil and gas into different operations: venting, flaring and fugitive (leaked) emissions; these sectors only include emissions from production to the point of export, and exclude those from distribution or end-use. More than 60% of these emissions originate from (onshore and offshore) oil production with two thirds from vented gas, defined as intentional releases for safety or operational (inspection and maintenance) requirements. Fugitive emissions – defined as unintentional or `leakage' of gas – account for 21%, two thirds of which are from onshore oil and gas. Flared gas – which the IEA records only in relation to oil production – accounts for 10% of total methane emissions. A quarter of emissions originate from (onshore and offshore) gas production with over 70% of those volumes from venting. For both oil and gas, onshore production is by far the most important source of emissions, although this may be a consequence of limited availability of measurements from offshore activities and stricter safety standards. Gas pipelines and LNG facilities – treated as a single element in the IEA data - account for less than 10%. But as discussed in Section 7, these figures can be far higher for individual countries, and particularly for individual projects.

Table 1: Global Emissions of Methane from Global Oil and Gas Operations 2023* (Kt)

	Fugitive	Vented	Flared	TOTAL
Onshore Oil	5903	23613	6250	35766
Offshore Oil	1935	7741	1272	10948
Onshore Gas	4243	10588	0	14831
Offshore Gas	1166	2910	0	4076
Gas Pipelines and LNG facilities	2762	4362	0	7124
Other Oil and Gas	0	0	0	2450
TOTAL	16009	49214	7522	75195

*not including international trade and end use
Source: IEA (2024b)

Emissions from gas flaring

Although flaring and fugitive (leakage) of emissions tend to attract headlines, a conclusion from Table 1 is that in relation to *methane* they are far less important than emissions from venting.

[8] See Sections 4 and 5 for a review of pledges and initiatives.
[9] IEA (2024b), Key Findings.

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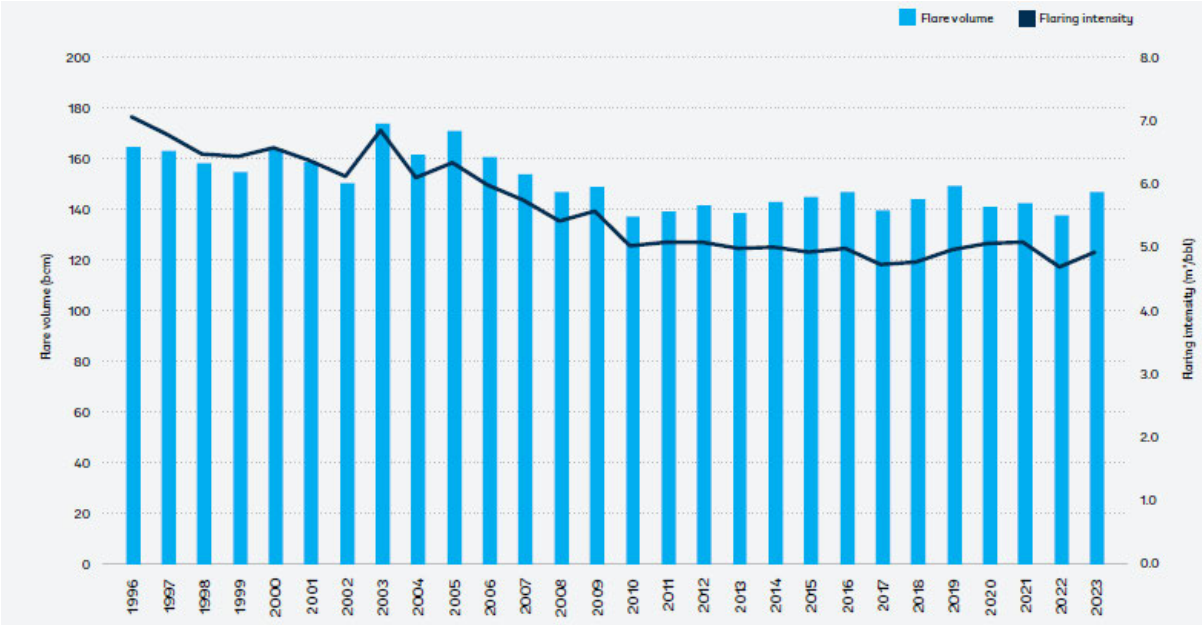
Figure 2: Global Gas Flaring at Upstream Oil and Gas Facilities, 1996-2023



Note: bcm = billion cubic meters; M Mbbl/d = million barrels of oil per day
Source: World Bank (2024), Figure 3, p.2

Figure 2 shows upstream gas flaring declined significantly in the first decade of the century followed by a plateauing and slight increase in volumes, but a slight decline in intensity (ie volumes flared per unit of oil production) thereafter. This is a more successful historical trend than for methane emissions (which continued to increase through the 2000s) but a similar more recent trend with plateauing or slightly increasing in the 2020s. Comparing Figure 2 with Table 1, the vast majority of flared gas is assumed to be associated with oil production.[10]

Emissions from flaring involve significant complexity of measuring, on an ongoing basis, the proportion of flared gas that is fully combusted – so-called `flare (or `combustion) efficiency'. It had been traditionally assumed that a flare constituted 98% carbon dioxide and 2% methane – i.e. a 98% flare efficiency. But, due to US studies showing that malfunctioning equipment resulted in many flares being partially or fully extinguished (i.e. emitting 100% methane), in 2021 the IEA reduced its flaring efficiency assumption from 98% to 92%.[11] The importance of flaring efficiency is emphasized in the World Bank's Global Gas Flaring Tracker Report which shows that at 92% efficiency the carbon dioxide equivalent (CO2e) emissions for globally flared gas in 2023 was 494 tons CO2e, compared with a 98% efficiency of 381 tons CO2e – a difference of 23% - with every 1% reduction in flaring efficiency resulting in a 4-5% increase in total CO2e emissions.[12] A major problem is that accurate measurement of flaring efficiency is extremely complex requiring, according to detailed experimental research, `a new generation of reference methods'.[13] The majority of the literature on methane emissions from flaring fails to make clear how (or whether) combustion efficiency was measured or simply assumed.

[10] This is because natural gas collection and evacuation facilities are not always available at oil production sites, at least not from the start of production. Whereas at a gas field those facilities are an integral part of the project from the outset of production. While the vast majority of flaring is associated with oil production, flaring does occur at facilities along gas supply chains.
[11] IEA (2021), p.76. For more detail on flaring from LNG exporters see Section 8. In contrast, the World Bank data have maintained a 98% `destruction efficiency'. World Bank (2024), p.30.
[12] World Bank (2024), Figure 23, p.32. This data assume CO2 equivalence (CO2e) of methane measured over a 100-year period of 28 (see Metrics section below). Using a 20-year time horizon increases the CO2e of methane to 84 which would increase total emissions nearly 20% significantly to 470Mt CO2e in the case of 98% efficiency. Assuming 92% flaring efficiency and a 20 year time horizon raises total emissions by nearly 60% to 852Mt CO2e.
[13] Evans et al (2024).

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The IEA and the World Bank data are global, current and detailed by segment and use a consistent methodology to produce a set of *country-level* estimates of emissions. They cannot be used to calculate specific *project-level* emissions.

3. Limitations of sources, methodologies, metrics and verification/certification

3.1 Sources

From what has been said above, it is clear that public domain data on fossil fuel methane emissions are difficult to interpret and, outside North America, relatively scarce. Most of the public domain data in general literature can be traced back to sources in Figures 1 and 2, and Table 1 specifically: the IEA's Methane Tracker, the World Bank's Global Gas Flaring Tracker, and proprietary data from consultancies Rystad Energy and Wood Mackenzie. In turn, much of the data from these sources – to the extent they are transparent – can be traced back to US government engineering estimates or actual measurements, or information from satellite providers. The methane literature is dominated by studies of US emissions which provide public domain data from corporate, academic and NGO studies relating to specific companies and projects, but it is not easy to identify the assumptions on which these are based, creating difficulties to compare their findings.

To the extent these studies either use US government data, or focus on emissions from US companies or projects, they are heavily influenced by independent academic and NGO studies starting from the 2010s, which found that US Environmental Protection Agency (EPA) statistics based on generic emission factors and engineering estimates had systematically under-estimated US methane emissions over a long period of time.[14] A 2021 study found methane emissions from production about 1.8 times greater than EPA's Greenhouse Gas Inventory estimates due to differences in equipment leakage measurements, and the frequency and magnitude of emissions from controlled and uncontrolled liquid storage tanks.[15] A study of 15 aerial campaigns integrating one million site measurements from regions accounting for 52% of US oil and 29% of gas production found weighted average emissions roughly three times the national government inventory.[16] EDF's `Methane Air' Study conducted using specially equipped jet aircraft, measuring emissions from regions accounting for 70% of onshore contiguous U.S. oil and gas production, found US emissions were over four times higher than EPA estimates and eight times greater than industry targets.[17]

In relation to LNG, US studies tend to be polarised between the industry and academics/NGOs, and between pro- and anti-LNG export views. The leading proponent of negative views is Robert Howarth who has become a scourge of the US natural gas and LNG community. He first drew attention to the importance of methane emissions in 2011, concluding that emissions from US shale gas were `at least 30% more than and perhaps twice as great as those from conventional gas'.[18] Since then, his published research has concluded that US natural gas production, US LNG exports and blue hydrogen (hydrogen produced from natural gas) in the US have higher GHG emissions than coal, and can make no contribution to the energy transition.[19]

These (and other) studies raise several inter-related problems:

- Data availability has increased enormously in the United States and Canada, but availability elsewhere is far more limited or completely absent.

[14] The seminal work which created a major impetus for other studies was Alvarez et al (2018).
[15] Rutherford et al (2021).
[16] Sherwin et al (2024).
[17] Environmental Defence Fund (2024).
[18] Howarth et al (2011).
[19] Howarth (2014), Howarth (2022), Howarth (2024), Howarth and Jacobsen (2021).

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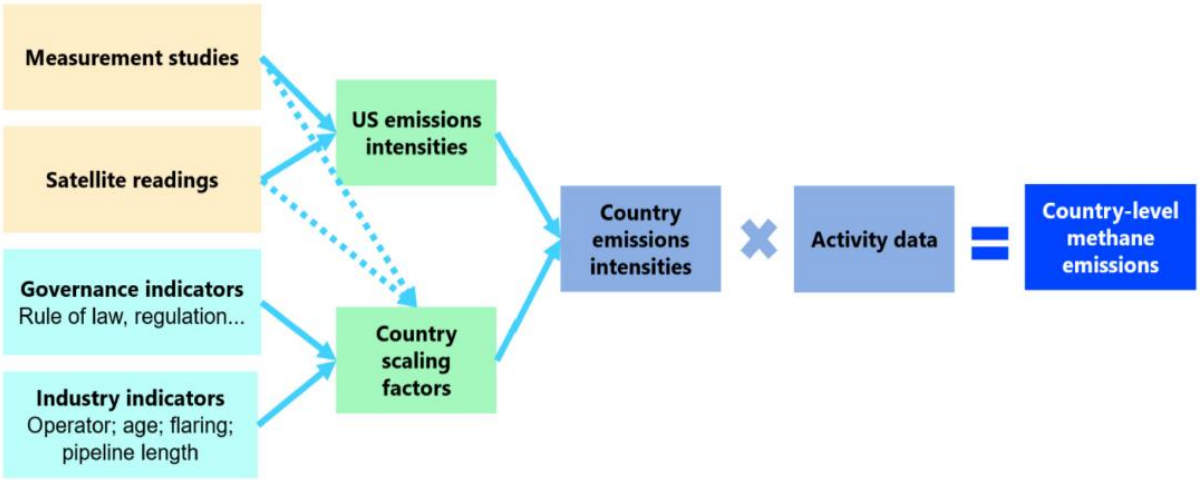
- Lack of specificity as to how much of the emissions from the full supply chain have been measured or estimated using default emission factors, which methodologies or models have been used, and (if reported in CO2 equivalent) how data are being reported in terms of time horizons and emission factors.
- Uncertainty as to whether data has been independently verified and if so using which methods and methodologies, and whether verifiers (or certifiers) were accredited as being technically qualified.

3.2 Methodologies

The IEA Methane Tracker

Section 2 of this paper used the IEA Methane Tracker database (Tables 1 and 2) which is the only current public domain dataset which includes all countries and substantial granularity on emissions from different energy sub-sectors. But it is important to understand the methodology behind the Tracker data shown in Figure 1 and Table 1.

Figure 3: IEA methodology for estimating methane emissions from oil and gas operations



Source: IEA (2024c), Figure 1, p.6

The Tracker methodology is based on a combination of measurements and estimates from ground level and satellite information which are translated into country scaling factors (informed by government and industry indicators from individual countries). These factors and US emission intensities are then converted into national emission intensities which, multiplied by activity data, provide the country-level emission estimates.[20] The Tracker estimates are therefore highly dependent on US emission intensities and the country scaling assumptions derived from them.

> `*This scaling is based upon a range of auxiliary country-specific data. For the upstream emission intensities, the scaling is based on the age of infrastructure, the type of operator within each country (namely international oil companies, independent companies or national oil companies) and average flaring intensity…For downstream emission intensities, country specific scaling factors were based on the extent of pipeline networks and oil refining capacity and utilisation'.*[21]

[20] Appendix 1, Tables A1 and B1 show the US sources and intensities on which scaling factors are based and how these were applied to nine leading global LNG exporting countries.
[21] IEA (2024), p.6.

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The methodology raises questions about the extent to which this data should be relied upon, specifically:

- whether methane intensities of subsectors in an oil and gas sector as large and diverse as the US can be generalised to a single figure.
- how emission estimates for other countries based on US data are interpreted using quantitative but also qualitative judgements.
- Whether the data can or should be used to estimate emissions from a specific project or supply chain.

A specific question which the methodology raises is whether the very high venting intensities for both oil and gas upstream onshore and offshore, which account for 65% of global emissions in Table 1, are a typical reflection of conditions outside the US, taking into account the extremely high venting intensity numbers from unconventional oil and gas production which is not produced in significant volumes outside North America.[22]

Having noted these reservations, the methodology is transparent and there are no recorded objections from governments claiming that the data is wrong or over-stated.[23] The IEA Tracker is the only comprehensive public domain source of current methane emissions from the oil and natural gas sectors in the majority of countries which produces comparable data using a common methodology.[24] The World Bank's Global Gas Flaring Tracker Report provides the same service for emissions from flaring.[25] Methane emissions data are available from the UNFCCC for all countries, but can be substantial numbers of years – and in some cases decades – out of date with no indication of how they were derived.[26]

Measurement of emissions has generally been referred to as `bottom up' – ie measured at an individual source, and top-down ie measured aerially. But these must now be combined with the OGMP 2.0 (see Section 5) formulation of `source level' and `site level' noting that:[27]

> *`Sometimes the term "top-down" is used to describe "site-level" measurements, which is interpreted by some to mean that a technology should be applied from a vantage point that is physically above an asset. This is not the case. "Site-level" measurements are simply measurements that can capture emissions at a site or facility level.'*

Reconciliation between source level and site level data is key to the credibility of emission estimates and an important part of achieving OGMP 2.0 Level 5 reporting (see Section 5). The two data sets will not coincide exactly and, as important as the data will be, neither will the description of the methodologies employed to arrive at these estimates. For granularity at the level of all material operating assets, an acceptable degree of uncertainty will need to be established. The need for public domain asset-level detail of emissions raises the issue of confidentiality which is discussed in Section 9.

3.3 Satellite development

Figure 4 shows how different measurement techniques compare in relation to the geographical and coverage limits. On the left side of the chart are bottom-up site measurement techniques ranging from handheld devices to low level top-down measurements such as Unmanned Aerial Vehicles (UAVs or drones) and low flying aircraft which can detect emissions at low concentration levels but over limited

[22] Argentina is an exception, but US unconventional oil and gas production far exceeds that of any other country.
[23] The only objection of which this author is aware was from Norway which provided documentation of lower emissions resulting in changes to the Tracker data.
[24] The emphases here are on `comprehensive' and `current' with coverage of every country regularly updated to the current year.
[25] World Bank (2024).
[26] https://di.unfccc.int/time_series
[27] FAQ – OGMP 2.0 Top-down and bottom-up are spatially descriptive but have been adjusted by OGMP (see Section 5) to `source level' and `site level' to better reflect oil and gas industry realities.

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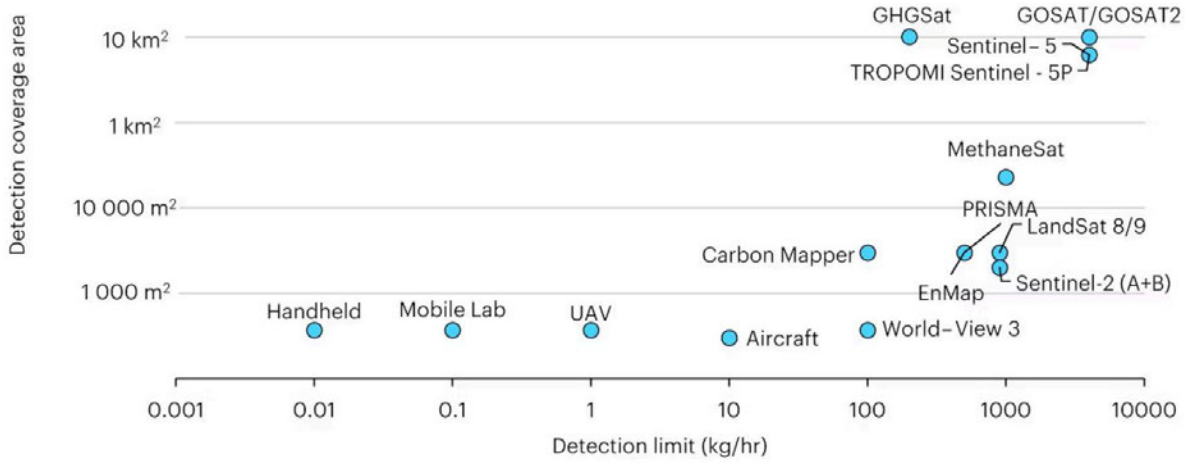
geographical areas. On the right side of the chart are satellites which provide emission estimates over wider areas but detect large emission sources with varying time periods between overflights. An important element is the visit frequency i.e. the time gap between satellite observations.

Figure 4: Coverage Area and Emissions Limit for Methane Detection Devices



Source: IEA (2024d)

Since 2020, methane emission estimates have been revolutionised by the use of high altitude satellites which can identify emissions on a periodic basis as they circle the globe.[28] These have the advantage of not needing source- or site-level access to oil and gas assets which their owners and operators may be unwilling to grant.[29] However, they also have limitations for assets which are located offshore, in snow-covered regions, in tropical regions, dense forests and anywhere with substantial cloud cover. These limitations vary between complete inability to identify emissions with any accuracy, to limited time periods (e.g. seasons) when they are available. This is particularly important in relation to emissions from flaring where readings tend to be taken during the hours of darkness with longer periods in winter than in summer. Satellite detection is continuously improving but where greater accuracy is required, collection of data from low flying aircraft is increasingly being used.

There is significant difference between satellites which detect very large emissions – so-called `super-emitters' (in excess of 100kg/hr) and those able to detect much smaller emissions with a high degree of accuracy attributable to a particular asset. As many satellite data providers are commercial companies, data may only be available on a commercial basis. The launch of EDF's MethaneSAT and Carbon Mapper's Tanager-1 in 2024, and in 2025 the GOSAT-GW promise higher spatial resolution of sites with publicly available data.[30] However, all satellite data depend not only on accurate observations but also on algorithms which convert atmospheric methane concentrations into emission estimates. As regulations in Europe raise the possibility of imposing financial penalties on fossil fuel production and delivery to markets with emission intensities in excess of certain limits, the accuracy of these estimates will become increasingly important.

In general, we should expect continuous improvements in satellite data, for both large and small emission sources, but reconciliation with source- and site-level data will be required for accurate estimates. The assertion that emitters will have `nowhere to hide' raises the important issue of action

[28] Vollrath et al (2024), Figure 6 shows that significant numbers of studies using satellite data only began to appear in the early 2020s.
[29] North America is unique in that the majority of oil and gas production assets are onshore in locations which can be accessed by road and drone and aircraft overflights. In many countries accessibility of assets and permission from political and security authorities may be substantial obstacles to measurement studies.
[30] A study of methane emissions from oil and gas in Continental US in 2021 found that 70% originated from well sites emitting less than 100kg/hour (i.e. not `super-emitters), and this finding was similar across eight major basins. Williams et al (2025).

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that can be taken against those who ignore or deny emissions even when alerted to their existence.[31] Even when substantial emissions are identified, the International Methane Emissions Observatory (IMEO – see Section 5) has found responses to its Methane Alert and Response System (MARS) very disappointing. Over the 1200 emission notifications that MARS delivered to governments and companies in the period January 2023-September 2024, fewer than half were acknowledged by recipients. Of those, only 15 (just over 1% of the total) responses provided information about the source of the emissions and whether any mitigation action was considered or taken.[32]

3.4 Metrics

Global Warming Potential (GWP) and other metrics

Two major analytical and policy issues impact how methane emissions are reported in relation to carbon dioxide equivalents. First, which time horizon should be chosen to measure the impact of methane in terms of its equivalence to CO2. Second, which metric should be used for this comparison. Methane is a much more potent greenhouse gas than carbon dioxide, although it has a much shorter atmospheric life. Emissions are very often reported in terms of carbon dioxide equivalent (CO2e), with the most common metric, established in the IPCC Assessment Reports (ARs), being the global warming potential (GWP) of methane.

IPCC ARs progressively raised the GWP for methane to 28 over a 100-year, and 84 over a 20-year, horizon in AR5 published in 2014; but adding climate feedback mechanisms and oxidation, these figures increase to 36 and 87.15. AR6, published in 2021, raised the GWP of methane to 29.8 over a 100-year horizon (GWP-100) but reduced the 20-year horizon (GWP-20) factor to 82.5.[33] With the adoption of the COP 21 (Paris Agreement), and particularly of net zero, targets for 2050 there is a convincing case for taking a 20–30-year, rather than a 100-year horizon. A time horizon of 2050 would produce a 2.5-2.8-fold increase in CO2 equivalent emissions for methane compared with a 100-year horizon, and would substantially impact emission calculations and therefore the achievement of targets. The original agreement by the Conference of Parties (COP) did not rule out the use of shorter horizons, but 100 years is the standard which is near-universally used by governments and companies, many of which are also still using a GWP100 of 25 from AR4.[34]

The importance of the AR GWP and time horizon metrics is demonstrated in a study which used a dataset from CDP (formerly the Carbon Disclosure Project) for the period 2014-23 taking data over that period from the 371-2072 companies which explicitly reported methane emissions and used an AR metric.[35] Only around 20% of companies disclosed methane emissions and 82-90% used a 100-year time horizon sourced from older AR metrics which had a substantial impact on total emissions. The study found that over the 10 year period using a harmonized GWP for a 100-year horizon, Scope 1 methane emissions would have been 170MtCO2e higher than reported, and using a 20-year horizon that figure would have risen to 3300MtCO2e.

The second issue is which of the different metrics could (or should) be used as alternatives to GWP. There are at least 15 different climate metrics related to global methane impacts with different values over three different time frames including: global temperature potential (used by a number of different sources), sea level rise potential, precipitation change potential, cost potential, and damage potential.[36] In addition, GWP* has been advanced as superior to GWP but does not seem to have been widely

[31] Elkind et al (2020). Also attributed to former US Climate Envoy John Kerry at COP 29: `With better tracking, you can run but you can't hide….We'll be able to see who is cutting their emissions and who isn't,'. https://www.catf.us/2023/12/turning-pledges-action-cop28-global-methane-pledge-ministerial/

[32] UNEP (2024a), p.21. Alongside this rather negative finding the same source includes positive examples of governments and companies taking action after receiving alerts.

[33] IPCC (2021), Chapter 7, Table 7.15, p.1017. GWP-20 has a confidence factor of +/–11, the GWP-100 confidence factor is +/–25.8. Note these are metrics for fossil gas, non-fossil gas metrics are slightly smaller for both time horizons.

[34] Although AR5 established a GWP of 28, further increased to 29.8 in AR6, this has not been formally agreed by governments.

[35] Cenci and Biffis (2025).

[36] Balcombe et al. (2018), Table 3.

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adopted.[37] GWP aside, the most widely used metric is global temperature potential (GTP) which is included in the IPCC assessment reports. GTP100 for fossil methane is shown as 7.5 +/- 2.9 in AR6, which is around a quarter of the GWP100 figure.[38] However, given that IPCC governments have struggled to update their data in line with successive Assessment Report findings, it seems unlikely that they will be persuaded to move their standard metric away from GWP.

Methane Intensity

There are two types of methane-related mitigation targets: absolute (e.g. Global Methane Pledge) and intensity (emissions per unit of output).[39] They both have advantages and disadvantages. Absolute targets provide greater certainty as to the achieved environmental outcomes, but require a robust baseline, against which to measure mitigation progress. Intensity-based targets on the other hand enable straightforward comparisons across operators, but do not guarantee that environmental benefits are achieved, since intensity can increase or decrease without any changes to emissions if production increases or decreases. Another issue with intensity-type targets is that there are different ways of calculating and presenting (e.g. using simple calculations or more sophisticated Life Cycle Assessment models), which are not equivalent, since they lead to different conclusions, e.g. when comparing the intensity of dry and associated gas wells.

With the need to draw comparisons between assets, different certification organisations created different rankings of intensities of oil and gas producing countries, regions (basins) and projects, which led to more confusion than clarity.

3.5 Certification schemes, verification and standards

Certification Schemes

Natural gas certification schemes originated and remain focussed on the North American (particularly the US) market, where the gas in question is known as `certified', `differentiated' and `responsibly sourced' gas, but also operate internationally.[40] They were created as a response to ESG concerns from investors and to allow companies to monetise emission reduction efforts and differentiate themselves from competitors. The three best known certification schemes are operated by Equitable Origin, MiQ and Project Canary. These companies claim to have certified significant shares of US gas production.[41] A comparison of the services offered by these three companies in relation to supply chain coverage, certification processes and periods is shown in Appendix 2 Table A.[42]

In the context of this paper, MiQ is the only company with supply chain coverage which includes offshore production and LNG, and the only company which requires direct measurement of emissions. Project Canary is the only company which does not employ a third party (verification) assessment.

Appendix 2 Table B shows the grade levels for the three main certification schemes. All three companies define emissions in terms of grades with letters or colours: A-C (Equitable Origin), A-F (MiQ) and platinum/gold/silver-rated (Project Canary). These bespoke metrics are then related to intensity percentages and various other metrics of company practice. None provide public domain emissions data in physical units of methane per unit of production, methodology of measurement (or estimation) for specific assets, or detailed supply chain boundaries in relation to the specific assets which have been certified.

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[37] Lynch et al. (2020). For a discussion of the merits of GWP* see House of Lords (2024), paras 83-104.
[38] IPCC (2021), Chapter 7, Table 7.15, p.1017.
[39] Olczak (2025).
[40] Some European companies have had North American and European assets certified. Handler and Ayaburi (2024), National Petroleum Council (Forthcoming).
[41] As of November 2024 MiQ reported that it was certifying 5% of global gas supply or 24bcf/d Home - MiQ ; Equitable Origin reported that it was certifying `approximately 15% or over 15bcf/d of North American gas production', Home - Energy Standards ;
[42] ERM (2023). Other comparisons can be found in Highwood Emissions Management (2023) and Garg et al (2023).

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Commentaries on certification schemes range from an upbeat summary of progress and future prospects:

> `*The differentiated gas market is positioned for growth as energy and industrial buyers focus on the environmental attributes of their purchased gas and as systems are put in place to track these environmental attributes*.'[43]

To the National Petroleum Council's qualified acceptance with recommendations:

> `*While certified gas markets and price formation around certified natural gas are still developing they are limited in scale, without a price premium, and lack uniform measurement-based criteria to justify differentiation…The NPC recommends standard-setting bodies develop mechanisms to enable utilities, gas marketers and consumers of natural gas to differentiate lower GHG intensity natural gas, specifically providing recognised standards, frameworks and metrics for buyers and sellers to incorporate into gas transaction contracts. These standards should be measurement-based where feasible.'*[44]

To the Environmental Defence Fund's somewhat sceptical view:

> *"Few companies currently do the kind of robust measurement-based accurate monitoring and reporting necessary to sustain a claim that the gas they produce is fundamentally cleaner than the industry average, and none we're aware of do so with the kind of transparency required to enable independent verification that the so called certified gas is really worth the premium price….With no uniform and mandatory standards for certification, it is critical that those seeking to differentiate their natural gas based on methane intensity provide complete transparency around their criteria and methodologies.*
>
> *Without strong and uniform standards on the measurement and verification of emissions from any particular supply chain, it is impossible to reach reliable conclusions about the climate impact of purportedly differentiated natural gas. This creates ample opportunity for customer confusion or misinformation…Companies can choose to seek certification of better performing facilities while leaving older, leakier facilities outside of the analysis. Thus, certification doesn't accurately depict the practices or overall emissions of the operator…Third-party certification is no substitute for comprehensive nationwide standards to reduce industry methane emissions — particularly because federal requirements can apply to all oil and gas facilities, not just those cherry-picked for voluntary certification programs."*[45]

At the extreme negative end of the critical spectrum, Oil Change International dismissed the services of one specific provider as a `certified disaster' and `certified gaslighting', receiving a measured response from the company at which these accusations were levelled.[46]

And perhaps most devastating, a letter from seven US Senators to the Federal Trade Commission:[47]

> `*Gas producers sometimes publicly describe their product as "certified," "responsible," or "differentiated" and market it as a climate-friendly fossil fuel. But too often these green claims are false or misleading due to opaque methodology, unreliable technology, and unacknowledged downstream climate effects of gas combustion…This greenwashing scheme demands an FTC investigation and the express inclusion of guidance for third-party natural gas certification regimes in revised FTC Green Guides. These steps will help prevent gas producers and certification companies from misleading and ripping off consumers, harming the environment, and hindering progress on climate change.'*

[43] Handler and Ayaburi (2024).
[44] National Petroleum Council (2024b), Finding 19, Recommendation 18, p.81.
[45] Murphy (2023).
[46] Oil Change International (2023) and (2024). Project Canary (2024).
[47] Markey et al (2024).

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Certification schemes have been brought together in the creation of `certified natural gas registries' which are registry and marketplace platforms where certified natural gas certificates can be stored, tracked and exchanged. The four most active registries at the time of writing were CG Hub, EarnDLT, MiQ Digital, and Xpansiv Digital Fuels.[48] The aim is for certified natural gas to develop into a market with trading capability. An obstacle to that development is the lack of transparency surrounding how emissions are calibrated between the major schemes. Another issue is uncertainty about whether there will be a commercial premium attached to certified low GHG gas nationally and internationally, which may only become clear when regulation and legislation, currently under development, is implemented (see Section 6).

Verification and Standards

A verification statement from an accredited third party is required by most certifiers and forms part of the EU Methane Regulation requirements. Verification standards are generally expressed in terms of `reasonable assurance' and `limited assurance'. The difference between the two is explained as follows:

> *`..a limited assurance engagement is..framed in a negative sense: "Based on the procedures performed, nothing came to our attention to indicate that the management assertion on XYZ is materially misstated." In contrast, a reasonable assurance conclusion would be formed in a positive sense, i.e.: "Based on the procedures performed, in our opinion, the management assertion on XYZ is reasonably stated.'*[49]

The EU Methane Regulation states:

> *`If, following the verifier's assessment, the verifier concludes with reasonable assurance that the emissions report complies with the requirements of this Regulation, the verifier shall issue a verification statement attesting the conformity of the emissions report and specifying the verification activities carried out.*
>
> *The verifier shall issue a verification statement only where reliable, credible and accurate data and information allow for methane emissions to be determined with a reasonable degree of certainty and provided that the reported data is coherent with the estimated data, complete and consistent.'*[50]

Discussions with oil and gas companies suggest that limited assurance is a desktop exercise carried out using records from a very limited number of sites. Reasonable assurance will involve visits to a larger number of sites over a longer period. Notably neither standard requires verifiers to make their own measurements for comparison with those of the asset owner.

Summarising the problems of MRV and data collection, it is clear that ground-level measurements can only take place with the agreement of the asset-owner(s) and probably require significant financial resources to be verified on any ongoing basis.[51] This tends to result in relying on measurement data from asset owners, the credibility of which is likely to be questioned by independent researchers. This in turn lays stress on the independence and technical competence of verifiers, as set out in the EU Methane Regulation. To the extent that verified site level data are not available, satellite data are the main source which can be obtained independent of asset owners. Overflight and drones can also be used in countries where these are not restricted by authorities on security grounds.

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[48] National Petroleum Council (forthcoming). But there are many other organisations offering tracing and registry services including Context Labs, Fiùtur, Attributes and Agora.

[49] Limited assurance vs reasonable assurance | ICAEW The QatarEnergy Greenhouse Gas Verification Statement for the company's Scope 1 and Scope 2 emissions states that these `are verified to a reasonable level of assurance..the data quality management system, data quality and completeness of reporting are of sufficient quality when assessed against the verification criteria, not to have resulted in a material error.' QatarEnergy (2024), p.121. See Section 7.2 for a different definition of these levels.

[50] European Commission (2024), Article 8(4).

[51] `Significant' in this context could mean millions (or even tens of millions) of dollars depending on the size of the assets. This may be significant for small operators, but not for international companies or LNG exporters with multi-billion dollar assets.

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Thus `Competent Authorities' (regulators appointed by Member States) which are either unable to access source and site level data, or believe data provided by asset owners are unreliable, will be forced to rely on satellite data despite its limitations noted above. This may put pressure on asset owners to cooperate with the MRV requirements of regulators, or being required to accept satellite estimates.[52] Given the variability of emissions over time, it may be necessary for Competent Authorities to define more precisely the type and frequency of measurements which will be deemed acceptable. Certification companies could act as `verifiers' in the context which that term is used in the EU Methane Regulation but would need to be much more transparent about asset-related data, verification methodologies, and divergence from estimates provided by the asset holder. Transparency requirements of the EU Methane Regulation are discussed below (Section 9).

4. Intergovernmental Methane Initiatives

The 2020s have seen a proliferation of international, and national, governmental and corporate initiatives to address methane emissions. This section provides an overview of the main general initiatives (a more complete list can be found in Appendix 3), some of which are specifically targeted at natural gas and LNG sectors. In each case, only the major points are included here with more detail available in the Appendices.

4.1 The Global Methane Pledge

The Global Methane Pledge is a landmark inter-governmental initiative launched at COP26 in 2021 by the European Union and the United States. By the end of 2024 the Pledge had 160 participants, 60% more than at its creation, although important countries such as China, Russia, India, Iran, Algeria and South Africa were not signatories.[53] The main commitments to which signatories are committed are:[54]

- to collectively reduce global anthropogenic methane emissions across all sectors by at least 30 percent below 2020 levels by 2030.
- to take comprehensive domestic actions to achieve that target, focusing on standards to achieve all feasible reductions in the energy and waste sectors and seeking abatement of agricultural emissions through technology innovation as well as incentives and partnerships with farmers.
- to mov[e] towards using the highest tier IPCC good practice inventory methodologies, consistent with IPCC guidance, with particular focus on high emission sources, in order to quantify methane emissions; as well as working individually and cooperatively to continuously improve the accuracy, transparency, consistency, comparability, and completeness of national greenhouse gas inventory reporting under the UNFCCC and Paris Agreement, and to provide greater transparency in key sectors.
- to maintain up-to-date, transparent, and publicly available information on our policies and commitments.
- to support existing international methane emission reduction initiatives, such as those of the Climate and Clean Air Coalition, the Global Methane Initiative, and the relevant work of the United Nations Environment Programme, including the International Methane Emissions Observatory (IMEO – see Section 5), to advance technical and policy work that will serve to underpin Participants' domestic actions.

[52] The EU Methane Regulation requires importers to obtain emissions data from domestic (EU) and external fossil fuel suppliers which, if they are either unable to achieve or if such data is deemed unsatisfactory by their Competent Authorities (regulators), may be subject to penalties (fines or taxes) in relation to methane intensity standards (see Sections 6 and 7).
[53] Global Methane Pledge (2024).
[54] The full text of the Pledge is at Appendix 4.

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4.2 The G7

Meetings of the leaders and energy ministers in 2023[55] and particularly in 2024, recognised the importance of methane emissions:

> *`Recognizing that cutting methane emissions from fossil fuel operations by means of already existing technologies is largely feasible and cost effective for oil and gas operations, we will intensify efforts to tackle methane emissions in line with the global reduction level of at least 35 percent in methane emissions by 2035. We commit to pursue a collective effort towards a 75 per cent reduction in global methane emissions from fossil fuels, including by reducing the methane emissions intensity of oil and gas operations by 2030, through developing a robust methodology and use of measure data, and work with non-G7 oil and gas producing countries particularly in Africa, to deliver deep cuts to methane emissions..'*[56]

> *`We highlight that G7 countries are putting in place measures to collectively deliver reductions in methane emissions across all sectors, including energy, waste, and agriculture, aligned with the Global Methane Pledge's collective goal of at least 30 percent reduction by 2030.'*[57]

At the 2023 GMP Ministerial more than a billion dollars of additional funding was announced including initiatives under the Methane Finance Sprint.[58] But a major problem with the Pledge is the generality of its scope including all methane emitting sectors and 160 country participants, which makes it impossible to determine what has been achieved since its creation in 2021. While the Pledge does commit participants to `comprehensive domestic actions' to achieve the 30% target, there is no way to monitor the degree of progress towards reducing national methane emissions in the period 2021-24, with most evidence suggesting that global emissions are still increasing.[59]

4.3 Joint US-EU Energy Council

Following the Russian invasion of Ukraine and the resulting natural gas crisis, the US and EU set up a Joint US-EU Energy Council which specifically targeted methane:

> *`The Council intends to continue advancing the reduction of global methane emissions in line with the Global Methane Pledge and the Joint Declaration from Energy Importers and Exporters on Reducing Greenhouse Gas Emissions from Fossil Fuels. The Council recognized the International Methane Emissions Observatory as a key independent methane emissions data collector and verifier, and the Council recognized the need to develop effective global schemes to limit leakage, venting, and flaring, such as the mutually beneficial You Collect We Buy.'*[60]

4.4 International Working Group on MMRV

International Working Group to Establish Universal Approach to Measuring, Monitoring, Reporting, and Verifying Greenhouse Gas Emissions Across the Natural Gas Supply Chain.

In November 2023 The U.S. Department of Energy's (DOE) announced an international working group to advance comparable and reliable information about greenhouse gas emissions across the natural gas supply chain to drive global emissions reductions.[61] In October 2024 the group had 21 participating

[55] G7 (2023).
[56] G7 (2024).
[57] The full text of the 2024 G7 Climate, Energy and Environment Ministers' Communique relating to methane can be found at Appendix 5.
[58] Global Methane Pledge (2023).
[59] It is possible that reported emissions are increasing as measurements replace standard emission factors which have tended to underestimate true levels. Also countries where fossil fuel production is increasing may be achieving declining methane intensity, but an increase in absolute emission levels.
[60] Joint Statement on the US-EU Energy Council (2023), para 18. `You collect we buy' was replaced at COP29 by the Methane Abatement Partnership Roadmap (see Section 6).
[61] MMRV Framework (2023).

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countries with the aim of developing a consistent framework for the measurement, monitoring, reporting, and verification (MMRV) of methane, carbon dioxide and nitrous oxide emissions that occur during the production, processing, transmission, liquefaction, transport, and distribution of natural gas.[62]

The Group has two overarching goals:

- to provide emissions and operating data at a level of granularity needed to enable calculation of the emissions intensity of delivered natural gas.
- To provide emission and operating data and supplemental information needed to provide a Data Quality (DQ) score of the reported data.

And two main objectives:

- to provide flexibility by leveraging the use of existing methods (i.e., protocols) that companies are already using to collect and report emissions and operating data for other but similar purposes;
- to develop the requirements for reporting emissions and operating data in a manner that ensures an accurate assessment of data quality can be conducted and provided to the buyer.

With the arrival of the Trump Administration in January 2025, continued US participation in the Council and the Working Group became unclear.

5. United Nations and Corporate Initiatives

5.1 The Oil and Gas Methane Partnership (OGMP) 2.0 and The International Methane Emissions Observatory (IMEO)

The Oil and Gas Methane Partnership (OGMP) 2.0 of the UN Climate and Clean Air Coalition is `a multi-stakeholder partnership that brings together oil and gas companies as well as international organisations, governments and non-governmental organizations to improve the accuracy and transparency of reporting of methane emissions'. OGMP 2.0 members account for around 42% of global oil and gas production, 80% of LNG flows and over 20% of global gas storage capacity.[63] In October 2024, OGMP had 63 members from upstream companies, and 78 members from mid- and downstream companies.[64] 80% of the members are from North America (mostly the US) and Europe. There were five members from the Middle East, eight from South America, four from Caspian and Central Asian countries, and notably only four from Asia (one each from China, Japan, Indonesia and Thailand), two from Africa (both from Nigeria) and one from Australia.[65]

Figure 5 shows the five different reporting levels. Level 5, which requires source- and site-level reporting and reconciliation, is regarded as the OGMP Gold Standard. Levels 4 and 5 informed the text of the EU Methane Regulation but the latter includes independent verification which OGMP does not. The levels of reporting represent a continuum from general categories based on generic emission factors through source-level emissions to site-level measurements.

[62] The text and participants can be found in Appendix 6.
[63] UNEP (2024a), p.3
[64] Membership | The Oil & Gas Methane Partnership 2.0
[65] UNEP (2024a), Figure 3, p.3 shows the share of OGMP 2.0 members' share of production by region.

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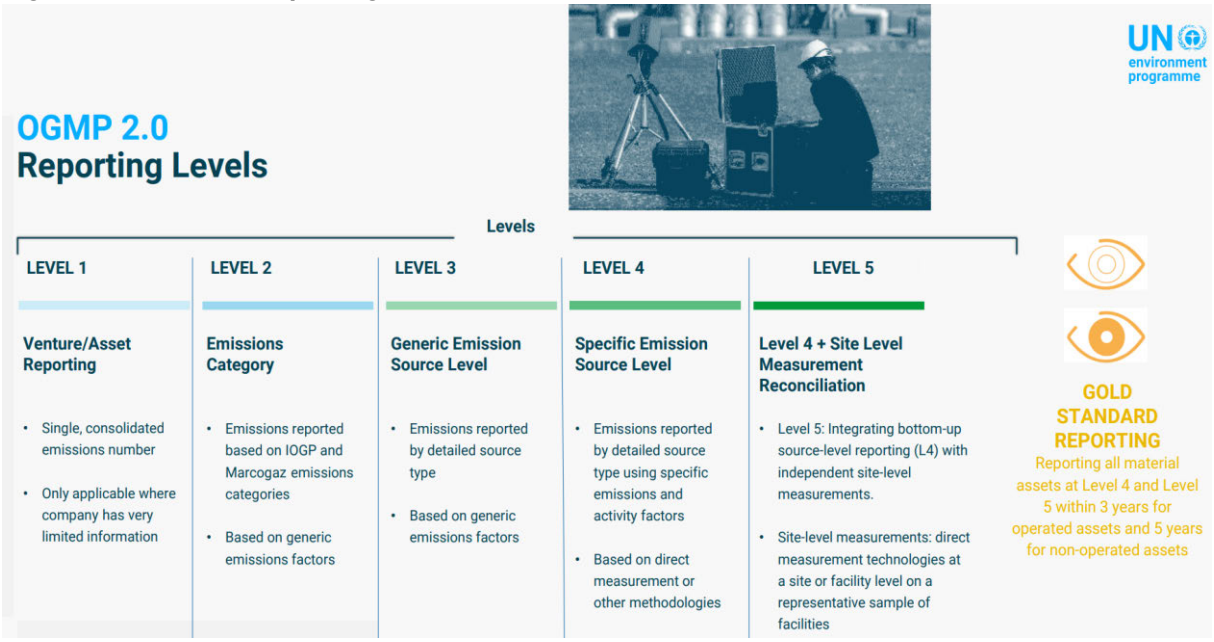
Figure 5: OGMP 2.0 Reporting Levels



Source: OGMP (2024).

The International Methane Emissions Observatory (IMEO), part of the United Nations Environment Programme, collects data from OGMP 2.0 as well as satellites via its Methane Alert and Response System (MARS), other scientific sources and national emissions inventories.[66] It tracks and publishes corporate data from OGMP 2.0, including levels attained by companies, on an annual basis.[67] It is therefore highly likely that the EU Methane Regulation's transparency database (see Section 6) will rely on IMEO data. The IMEO makes an important distinction between `Gold Standard Pathway' and `Gold Standard Reporting' where companies are measure across all operated and non-operated assets. In 2024, out of 122 members, 56 companies were recognised with Gold Standard Reporting and 41 with Gold Standard Pathway [68]

The definition of `reconciliation` in the context of Level 5 is complex and explained by OGMP as follows:[69]

> *`Level 5 represents the reconciliation of source-level inventories (Level 4) with independent site-level measurements. Site-level measurements complement – rather than replace – source-level estimates, and the process of reconciliation helps improve accuracy, thoroughness and confidence in reported emissions. Site-level measurements, alone, are typically difficult to extrapolate to an annual reporting basis, and more importantly, source-level estimates are necessary to guide and prioritize mitigation activities. Site-level contributes to ensuring that all sources of methane emissions are identified, quantified, reported and included in the mitigation strategy of the company. Reconciliation is an iterative process of investigation, year over year, and should not be thought of as a one-off comparison of two independent values.'*

[66] UNEP (2024), p.ix.
[67] UNEP (2021), UNEP (2022), UNEP (2023), UNEP (2024a). For 2021-23, the corporate data was included within the earlier reports but was published separately in 2024.
[68] Gold Standard Reporting is based on measurements reconciled between source and site level. There is considerable variation between companies on the percentage of their assets that meet Level 5. Generally percentages for non-operated assets are much lower than operated. UNEP (2024a), pp.1-2.
[69] OGMP (2022), p.2.

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The complexity of the reconciliation process may account for the fact that IMEO data shows that aggregating the first three years of OGMP 2.0 reporting, less than 10% of more than 2 million tons of methane emissions was assessed as meeting Level 5 standards.[70]

There is a significant lack of clarity as to how companies are graded by OGMP especially in relation to Levels 4 and 5. OGMP 2.0 is a reporting framework[71] containing the elements which need to be considered for each Level. In addition, Section 4.5 includes the concept of `materiality'. All assets that account for 95% of total emissions from a given operator are considered material. This focusses attention on measurement and reconciliation of emissions per asset, which introduces an element of subjectivity in how grades are awarded.

5.2 The Oil and Gas Climate Initiative (OGCI) and the Oil and Gas Decarbonization Charter (OGDC)

OGCI is a collective of 12 international oil and gas companies.[72] In 2018, these companies agreed to a collective target to reduce upstream methane intensity (volume of methane emissions from oil and gas operations/volume of marketed gas) from operated assets only, from 0.30% in 2017 to (0.25% (updated in 2020 to `well below 0.20%'} by 2025, and achieved an intensity of 0.14% in 2023.[73] OGCI's Aiming for Zero Methane Emissions Initiative provides `Guidance on near zero methane emissions'.[74] `Near-zero' can be interpreted in a number of ways. The OGCI figure of 0.20% methane intensity is widely quoted by a number of organisations, recalling this is a corporate (rather than a regulatory) target.

At COP28 in 2023, OGCI agreed to assist in an initiative to create the OGDC and became its Secretariat in 2024. By early 2024, OGDC had 32 national oil companies and 23 international oil companies and independents.[75] It has a wider geographical scope than similar organisations and initiatives reviewed above, as it includes companies from China and Russia. OGDC's detailed aims in relation to methane emissions and flaring are reproduced at Appendix 7, and we return to its transparency commitments in Section 9.

5.3 Zero routine flaring

The Zero Routine Flaring by 2030 initiative was launched in 2015 and `brings together governments, oil companies, and development institutions who recognize the flaring situation described above is unsustainable from a resource management and environmental perspective, and who agree to cooperate to eliminate routine flaring no later than 2030.'

`Routine flaring' is defined in the initiative as:

> *`flaring during normal oil production operations in the absence of sufficient facilities or amenable geology to re-inject the produced gas, utilize it on-site, or dispatch it to a market. Venting is not an acceptable substitute for flaring.'*[76]

By early 2025, the initiative had been endorsed by 36 governments, 59 companies and 15 development institutions which agreed that:[77]

> *`…Governments will make every effort to ensure that routine flaring at existing oil fields ends as soon as possible, and no later than 2030'.*

[70] UNEP (2024a), Figure 4, p.4.
[71] OGMP 2.0 (2020).
[72] Saudi Aramco, BP, Chevron, CNPC, ENI, Equinor, ExxonMobil, Occidental, Petrobras, Repsol, Shell and TotalEnergies.
[73] OGCI (2024a), p.11. The definition of methane intensity is methane emissions from oil and gas divided by marketed production of oil and gas.
[74] OGCI (2024b).
[75] OGDC (2025).
[76] Flaring for safety reasons is not included in the definition.
[77] World Bank (2025). For the full text of the initiative see Appendix 8.

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`Oil companies…will develop new oil fields they operate according to plans that incorporate sustainable utilization or conservation of the field's associated gas without routine flaring. Oil companies with routine flaring at existing oil fields they operate will seek to implement economically viable solutions to eliminate this legacy flaring as soon as possible, and no later than 2030.'

Half of the governments from the 10 leading LNG exporting countries, (US, Russia, Indonesia, Oman and Nigeria) have endorsed the initiative. Major LNG exporting companies which have done so are: Sonatrach (Algeria), Woodside (Australia), QatarEnergy, Petronas (Malaysia), PDO (Oman) and NNPC (Nigeria); as well as all of the international oil company LNG exporters.

In September 2024, the IEA (together with UNEP and EDF) published a document entitled `Turning Pledges into Progress' which highlighted that the industry was a long way from fulfilling their pledges under OGDC, near zero methane and zero routine flaring by 2030.[78]

5.4 Other Initiatives

There are a number of other significant methane initiatives which, for reasons of space, will only be noted briefly here.

The Methane Guiding Principles (MGP) group was created in 2017. It has 46 members including major national and international oil and gas companies from different parts of the supply chain, international organisations, NGOs and civil society groups.[79] Its five guiding principles are:[80]

- Continually reduce methane emissions.
- Advance strong performance across the gas supply chain.
- Improve accuracy of methane emissions data.
- Advocate sound policy and regulations on methane emissions.
- Increase transparency.

MGP has a number of outreach activities and issues best practice guides for: flaring, venting, equipment leaks, pneumatic devices, operational repairs, transmission, storage, LNG terminals, distribution; identification, detection, measurement and quantification.[81]

The Global Methane Initiative (GMI), founded in 2004, is an international public-private partnership committed to reducing methane emissions and capturing methane as a valuable energy source. GMI has 48 country members, numerous key strategic partners, and hundreds of private sector and multilateral organizations collaborating to take action on methane around the world. GMI advances information sharing, promotes ambitious activities, trains stakeholders, and builds capacity to abate methane.[82]

Veritas is the US GTI Energy's Methane Emissions Measurement and Verification Initiative. It provides comparable methane emissions measurement and accelerating actions that reduce methane emissions reductions. It has standardized, science-based, technology-neutral, and measurement-informed protocols which were built to assemble methane emissions inventories that are verified by direct field measurements. The technical protocols which calculate methane emissions for natural gas systems from production through distribution and LNG are available online on the Veritas website.[83]

[78] IEA (2024e).
[79] Collaborating To Drive Change | MGP Members
[80] https://methaneguidingprinciples.org/about/frequently-asked-questions/
[81] https://methaneguidingprinciples.org/resources/methane-guiding-principles-2024-best-practice-guides/
[82] Global Methane Initiative
[83] veritas.gti.energy

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One Future is a US coalition of 49 member companies representing more than 39% of the US natural gas supply chain, with the target of reducing methane emissions to less than 1% by 2025. The coalition surpassed this target and, in 2023, its members achieved a collective methane intensity of 0.331%.[84]

6. US and EU Legislation and Regulation

Over the past three years the US and the European Union have passed major legislation and regulation to control and reduce methane emissions. The documentation is extremely complex and only the main points are listed here with references for those wishing to access more detail.

6.1 United States: the Biden Administration regulations and the potential impact of the Trump Administration

Under the Biden Administration, five key US methane regulations were established dealing with emissions control and reduction:[85]

The Environmental Protection Agency (EPA) methane standards apply to:[86]

- New (constructed, modified or reconstructed after December 6, 2022) and existing onshore oil and gas production and processing facilities and natural gas transmission (including compressor stations) and storage facilities.[87] New facilities must meet the requirements by May 7, 2024, with an additional 1-2 years to phase out certain types of equipment and routine flaring. For existing facilities (constructed before December 6, 2022) requirements will depend on state plans approved by EPA.
- All operators are required to apply leak detection and repair (LDAR) measures using technologies that need to be approved by EPA, and with a frequency which depends on the type of equipment and technology.
- Routine flaring must be eliminated for all but exceptional cases (where flaring efficiency of 95% must be verified).
- All existing process controllers and pumps (which have been a major source of emissions) must be transitioned to alternatives with zero emission methane and volatile organic compounds.
- A new `super-emitter' program which requires reporting of events which result in a release of more than 100kg/hour and at individual well or other facility.
- These standards will be harmonized with the Methane Emissions Reduction Program.

The Methane Emissions Reduction Program (MERP).[88] The requirements of the Inflation Reduction Act (IRA) caused EPA to update the requirements for the oil and gas sector under Subpart W of the Greenhouse Gas Reporting Program (GHGRP).[89] Subpart W reporting applies to onshore and offshore oil and gas production (and associated) facilities that emit more than 25,000 tons of CO2e (equivalent to 1000 tons of methane at a GWP of 25) annually. From the start of 2025, reporting must be on the basis of direct measurement, not engineering estimates and an operator's Waste Emissions Charge (WEC) for that year will be assessed in March 2026.[90] The WEC will apply to each ton of methane which an operator emits above threshold (ie methane intensities) levels: 0.2% for production; 0.05% for gathering, boosting, processing and storage, and 0.11% for transmission; charges start at $900/ton for 2024 reported emissions, rising to $1200/ton for 2025 and $1500/ton for 2026 and future years.[91]

[84] One Future (2024)
[85] Much of this section is taken from Environmental Defence Fund (2024a).
[86] EPA (2024)
[87] These requirements are often referred to as OOOOb (for new and modified sources) and OOOOc (for existing sources).
[88] FECM (2024).
[89] EPA (2024a).
[90] EPA (2024b). Optional calculations can be made starting in July 2024 which will then be paid in 2025.
[91] In March 2025 it was reported that Congress had repealed these charges. Senate sends repeal of methane fee implementation to Trump's desk

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The Bureau of Land Management (BLM) Waste Prevention Rule relating to oil and gas waste on federal and tribal lands became effective in June 2024 and includes measures to reduce waste, develop LDAR plans and pay royalties on emissions. Rules will be phased in over 18 months depending on flow rates. Measures are similar to those of EPA with the exception that there is no distinction between new and existing sources and effective dates are slightly earlier. The Rule was published in the Federal Register on October 4, 2024 and will go into effect six months after that date.[92] Given that the majority of oil and gas is produced on private land the impact of this measure may be limited.

The Pipeline & Hazardous Materials Safety Administration (PHMSA) updated Leak Detection and Repair Rules becomes effective six months after publication in the Federal Register.[93]

Since the arrival of the Trump Administration in January 2025, much of the Biden framework is being substantially modified with the possible ambition of abolishing it altogether. At the time of writing, waste emissions charges (also known as methane fees) have been rescinded; and the OOOOb and OOOOc and the GHGRP requirements may also be reconsidered, which would dismantle a large part of the framework.[94] However, close scrutiny of the Biden Administration's regulation suggests that abolition of the framework may be a difficult legislative task and, even if attempted, could take some years.[95] In addition, major industry players, particularly those intending to export to the EU and therefore needing to comply with the EU Methane Regulation, are reported to be continuing to monitor and reduce their emissions.[96]

6.2 The European Union Methane Regulation[97]

The original Methane Strategy was published in October 2020[98] but the EU Methane Regulation only entered into force on August 4, 2024. The main reason for this long gestation period relates to the 2022-23 gas (and energy) crisis caused by the Russia-Ukraine war which resulted in a substantial increase in EU LNG imports to replace Russian pipeline gas. The crisis also partly accounts for the near 4-year delay in agreeing the Regulation as political attention was concentrated elsewhere.

The scope of the Regulation covers emissions from the production of all fossil fuels - oil, gas and coal – but the initial focus is on natural gas and LNG which is also the focus of this paper.[99] It has a domestic and an international dimension with the latter reflecting the EU's more than 90% dependence on fossil fuel imports, meaning that the vast majority of GHG emissions associated with the burning of fossil fuels originate from imports.

The essence of the Regulation is to introduce:

- measurement, reporting and verification (MRV) of methane emissions of both domestically produced fossil fuels and imports into the EU;
- Leak Detection and Repair (LDAR) standards;
- a ban on routine venting and flaring.

This builds on OGMP 2.0 which (as discussed in Section 5) is the United Nations Environment Programme's flagship oil and gas reporting and mitigation programme which it considers to be the `gold standard' of methane emissions reporting. It also relies on the IMEO (see Section 5), `to provide

[92] Federal Register (2024).
[93] Federal Register (2023).
[94] Book et al. (2025). A guide to these complexities can be found at Appendix 9.
[95] Ibid.
[96] Volcovici (2025).
[97] Only the main points of the Regulation will be set out and discussed here; for a more detailed discussion see Olczak et al (2024) and Olczak (2025).
[98] European Commission (2024), European Commission (2020). The strategy and early drafts of the Regulation are discussed in detail in Stern (2022), pp.10-12.
[99] Chapter 3 of the Regulation is specific to oil and gas; Chapter 4 is specific to coal. Chapter 5 deals with emissions from `crude oil, natural gas and coal placed on the Union market' (i.e. imports).

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accurate, unbiased, and up-to-date information on methane emissions', and to act as a repository for data. The Commission, Competent Authorities and verifiers will consider information made available by IMEO and OGMP 2.0 in their data analysis. The Commission will also submit publicly available methane data made available by the Competent Authorities, for example from its transparency database (see below) to the IMEO (Article 10).

Under the Regulation, domestic EU operators have 12, 18 and 30 months (from the date of entry into force) to achieve OGMP 2.0 Level 3-, Level 4-, and Level 5-compatible reporting (see Figure 5) respectively. By 5 February 2025, Member States were required to appoint `Competent Authorities' to which domestic operators and importers will report (Article 4).[100]

For EU-based operator obligations – quantification of source-level emissions and measurement of site level emissions for operated assets non-operated assets within the Union – are set out in Article 12:

> `*Operators and undertakings established in the Union shall submit a report to the competent authorities of the Member State where the asset is located containing quantification of source-level methane emissions, complemented by measurements of site-level methane emissions, thereby allowing assessment of and comparison with the source-level estimates aggregated by site: (a) for operated assets, by 5 February 2027 and by 31 May every year thereafter; and (b) for non-operated assets, by 5 August 2028 and by 31 May every year thereafter, where those assets have not been reported under point (a). Before submitting the report to the competent authorities, operators and undertakings shall ensure that the report is assessed by a verifier and includes a verification statement issued in accordance with Article 8.'*

Chapter 5 is the international dimension of the Regulation concerning emissions from fossil fuels `placed on the Union market' i.e. imported into the EU. However, it is important to note that the Regulation only applies to emissions from *production* of fossil fuels despite the fact that for imports of fuels with long supply chains – potentially involving processing, transportation, liquefaction and shipping – production may account for only 30-40% of the emissions from the product which is finally `placed on the EU market'. There is some speculation that full supply chain (life cycle) emissions could be included in Methane Performance Profiles which will be developed from the transparency database, and also in the definition of third country equivalence (see below) which `applies to producers and exporters'.[101]

Importer obligations are set out in Article 27 and Annex IX:

> ` *By 5 May 2025 and by 31 May every year thereafter, importers shall provide the information set out in Annex IX to the competent authorities of the Member State in which they are established. Where importers fail to provide that information, in whole or in part, they shall provide sound justification to those competent authorities for such failure and set out the actions that they have undertaken to obtain that information.[102] The Commission is empowered to adopt delegated acts in accordance with Article 34 to amend this Regulation by modifying the information required to be provided by importers.'*

Annex IX of the Regulation places obligations on importers to provide information on whether the producer or exporter:[103]

- is carrying out source and site level quantification, and whether that data is subject to third party verification;
- includes measures such as LDAR surveys or measures to control or restrict venting events and flaring events;

[100] At the end of February 2025 it appeared that most Member States had missed this target.
[101] European Commission (2024), Article 30 (4).
[102] The inference here is that if `sound justification' means that the importer has not received the required information from a supplier then the Competent Authority and eventually the European Commission may directly require this information to be provided and, in the event this fails, impose penalties for failing to meet intensity standards.
[103] The full text of Annex IX can be found at Appendix 10.

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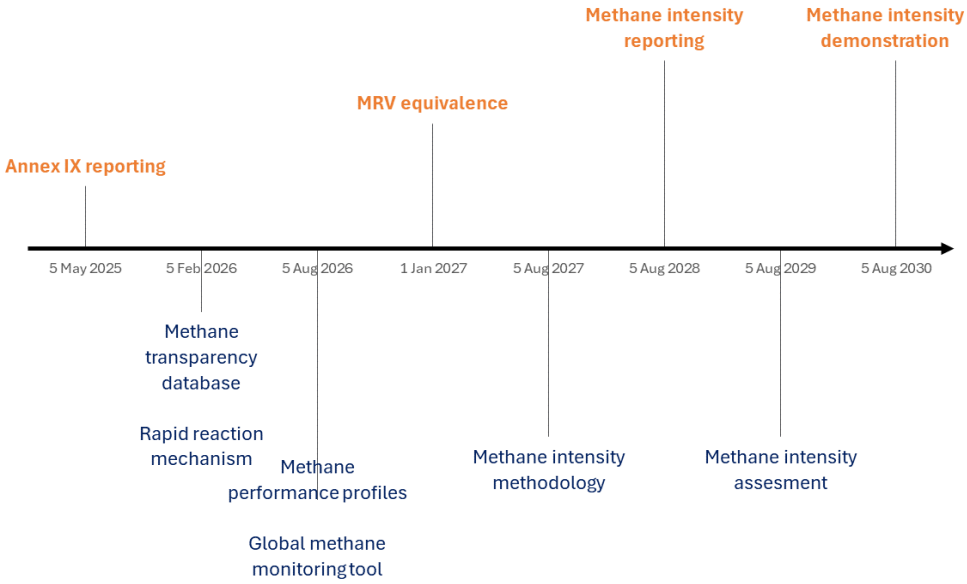
- has information showing that the crude oil, natural gas or coal is subject to monitoring, reporting and verification measures at producer level that are equivalent to those set out in this Regulation.

Figure 6 shows the key dates taken from Annex IX of the Regulation by which the various methodologies, metrics and reporting obligations must be established.

Figure 6: Annex IX: Timeline of information to be provided by EU importers



Source: Olczak (2025), Figure 2

Most of the key definitions, methodologies and metrics remained to be determined when the Regulation entered into force. The following articles deal with the obligations on importers but the methodologies to be used to define equivalence and intensity have yet to be decided.

Article 28 deals with equivalence:

> `*From 1 January 2027, importers shall demonstrate, and report in accordance with Article 27(1), to the competent authorities of the Member State in which they are established that the contracts concluded or renewed on or after 4 August 2024 for the supply of crude oil, natural gas or coal produced outside the Union cover only crude oil, natural gas or coal that is subject to monitoring, reporting and verification measures applied at the level of the producer that are equivalent to those set out in this Regulation.*
>
> `*For contracts concluded before 4 August 2024 for the supply of crude oil, natural gas or coal produced outside the Union, importers shall undertake all reasonable efforts to require that crude oil, natural gas or coal is subject to monitoring, reporting and verification measures applied at the level of the producer that are equivalent to those set out in this Regulation. Those efforts may include the amendment of those contracts.'*

There are two levels of equivalence – country level and company level. To achieve country-level:

> `*the third country has demonstrated that those monitoring and reporting requirements ensure at least source- and site-level quantification and regular reporting equivalent to those set out in Article 12, for crude oil and natural gas..and that effective verification by an independent third party…as well as effective supervision and enforcement are in place.'*

For producers to achieve equivalence it is assumed that the OGMP2.0 Level 5 plus the verification requirements of the Regulation will be required.

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Article 29 deals with intensity:

> `*By 5 August 2028 and every year thereafter, for the supply contracts concluded or renewed on or after 4 August 2024, Union producers and, pursuant to Article 27(1), importers shall report to the competent authorities…the methane intensity of the production of crude oil, natural gas and coal placed by them on the Union market..'.*
>
> `*For supply contracts concluded before 4 August 2024, Union producers and, pursuant to Article 27(1), importers shall undertake all reasonable efforts to report to the competent authorities...th[is] methane intensity...From 5 August 2028, Union producers and importers…shall report annually to the competent authorities...'.*
>
> `*By 5 August 2030 and every year thereafter, Union producers and importers..under supply contracts concluded or renewed after 5 August 2030 shall demonstrate to the competent authorities..that the methane intensity..is below the maximum methane intensity values established..'.*

The Commission has made it clear that: "To preserve security of supply, failure to meet the requirements of the Regulation will not lead to an import ban, instead a system of penalties will be put in place".[104] The following infringements shall be subject to penalties if operators/importers fail to: provide the competent authorities or verifiers with necessary assistance; carry out the actions set out in the inspection reports; submit the methane emissions reports and the verification statements; comply with maximum intensity values; provide various other types of information including an LDAR programme, venting and flaring.[105]

Article 33 sets out the penalties which member states may apply to infringements of the Regulation which must be effective, proportionate and dissuasive and shall include at least:

- `fines proportionate to the environmental damage and impact on human safety and health, set at a level which: (i) at least deprives those responsible of the economic benefits derived from the infringement in an effective way; and (ii) gradually increases for repeated serious infringements';
- `periodic penalty payments to compel operators, undertakings, mine operators or importers to put an end to an infringement, comply with a decision ordering remedial actions or corrective measures, provide information or submit to an inspection, as applicable. By 5 August 2025, Member States shall notify the Commission of those rules and those measures and shall notify it without delay of any subsequent amendment affecting them.'

Penalties have been a cause for concern since they can involve `up to 20% of annual turnover in the previous business year'. Member states are required to publish details of the penalties and the operators/importers on which they have been imposed.

Transparency of emissions is a significant part of the Regulation. Article 30 establishes a Methane Transparency Database and methane performance profiles for both EU producers and third countries `where crude oil, natural gas and coal is produced and from which it is exported to the Union'. The database will be established by February 2026 and include publicly available information on whether the Member State or Third Country has signed the Paris Agreement and the Global Methane Pledge. However, given the size of this task, and the capacity of the European Commission to collect such data, it seems highly likely that the database will rely on OGMP 2.0 data collected by the IMEO (see Section 5).

Methane Performance Profiles of individual countries will also be published (and updated annually) and will include methane emissions, a data quality assessment, MRV efforts undertaken, and an analysis of

[104] European Commission (2024a). There is a ban on signing new long term contracts for unabated fossil gas with a duration beyond 2049. European Commission (2024b), Article 31.3.
[105] This is a summary of a much longer list at Article 33.5.

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super-emitting events. This last point relates to Article 31 which obliges the Commission to establish a Global Methane Monitoring Tool (by August 2026) and a rapid reaction mechanism (by February 2026). Using satellite data, the aim is to detect and alert countries and companies to super-emitting events and eliminate these as soon as possible.

The issue of transparency, and information which will be made publicly available is a key issue discussed further in Section 9.

The EU Methane Regulation: (as yet) undefined metrics and clarifications

As noted above, from the point of view of implementation it is clear that most of the key metrics have yet to be defined and agreed. These will be included in a series of *delegated and implementing acts* shown in Table 2.

Table 2: Content and Timing of Delegated and Implementing Acts Foreseen in the EU Methane Regulation

DELEGATED ACTS	IMPLEMENTING ACTS
Art. 22(3) restrictions on venting methane from ventilation shafts for coking coal mines [2027]	**Art. 12(4)** MRV reporting templates *(advisory procedure)*
Art. 27(1) further information to be required from importers, amending Annex IX	**Art. 14(7)** Minimum detection limits and detection techniques for LDAR surveys, the thresholds applicable to the first step of LDAR surveys [2025] (*examination procedure)*
Art. 29(4) the methodology for calculating, at the level of producer, the methane intensity values associated with imports [2027]	**Art. 28(6)** MRV equivalence for third countries: a) procedure and evidence requirements for establishing equivalence and b) decisions establishing/revoking equivalence *(examination procedure)*
Art. 29(6) maximum methane intensity values and classes for crude oil, natural gas and oil	
Art. 32 EU COM can establish mandatory standards or technical prescriptions concerning e.g. measurement and quantification, LDAR	

Source: Olczak et al (2024), Table 4, p.15

A clarification on Implementing Acts (IAs) was provided by the Commission:

> *`As per Article 28(6), the Commission will set out by means of an implementing act, the procedure and requirements concerning evidence to be provided by a third country for establishing [regulatory] equivalence. It will form the benchmark that will be used to undertake the individual country-specific assessments of equivalence in view of a recognition of regulatory equivalence for individual third countries in the various country- specific implementing acts (IA)s. The country-specific IAs will therefore not be adopted before the general IA is adopted.'*[106]

This also includes the minimum requirements for regulatory `equivalence':[107]

- Setting out the method for the assessment, notably the existence of an equivalent legal framework, effective supervision, and enforcement;
- Clarifying what input and evidence will be required by the Commission and how these should be provided;

[106] European Commission (2024c), Answer A16.
[107] Ibid.

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- Clarification of the process for ensuring continued compliance with equivalence requirements after the initial decision on MRV equivalence was taken;
- Determination of the inspection methods that will verify the compliance with the criteria and provide input to the Commission;
- Description of the process and indicative timelines;
- Description of the involvement of third country authorities, including regular monitoring and enforcement;
- Description of the monitoring and review/withdrawal process envisaged after an equivalence decision has been taken, if not regulated in the basic act, or providing further details to ensure uniform application at Union level.

Importers and contracts

An importer is defined as: `a natural or legal person who (…) places crude oil, natural gas or coal originating from a third country on the Union market (…) (art. 2(59))'. But given the nature of internationally traded fossil fuels – especially seaborne trades – the definition of the commercial entity responsible for `placing' on the EU market has been clarified by the Commission as the entity which makes the product physically available for distribution.[108] Related to this, a generic issue for all seaborne imports is the definition of the supply chain for imported emissions, given that although LNG shipping is covered under the OGMP 2.0 framework, from 2024, greenhouse gas emissions during shipping were made part of the EU Emissions Trading System.[109] This raises the question as to whether emissions from shipping will be included in methane intensity profiles given that, as shown in Table 6 below, shipping distances – and hence emissions from shipping – are significantly different for different trading routes with rerouting of voyages to take advantage of fast-changing spot prices in different locations adding additional complexity.

New contracts should include clauses which include the requirements of the Regulation and the Commission. These requirements will also apply to a `renewed' contract which the Commission has clarified as containing a renewed duration or substantial revision of key elements.[110] For existing contracts `importers shall undertake all reasonable efforts' to ensure imports are subject to MRV measures and are applied at the level of producer that are equivalent to those in the Regulation which may include amendment of the contract. For both new/renewed and existing contracts the Commission `shall issue recommendations containing optional model clauses related to the information to be provided..'.[111]

In relation to existing contracts, the term `all reasonable efforts' has given rise to questions of interpretation and specifically whether those efforts also require the importer to propose contract amendments and how these would be interpreted if they were rejected by the exporter. The response of the Commission is as follows:

> *`The assessment of "reasonable efforts" would have to be done on a case-by-case basis by the competent authorities. The assessment would typically include at least: whether the obligated party took timely appropriate actions based on available information, explored feasible alternatives, and acted in line with the requirements of the Regulation and industry standards or common practices that are compliant with that Regulation.'*[112]

This suggests that in relation to MRV data from exporters, reasonable efforts may be judged by different, standards. For example, for a relatively simple LNG supply chain – such as Qatar – a reasonable effort may have a higher standard than for the US or Nigeria which have much more complex supply chains.

[108] Which is deemed to be the entity listed in the Customs Clearance documentation. Ibid, Answers A32-33.
[109] Olczak and Piebalgs (2023).
[110] European Commission (2024c), Answer A7.
[111] European Commission (2024), Article 28 (1-3).
[112] European Commission (2024c), Answer A14.

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But much greater publicly available information about emissions from US production (and supply chains) may lead to a higher standard for reasonable efforts compared with information available from Algeria or Nigeria.[113]

Another commonly asked question is about a situation where a third country exporter which sources commingled gas from trading hubs is required to provide MRV data to an EU importer and/or the importer does not have contractual relationship with the producer. The Commission's response to both questions is: `Importers and exporters need to make sure that the required information is passed down to them via the person/entity they have a direct relationship with.' This requires the importer to ensure that MRV data for each transaction is passed between the entities which take title to the gas as it moves through the supply chain.

The Methane Abatement Partnership Roadmap (MAPR)

The Roadmap was launched at COP29 in November 2024.[114] A similar previous initiative, `You Collect We Buy' was never precisely defined. The basic idea was for countries which were flaring gas to implement collection schemes with financial and technical assistance from Brussels, which could then result in additional purchases by EU member states, potentially combined with the Aggregate EU initiative.[115] You Collect We Buy was aimed at reducing flaring in Algeria and Egypt, but MAPR is focused on all methane emissions and is better defined in terms of actions but lacks any commitment to financial assistance. Egypt and Azerbaijan have been named as initial target countries, although larger suppliers will be needed if the initiative is to achieve significant reductions.[116]

6.3 Other National and International initiatives

A range of other initiatives, measures and targets from governments around the world were announced at the COP29 summit. Other countries included: Azerbaijan, Republic of Korea, United Arab Emirates, Kazakhstan, UK, Brazil, Canada and Nigeria.[117] This also included an update on the November 2023 US-China Sunnylands statement and China's First Methane Reduction Action Plan.[118] Methane policies have only evolved relatively recently, principally in North America and Europe, and are developing relatively slowly elsewhere.[119]

7. Corporate and Government LNG Initiatives

The final sections of this paper are focused on LNG because, as explained in the Introduction, although accounting for a relatively small subset of fossil fuel emissions, the significant expansion of global LNG trade over the next five years means that it is attracting considerable attention. There have been a number of mostly industry-led initiatives.

7.1 Statement of Gas Emissions (SGE)

In November 2021, a framework for MRV of emissions from LNG was published by the (SGE) partners.[120] This was based on a 2020 tender for up to 2 Mt of LNG with a defined GHG content, issued by Pavilion Energy. Three contracts were signed with Qatar Petroleum Trading, Chevron and BP. These contracts are long-term sale and purchase agreements which do not require either seller or buyer to offset all the emissions. The parties created an MRV methodology to 'create a consistent, verified SGE for each delivered LNG cargo', from production to the delivery point at the import terminal. The

[113] For a review of supply chains and emissions data from the 10 largest LNG exporters see Section 8.
[114] The text of the Roadmap can be found at Appendix 11.
[115] Olczak (2025) has more information on MAPR..
[116] Particularly as Egypt's immediate future looks likely to be as a gas and LNG importer rather than exporter.
[117] US Department of State (2024).
[118] US Department of State (2023). Berkeley Law (2023) has details of China's Methane Action Plan.
[119] Olczak et al (2023).
[120] SGE (2021, The SGE framework is specific to contracts signed by the Singaporean company Pavilion, for more details see Stern (2022), pp.32-3.

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methodology covers all operational emissions associated with these life cycle stages, quantified and reported per cargo both as total GHG emissions in CO2 equivalent and methane intensity per energy content delivered.

At a minimum, emissions of carbon dioxide, methane, and nitrous oxide must be included. The methodology includes: reporting principles, boundaries (segments), quantification and allocation methods, reporting and assurance. Each Statement of Emissions requires a report containing: cargo details, GHG data (intensity and emissions breakdown) and verification details. Reporters are required to use the highest-quality data which (for operated assets) is expected to be primary data. For SGEs to achieve a 'reasonable' level of assurance, a third-party verifier must assure that emissions have been calculated using the methodology with no material errors or omissions. In 2023, Pavilion received its first SGE certified LNG cargo.[121] However, there are no reports of this methodology being used by others, or that it has been updated since the original publication.[122]

7.2 The GIIGNL MRV and GHG-Neutral Framework[123]

The GIIGNL framework was also published in November 2021.[124] It is designed to:

- Provide a common source of best practice principles in the monitoring, reporting, reduction, offsetting, and verification of GHG emissions associated with a delivered cargo of LNG.
- Promote the commitment to, and disclosure of, verified emissions on consistent GHG accounting criteria and definitions, facilitating the calculation of an LNG cargo's GHG footprint that genuinely reflects its climate impact.
- Promote a consistent approach to declarations related to emission reduction actions and carbon offsets that are associated with an LNG cargo.
- Position emission reduction action as the primary focus of a claim of 'neutrality', with the use of offsets to compensate for residual emissions that cannot be reduced.
- Promote full accounting for methane emissions as well as carbon dioxide and other applicable GHGs.

The Framework includes a cargo statement which requires companies to provide details of: the different segments of the life cycle (stage statements), emissions from those segments, the standards applied, the offsets used, an emissions reduction plan and (if claimed) a GHG neutrality declaration. Reporters will use the framework to quantify the GHG emissions associated with a delivered cargo in a "GHG footprint" statement. Responsibilities for MRV of emissions are separated from the issue of offsets, with the option to make a claim of "GHG Offset", "GHG Offset with Reduction Plan" or "GHG Neutral" Cargo.[125] There are two levels of assurance which must be agreed with verifiers (certifiers):[126]

- `limited' - where the nature and extent of verification activities have been designed to provide a reduced level of assurance on historical data and information.
- `reasonable' - where verification activities have been designed to provide a high but not absolute level of assurance on historical data and information;

[121] Pavilion (2023).
[122] In June 2024 agreement was reached for Shell to acquire Pavilion Energy. Shell (2024).
[123] GIIGNL is an organisation representing companies active in the import and regasification of LNG. It has 94 members representing the LNG import industry from around the world in the Americas, Asia, and Europe.
[124] GIIGNL (2021).
[125] The options are: GHG Offset, GHG Offset with Reduction Plan" and GHG Neutral Cargo. GIIGNL (2021), p.2.
[126] Ibid, p.38.

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In January 2023, GIIGNL announced that a cargo had used its MRV framework for the first time.[127] The use of carbon offsets to create GHG-neutral LNG is challenging given the debate about the variability of offset quality.[128]

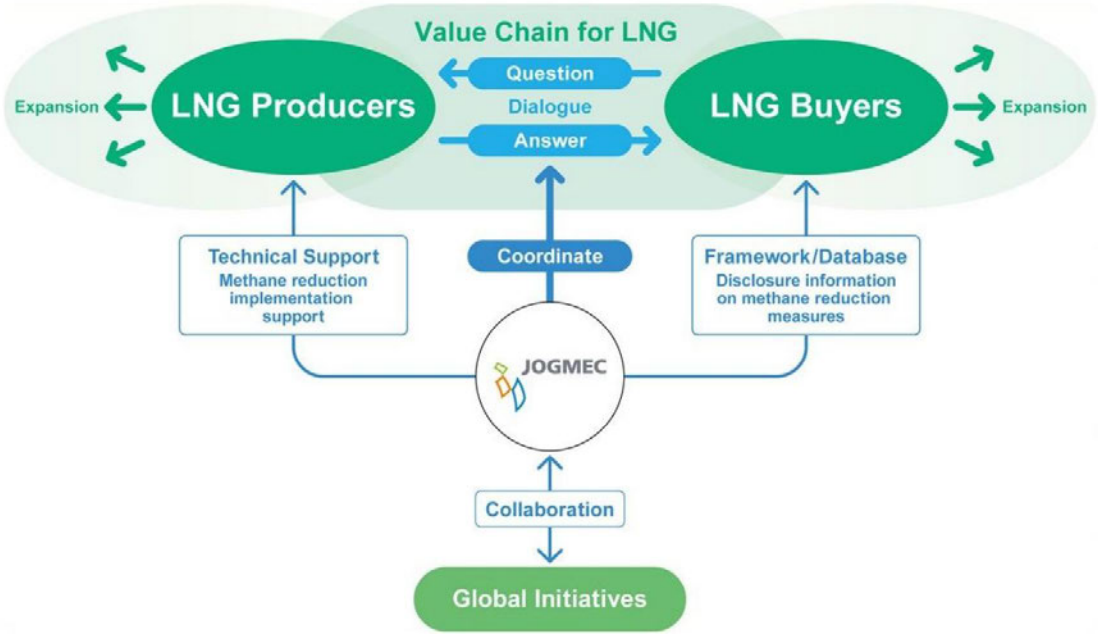
7.3 Carbon-Neutral LNG Cargoes

From 2019-2023, 76 carbon-neutral LNG trades were publicly announced, the majority of which were purchased by Chinese and Japanese buyers.[129] These trades involved the purchase of various types of offsets equivalent to the greenhouse gas emissions from different stages of the supply chain of the cargo (although the details of the offsets were very often not available).[130] In many cases there was a lack of information about the country where the cargo originated, and its seller and buyer. 2021 was the high point of this trade when 34 cargoes were reported; no trades were announced in 2024 but cargoes are known to have been traded. In 2022, this author concluded: `Carbon-neutral LNG has become progressively limited to a small number of trades in Asia and cannot be considered a credible or reliable environmental standard.'

7.4 Coalition for LNG Emission Abatement Towards Net Zero (CLEAN)

In October 2023, the US, Australian, Korean and Japanese governments and the European Commission established the Coalition for LNG Emission Abatement toward Net-zero (CLEAN), which was announced by KOGAS (Korea Gas Corporation) and JERA (from Japan). As Figure 7 shows, the vision is of a globally aligned methane emission assessment of LNG projects, and to incentivize methane mitigation by LNG producers by facilitating the information collection process of methane leakage counter-measures and reduction targets announced by LNG producers. The aim is to move towards collection of methane emissions and emissions intensity data at the cargo, portfolio, and operator levels.

Figure 7: Coalition for LNG Emissions Abatement Towards Net Zero (CLEAN)



Source: CLEAN Annual Report (2024), p.11

[127] GIIGNL (2023).
[128] This is discussed at length in Atkin et al (2022).
[129] Sergeeva and Ward (2024), Figure 1 p.5.
[130] Stern (2022a), Table 1, pp.2-3 has CO2 equivalent and vintage dates of offsets for some cargoes from November 2020-July 2022.

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The priorities of the CLEAN Initiative are:

- For major importing countries to incentivise LNG producers to minimise methane leakage.
- For JOGMEC to provide a platform for methane reduction initiatives of LNG producers and create a globally aligned assessment of LNG producers by emission footprints.
- To share knowledge gathered from the methane reduction information collection and support methane reduction efforts of LNG producers.[131]

Within Japan, The Japan Organization for Metals and Energy Security (JOGMEC) provides support mechanisms for LNG producers and consumers by creating an initiative that collects methane measures and best practices, complementing the work of other existing platforms such as OGMP 2.0. Japan has also resolved to provide support for accelerated methane measurement and mitigation by LNG producers, especially in Asian countries, by leveraging its expertise from ongoing support on emission assessment and reduction in gas and LNG projects.[132] The CLEAN 2024 Annual Report showed that since the initiative was launched, 22 additional (mostly Japanese) utilities) had become participants and 11 international companies and six international organisations had expressed their support for the initiative.

The ASEAN Centre for Energy is developing a Methane Leadership Program comprising seven South East Asian countries which includes establishing an oil and gas methane emissions baseline in 2025.[133] While these initiatives are still at an early stage and would benefit from greater participation by Chinese and South Asian companies and governments, they are extremely important because typically up to three quarters of global LNG is traded in Asia.

8. Greenhouse gas emissions from natural gas and LNG supply chains

Table 3 shows methane emissions from oil and gas operations by category for the 10 countries which in 2023 accounted for 90% of global LNG exports. Taking Tables 1 and 3 together shows that these 10 countries accounted for 44% of the global emissions from onshore oil production, 23% of emissions from offshore oil production, nearly 60% of global emissions from onshore gas production and nearly 40% of offshore gas production. However, the 47% of emissions which originate from pipelines and LNG facilities is problematic because of the different characteristics of the two delivery systems, and because the US and Russia have long pipeline networks and account for more than 80% of the total. Given the extensive pipeline networks in both countries, it is likely that the vast majority of their emissions are from pipelines rather than LNG facilities. But nevertheless this data highlights that:

- a substantial proportion of global methane emissions originates from countries which are major LNG exporters;
- vented and fugitive emissions from onshore and offshore upstream oil and gas operations are estimated to be the most substantial contributors to any supply chain for domestic or export delivery to customers.[134]

[131] CLEAN Annual Report (2024), pp.10, 54-56.
[132] Joint Statement on Accelerating Methane Mitigation from the LNG Value Chain, 20230719001-2.pdf (meti.go.jp)
[133] IGU (2025), pp.28-29.
[134] Emissions from exports include those from shipping and regasification discussed below, but as noted above these are not taken into account in the EU Methane Regulation which is focused on production.

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Table 3: Methane Emissions from Oil and Gas Operations for the 10 largest global LNG exporters by category of emissions, 2023 (KT)

	Onshore Oil			Offshore Oil			Onshore Gas		Offshore Gas		Pipelines and LNG Facilities		Other Oil and Gas	
	Fugitive	Vented	Flared	Fugitive	Vented	Flared	Fugitive	Vented	Fugitive	Vented	Fugitive	Vented	All	TOTAL
United States	1076	4304	401	76	303	22	1245	3107	0	51	672	1061	577	12895
Australia	0	9	9	9	35	5	34	85	55	137	15	23	24	440
Qatar	18	1	21	58	233	17	3	6	142	355	21	32	5	912
Russia	1097	4390	958	47	189	39	881	2199	31	77	385	609	105	11007
Malaysia	2	9	7	51	205	34	0	0	94	235	31	49	18	735
Indonesia	72	288	45	18	74	9	43	108	69	172	43	68	45	1054
Oman	75	300	100	0	1	0	43	108	0	0	16	25	6	674
Algeria	285	1142	475	0	0	0	191	478	0	0	45	71	16	2703
Nigeria	86	342	88	177	710	128	48	120	23	58	28	44	22	1874
Trinidad	2	7	3	4	14	4	1	2	25	63	43	68	45	281
TOTAL	2713	10792	2107	440	1764	258	2489	6213	439	1148	1299	2050	863	32575
Global emissions	5903	23613	6250	1935	7741	1272	4243	10588	1166	2910	2762	4362	2450	75195
% LNG Exporters	46%	46%	34%	23%	23%	20%	59%	59%	38%	39%	47%	47%	35%	43%

Source: IEA (2024b)

Aside from methodological issues (discussed in Section 3) it is important to stress that the data in Tables 1 and 3 relate to countries rather than to LNG supply chain assets. However, before considering these supply chains in more detail, flaring of gas requires more examination.

8.1 Flaring in leading LNG exporting countries

Because of the rapid increase in LNG trade in the 2020s, emissions from LNG supply chains, in countries where associated gas plays an important part in supply to liquefaction terminals, has begun to attract particular attention.

Table 4 provides a four-year snapshot of progress in reducing gas flaring by the ten largest global LNG exporters, which accounted for 90% of global LNG exports and 40% of globally flared volumes in 2023.[135]

Table 4: Gas flaring and flaring intensity in top 10 global LNG exporting countries, 2019, 2023

	LNG Export 2023 (bcm)	Flared Gas 2019		Flared Gas 2023	
		Flared	Intensity	Flared	Intensity
United States	114.9	17.2	3.9	9.6	2.0
Australia	108.3	1.4	10.4	0.7	6.5
Qatar	106.4	0.9	1.9	1.2	2.4
Russia	42.7	23.2	5.9	28.4	7.7
Malaysia	36.6	2.1	9.3	1.5	8.2
Indonesia	21.3	2.0	7.4	1.9	8.6
Oman	15.5	2.6	7.4	1.9	4.9
Algeria	17.7	9.0	19.6	8.2	18.9
Nigeria	17.7	7.8	10.9	5.8	11.0
Trinidad+Tobago	10.5	0.2	8.6	0.1	7.3
Total top 10 LNG exporters	491.2	66.4		59.3	
TOTAL WORLD	545.9	150.0		147.6	
10 exporters as % of total world	90.0%	44.2		40.2	

Notes: GMFR – flared gas in bcm, intensity in cubic metres of gas per barrel of oil produced = annual volume of gas flared in a country/annual volume of crude oil produced in that country
Sources: GIIGNL (2024), p.10; World Bank (2024)

[135] 2019 was chosen in order to eliminate anomalous results which may have occurred because of the Covid pandemic. Data are for all gas flared in these countries.

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Over the four-year period, progress towards reducing overall gross flaring has been modest with a reduction of 7.1bcm or 11%, but this is skewed by the increase in Russian volumes over the period.[136] Taking Russia out of the data (but including the small increase in Qatar) flared volumes from LNG exporters fell by 12.3 bcm or 28% over the period.

But as a measure of progress in emissions reduction from gas produced for exports of LNG, the data is more complex to analyse. The general pattern of the data is one of reductions in both volumes flared and flaring intensity with only Russia and Qatar as exceptions in both cases, and Indonesia and Nigeria with higher flaring intensities. Emissions from flaring – which correlate to a substantial extent with oil (rather than gas) production – will be most relevant in relation to emissions from LNG exports for those countries where gas associated with oil production forms a significant part of supplies to their liquefaction plants. In Algeria, Nigeria and some plants in the US, a significant share of the gas used for LNG exports is known to originate from oil fields, measurement and reporting of which requires allocation of emissions between the two fuels.

For six out of the ten countries in Table 3, the Gas Exporting Countries Forum (GECF) provides alternative flaring data from the countries themselves.[137] With the exception of Qatar, the GECF flaring data are substantially lower than the GMFR numbers. The biggest differences are for Algeria where GECF has 2.7 bcm and 2.2 bcm for 2019 and 2023 compared with GMFR at 9.0 bcm and 8.2 bcm respectively; and Russia where GECF has 16.5 bcm and 14.0 bcm compared with GMFR at 23.2 bcm and 28.4 bcm for the two years. GECF also provides data for reinjection and shrinkage of gas which for some countries can be extremely large figures, well in excess of flared volumes.[138] For example GECF reports reinjected and shrinkage volumes in Algeria were 51 bcm and 28 bcm respectively in 2023, equivalent to more than 42% of gross production and it seems likely that some of the additional emissions identified as flaring in GMFR data were attributed to those functions in national data.[139]

8.2 Emissions from the ten largest LNG exporters: simple and complex supply chains

In Qatar and Australia, LNG supply chains originate from a single gas field (or fields in a limited geographical area) delivered via an easily identifiable group of transportation, processing and storage assets to a liquefaction plant. In the US, Nigeria and Algeria it is much more difficult to identify the source(s) of the gas and its possible route(s) to different liquefaction plants – due to the complexity of network assets including: gathering/boosting infrastructure, transmission pipelines, processing plants and storages. An example of a complex supply chain is shown in Figure 8. As noted above, supply chain complexity is increased if a substantial proportion of the gas is produced in association with oil.

[136] Russian flaring and intensity has risen steadily since 2019 to a peak in 2023. World Bank (2024), p.20 notes that the increase has occurred in each of the main oil producing basins and `suggests that the issues that led to flaring were system-wide…The increase is likely to have resulted from a prioritization of oil production without corresponding investments in the infrastructure to recover and utilise the associated gas. It is also likely that there has been a deterioration in the condition of oil and gas facilities caused by the limited availability of equipment, which is in part a consequence of supply chain disruptions due the ongoing invasion of Ukraine.'

[137] A comparison with the World Bank data in Table 4 for Qatar, Russia, Malaysia, Algeria, Nigeria and Trinidad and Tobago for the same years is shown in Appendix 12.

[138] Reinjection is defined as: `Volume of gas processed through non-associated gas processing plants and field activities returned to sub-surface formation to enhance recovery rate'. Shrinkage is defined as: `Volume reduction of wet Natural Gas due to the extraction of some of its constituents such as liquid hydrocarbon products and others'. GECF (2024), p.156.

[139] Ibid, Figure 4.1.2.2, p.60.

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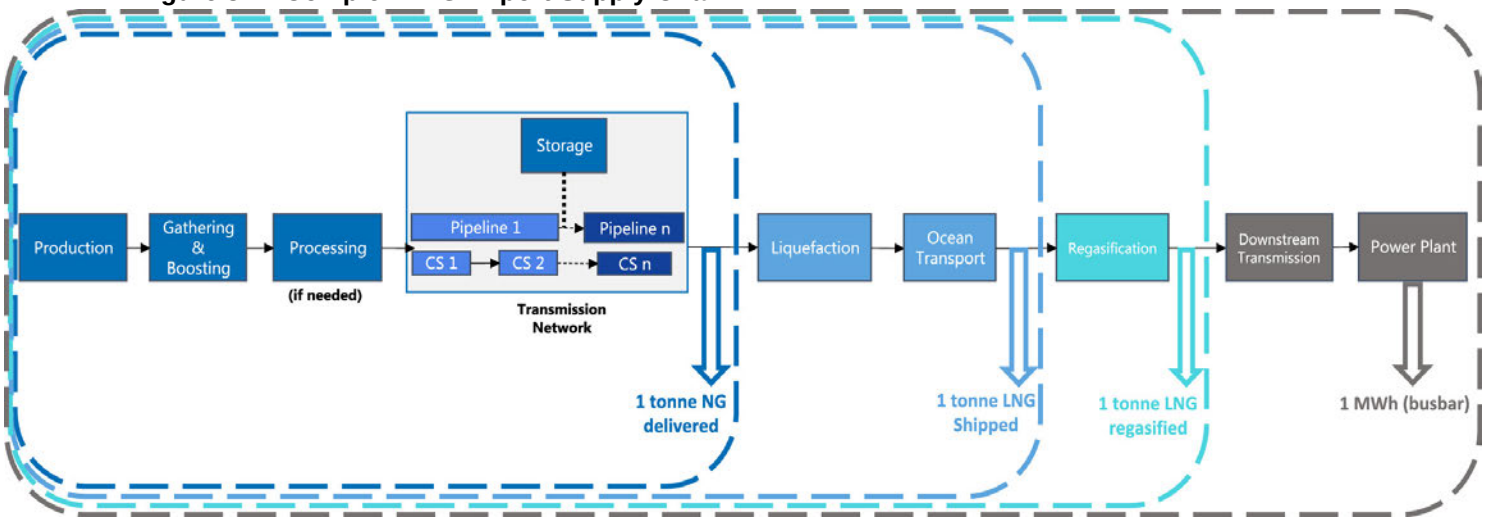
Figure 8: A Complex LNG Export Supply Chain



Source: Roman-White et al (2024), Figure 1

United States

Recent attention has focussed on LNG-related emissions from the US as one of the leading global LNG exporters. This is because it has substantial additional export capacity under construction and, more than for any other exporter, information and data from government, regulatory, corporate, NGO and academic sources is publicly available. US data emphasizes the point that, particularly in relation to the gas used as feedstock for LNG exports, a single percentage figure for emissions cannot account for variations between different supply chains.

In relation to flaring, a study of three US basins in the early 2020s demonstrated a considerable variability of flare efficiency.[140] More recent research focussing specifically on the Permian Basin, with a high percentage of gas associated with crude oil production, showed that reductions in flaring depended considerably on new wells in the first year of production, and availability of sufficient pipeline capacity to take away associated gas.[141] Nevertheless, the World Bank's GMFR Report showed Permian Basin flared volumes and intensity increased in 2023, while in the Eagle Ford Basins and the rest of the US, emissions and intensity increased slightly, and Bakken emissions were stable and intensity slightly lower.[142] But an additional layer of complexity is that flared volumes and intensity vary considerably on a monthly basis. Measurements in 2023 showed around a 50% difference in volumes and intensity with a low point in March and a peak in September.[143]

A study of 15 aerial campaigns over the period 2020-22 integrating one million site measurements from regions accounting for 52% of US oil and 29% of gas production found weighted average emissions roughly three times the national government inventory.[144] As noted earlier, a survey of basins comprising 70% of US oil and gas onshore emissions, carried out from June to October of 2023 by means of aircraft overflights, found emissions which were four times greater than the US EPA target and eight times greater than intensity targets adopted by industry associations.[145] The survey found that gas-dominant basins with high wellsite productivity (Appalachian, Haynesville) had methane loss rates of ~1%, while

[140] From 12 research flights in 2020 and 2021, Plant et al. (2022) quantified the performance of flares across three regions Permian, Eagle Ford and Bakken using aircraft-based sampling and observed an average mean effective efficiency of 91.1% (ranging from 94.1% in the Bakken to 86.8% in the Permian).
[141] Allen et al (2024).
[142] World Bank (2024) Figures 13 and 14, p.23.
[143] Ibid, Figure 15, p.26. This was due to power supply curtailments in a particularly hot summer
[144] Sherwin et al (2024).
[145] Environmental Defence Fund (2024).

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oil-dominant or mixed oil/gas basins (Permian, Eagle Ford, Bakken) had losses ~2%, and relatively mature basins (Uinta) had rates above 7%.[146] Only one study located by this author found that methane emissions from Permian oil and gas production declined by 26% in 2023 compared with the previous year.[147]

Variability of emissions from different basins in the United States is reinforced by a 2024 measurement study which found that US LNG exports sourced from the Permian basin delivered to the UK were 42% more emissions-intensive than exports sourced from the Marcellus Basin. The authors note that:

> `*The higher value of measurement-informed emission in the Permian Basin is partly attributable to the extensive flaring activities in that region which account for 12% of total measured methane emissions.*"[148]

In relation to emissions from a specific LNG project or liquefaction terminal – and particularly a specific LNG cargo - the most important factor will be not only the basins from which a company sources its gas, but the emission characteristics of suppliers from which it purchases. In 2022, Cheniere's suppliers from the Permian basin had a collective production intensity of 0.45% compared to a basin average of 1.2%.[149] Cheniere and ConocoPhillips are two major US LNG exporters which are OGMP 2.0 members and achieved Gold Standard Reporting status in 2024; approximately 30% and 95% (respectively) of their operated assets were reported as having met Level 5 standards in 2023.[150] ExxonMobil and Chevron are also OGMP2.0 members but as of 2024 there were no details of reporting levels.

Because the US represents the most complex set of LNG supply chains, it is often claimed that it is impossible to track gas from the wellhead to the liquefaction plant and accurately measure emissions from a specific cargo. Since 2022, Cheniere has been providing its long-term customers with Cargo Emissions (CE) Tags showing the estimated GHG emissions associated with each cargo produced at its two liquefaction facilities.[151] These are calculated from the company's supplier-specific life cycle assessment (LCA) model and provide a value chain emissions estimate from wellhead to point of delivery.[152]

This emphasises the point that using a single emissions percentage for US LNG – or even a single percentage for emissions from gas originating from an individual basin – will fail to reflect the complexity of identifying, and then measuring, emissions from the gas delivered to an individual liquefaction plant. But this only deals with the upstream component of emissions. Emissions from the rest of the supply chain are discussed in the following section. Nevertheless it is worth repeating that more public domain data on methane emissions from oil, gas and LNG is available for the US than any other major LNG exporter (other than Norway[153]), and that over the past five years huge advances have been made in the volume and accuracy of measurements. Much less information is available for other major LNG exporters.

[146] The source reports that the gas-dominant basins are more focussed on delivery of gas production to market, while the larger losses in the oil and mixed oil/gas basins may be due to inefficient flaring on insufficient gas gathering or takeaway capacity. The mature basin rates are thought to stem from ageing, leak-prone wells which continue to go unaddressed even as production declines. Ibid p.6.
[147] S&P Global (2024).
[148] Zhu et al (2024). See below Figure 11.
[149] Allen et al. (2024).
[150] OGMP (2024).
[151] https://www.cheniere.com/our-responsibility/climate Clarifying that there is no relation with certification company products, the company states that: `CE Tags are not a claim of a specific "differentiated" or "certified" or "responsible" LNG product, nor has Cheniere transacted in the commercialization of such products.'
[152] Details of the attributes of this model can be found in academic publications sponsored by the company: Allen et al (2024), Roman-White et al (2024), Zhu et al (2025), Khaliukova et al (2024).
[153] Equinor, the major exporter of Norwegian gas and operator of the country's only LNG plant reports that the methane intensity of its operated assets (upstream and midstream) is 0.02%. Reducing methane emissions - Equinor

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Qatar

In 2023, Qatar was the third most important LNG exporter after the US and Australia and has additional capacity under construction which will confirm its future position as the second most important exporter after the US.

Table 5: GHG emissions from, and intensity of, Qatari LNG Facilities, 2019-23 (Mt CO2e*)

	2015	2016	2017	2018	2019	2020	2021	2022	2023
Scope 1 Emissions	22.88	22.23	22.61	22.05	21.3	21.3	21.2	22	23.2
Scope 2 Emissions	0.42	0.42	0.41	0.42	0.43	0.3	0.4	0.4	0.4
Scope 1 Sequestration from LNG facilities	0.48	0.47	0.48	0.48	0.56	0.63	0.62	0.59	0.68
Scope 1+Scope 2 minus sequestration	**22.82**	**22.18**	**22.54**	**21.99**	**21.17**	**20.97**	**20.98**	**21.81**	**22.92**
Greenhouse Gas Emissions Intensity **	0.314	0.315	0.31	0.307	0.299	0.3	0.3	0.31	0.31
Methane Intensity (%)***					0.005	0.007	0.005	0.003	0.004
Flaring ****	29,217	26,558	24,442	21,091	16,894	21,706	17,564	15,818	16,828
Flaring Intensity (%)	0.57	0.59	0.54	0.47	0.38	0.49	0.39	0.35	0.38
LNG Exports (bcm)	105.6	107.3	103.6	104.9	105.8	106.5	106.8	110.5	108.4

*100 year time horizon GWP of 28; **MtC02e/Mt hydrocarbon production; ***different metric prior to 2019; ****MMSCF hydrocarbon flared/MMSCF
Source: QatarEnergy (2019), Appendix E, p.79; QatarEnergy (2024), Appendix E, pp. 113-4. Energy Institute (2024), p.43

Table 5 shows GHG Emissions from Upstream and LNG Facilities in Qatar from 2015-23. This gives detailed information for a range of metrics, including methane, from the LNG supply chain. The data also have the advantage of representing virtually all of Qatari LNG exports as joint ventures operated and non-operated by QatarEnergy are included. Qatar has a relatively simple LNG supply chain with the majority of gas originating from a single field, through relatively short offshore and onshore pipelines to a group of LNG plants in a limited geographical area. In addition, the fact that the energy and LNG sector is dominated by a single company, QatarEnergy, means that it should be possible to achieve considerable accuracy of emissions data.

While Qatar's LNG emissions data are generally low relative to other countries and individual projects, with some exceptions, emissions have been stable or very slightly increasing as have emission intensities, which corresponds to the data in Table 3. The variations over this period are interesting because LNG exports have remained relatively constant within a range of 104-111 bcm, and the peak of exports in 2022 does not correspond with peak emissions or intensities.

QatarEnergy is a leader in carbon capture and utilisation (CCUS) from LNG facilities with 2.2Mt of capacity already deployed (0.68Mt actually achieved in 2023) with plans to increase this to 7-9Mt by 2030 and 11Mt by 2035.[154] More than 4Mt of CO2 will potentially be captured from Qatar's seven LNG north and three LNG south trains, with the latter being utilised for enhanced oil recovery.[155] Scope 1 and 2 emissions in 2023 were 9% above those of 2019-21, but similar to the 2015 figure and rising CO2 sequestration from LNG facilities has not (yet) significantly changed that trend. Flaring emissions and intensity fell significantly from 2015-19, but then increased and have plateaued since 2021. The company is a member of OGMP 2.0 and for the years 2021-23 was awarded Gold Standard pathway status with 90% of its non-operated assets achieving Level 4 and all of its operated assets Level 3.[156]

In its Sustainability Report, QatarEnergy publishes an Independent Assurance statement and a Greenhouse Gas Verification Statement from companies meeting ISO 14065 and ISO 14064

[154] QatarEnergy (2024), p.48.
[155] Ibid.
[156] OGMP (2024).

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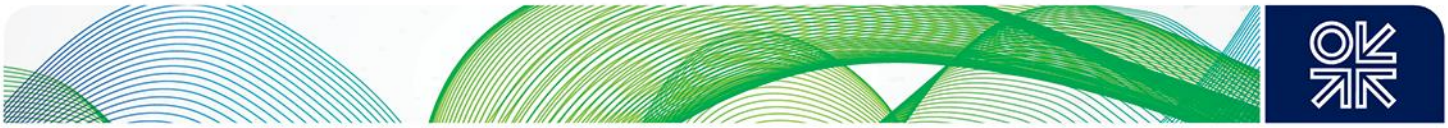

greenhouse gas accreditation requirements.[157] The statements provide qualified support for the QatarEnergy data but no detail as to methodologies which were used to produce it, or that these accreditors carried out their own estimates.[158]

Russia

While Russia has the highest flaring volumes but not the highest intensity (Table 4), our focus is emissions associated with the fields serving Sakhalin LNG (operated by Gazprom) and Yamal LNG (operated by Novatek) the two principal LNG export projects.[159] World Bank data shows 2023 flaring from East Siberia (where Sakhalin LNG is located) at 10.1 bcm, and Yamal (where Yamal LNG is located) at 5.5 bcm.[160] By contrast flaring data from Gazprom and Novatek in 2023 showed 1.6 bcm or 3.35Mt CO2e (94.7% utilization) and 43.4Mt CO2e (98.4% utilisation) respectively.[161] These very low figures could be explained by lack of adequate measurement data (although the published reports of the companies are relatively detailed), an alternative explanation could be that these are gas-focused companies as opposed to the companies producing the majority of Russian oil.[162]

Algeria

In 2023, Algeria had the sixth highest global flaring volume and a flaring intensity only exceeded by Syria and Venezuela.[163] Moreover Table 3 shows that volumes and intensity declined only modestly over the period. While Sonatrach assigned itself the goal of reducing flaring to less than 1% and eliminating routine flaring by 2030, its claim to have cut flaring by 20% during the period 2017-22 is not reflected in World Bank data or in data submitted to the GECF.[164] Nearly 80% of national flaring reduction since 2020 has come from gas recovery operations at the country's largest oil field, Hassi Messaoud, with the intention of implementing similar operations in other regions.[165] The National Gas Dispatching Centre (CNDG) is located at the country's major gas field Hassi R'Mel, where gas from that field is processed. Gas from around 20 other oil and gas fields (each with their own processing facilities) is comingled with Hassi R'Mel gas, for onward transportation to export pipelines and liquefaction plants. Emissions from export facilities would therefore need to be calculated from each of the fields which feed into CNDG, and a weighted average of these emissions then combined with emissions from pipelines between CNDG and the export facilities.

A satellite study of Algeria carried out by the Oil and Gas Climate Initiative (OGCI) during 2022-23 identified 106 detections of methane plumes in six areas.[166] 40% of these detections were from incomplete combustion at burning pits, 22% were from gas lift system venting and 18% venting from other equipment. In relation to the gaslift venting, the vast majority of the plumes occurred in the winter season (October-January).[167] The OGCI study found that more than 80% of the detected plumes were located within 3km of Hassi R'Mel which suggests these can be remedied relatively easily and cheaply.[168] This would have been a good candidate for the European Commission's `You collect we

[157] QatarEnergy (2024), Appendix F, pp. 117-121.
[158] See above note 49.
[159] Yamal LNG (operated by Novatek) with a capacity of 17.4Mt and Sakhalin LNG (operated by Gazprom) 10.8Mt are the two major Russian LNG export projects. There are two much smaller export projects – Portovaya LNG and Vysotsk LNG 1.5Mt and 0.9Mt respectively. Another major export project Arctic 2 LNG (operated by Novatek) started production in 2024 but deliveries have been delayed by western sanctions. Yafimava et al. (2024), Yermakov (2024).
[160] World Bank (2024), p.20.
[161] Gazprom (2024) p.179 and 196. Novatek (2024) p.46 and 88.
[162] Although Gazprom Neft – the oil subsidiary of Gazprom – is one of the country's three largest oil producers.
[163] World Bank (2024), Figures 1 and 2, pp.12-13.
[164] Sonatrach Annual Report 2022, p.75, although the company's 2023 Annual Report (p.56) shows a 28% reduction from 2020-23. World Bank data show national flaring at 8.8 bcm in 2017 and 8.2 bcm in 2022 – a 7% reduction – although of the flaring from the ten largest fields accounting for 5.7 bcm of flaring in 2020, 1.3 bcm were not operated by Sonatrach. Capterio (2020), p.3. GECF data show a 14% reduction from 2017-22. GECF (2024), Table 4.1.2.2, p.60.
[165] World Bank (2024), Figures 16 and 17, p.26.
[166] OGCI (2024), Figure 2, p.11.
[167] Ibid, Figures 2 and 6, pages 11and 17. `Burning pits' are used in oil and gas fields for the combustion of waste hydrocarbons. The causes of methane emissions could be separation inefficiency, malfunctioning of the pilot mechanism or lack of ignition.
[168] Ibid p.15.

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buy' scheme.[169] Another satellite study similarly focussed on Hassi R'Mel as the main sources of methane emissions.[170] There is very little public domain data available for Algerian emissions but an academic article acknowledges Sonatrach for providing `daily and hourly in situ flared gas volume measurements' for the Berkine Basin, which show that the company collects this data.[171]

Nigeria

Nigeria is another major LNG exporter which has substantial methane emissions and emissions from flaring. The main publicly available data found by this author is shown in Tables 3 and 4 showing that methane emissions and flaring continue to be significant problems. OGMP Factsheets show Nigeria LNG's Level 3-4 methane emissions of 33.4kt in 2023.[172] Flaring is a long-running and well understood problem but more recent publications suggest a greater awareness of methane emissions through participation in international initiatives.[173]

Flared gas volumes have continued to fall but 2023 intensity rose slightly. After the US, Nigeria may have the most complex LNG supply chain due to the large number of oil fields from which gas is supplied to the LNG plants and the network of pipelines and processing plants through which the gas travels.[174] Nigeria LNG is a member of OGMP2.0 and was awarded Gold Standard status for both 2023 and 2024. Around 40% of the company's operated assets achieved Level 4 with the remainder Level 3.[175]

For all other LNG exporters shown in Tables 3 and 4, methane emissions in 2023 were less than 1000kt (with the exception of Indonesia which was just above that level), and flaring less than 2 bcm.

Australia

Australia is one of the three largest global LNG exporters but Tables 3 and 4 show relatively low methane emissions from oil and gas at 440Mt CO2e and flaring at 0.7 bcm.[176] Australian government data show emissions from gas supply at 50Mt CO2e in 2022 of which 43% were fugitive and 44% from stationery sources.[177] LNG-related emissions in 2020 totaled 36Mt CO2e of which 12Mt were fugitive, 19Mt were from stationery energy sources and 6Mt from electricity supply.[178] These figures are projected to fall due to the renewables target and the Safeguard Mechanism policy which mandate progress towards net zero targets.[179] Australia's `Safeguard Mechanism' applies to facilities that emit more than 100,000 tons of CO2 equivalent per year.[180] The Mechanism involves a set of baselines and targets which asset owners are required to meet or to purchase domestic offset carbon credit units (ACCUs). Critics claim that emissions are substantially underestimated and that the Safeguard Mechanism has had a limited impact (although the latest reforms will only be implemented in the current fiscal year).[181]

Emissions from Australia's 10 LNG projects are variable, with east coast coal seam gas projects having much higher upstream emissions.[182] Some of the Western Australian and Northern Territory gas fields have a high CO2 reservoir content and a major carbon capture and storage project has been built at the Gorgon field, although this has encountered problems.[183] By contrast the Scarborough LNG project due to be commissioned in 2026, also located offshore Western Australia, has very low upstream

[169] Replaced by the `Methane Abatement Partnership' and refocused on Nigeria and Azerbaijan (see Section 6).
[170] Kayrros (2024), p.6.
[171] Benhalouche et al (2022).
[172] OGMP (2024), p.50.
[173] Abdulsamad and George-Ikoli (2024), Aminu et al (2024).
[174] To gain an idea of this complexity see Map 5 in Stern (2022).
[175] OGMP (2024).
[176] Unlike many other major LNG exporters, Australia is a relatively small oil producer (15.7Mt in 2023).
[177] Department of Industry, Sciences and Resources (2024), p.21.
[178] Department of Climate Change, Energy, and the Environment and Water (2023), Table 24, p.62. 2020 is the most recent year of estimation but the same source (p.61) gives the same figure for fugitive emissions in 2023.
[179] Department of Industry, Sciences and Resources (2024), pp.23-26.
[180] Department of Climate Change, Energy, the Environment and Water (2024),
[181] IEEFA (2024).
[182] For example the Queensland Curtis project. Heath and Ong (2022), Table 10, p.31.
[183] Heath and Ong (2022) p.23-24 carbon capture and storage | chevron australia — Australia.chevron.com

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emissions.[184] According to the national greenhouse gas inventory, three quarters of Australia's 2022 methane emissions came from coal production, particularly from the Bowen Basin.[185] Woodside which is a major LNG exporter is a member of OGMP 2.0.

Malaysia

The Malaysian company Petronas does not give detailed information on emissions from LNG facilities, but reported that in 2023 methane emissions from its groupwide natural gas value chain had fallen by 58% compared to 2019 levels, and that the methane intensity of gas sold had fallen from 0.91% to 0.42% over the same period.[186] The company reported 106.1 kt of Level 3 methane emissions to OGMP in 2023 but it is not clear whether this includes LNG assets.[187] The company introduced a zero routine venting and flaring programme which has reduced upstream GHG emissions per barrel of oil equivalent by 43% and upstream venting by 72% from 2019-23.[188] Volumes flared reduced by only 6% from 2018-22 but vented volumes by 55%.[189] Petronas is a member of OGMP2.0 and achieved Gold Standard reporting in 2023 and 2024; just over half of its operated assets achieved Level 4 and the rest Level 3.[190]

Indonesia

Similarly the Indonesian national oil and gas company Pertamina gives no detailed data for emissions from LNG operations but shows an increase in Scope 1 emissions for both its upstream and gas business sectors, although a slight fall in methane emissions from 2021-23.[191] Despite a fall in routine flaring, total flaring increased over the same period as did fugitive emissions, while there was a slight fall in process emissions and venting.[192] Pertamina is a member of OGMP2.0 but there is no information about reporting levels achieved.

Aside from data in Tables 3 and 4, there is little information about emissions from oil and gas operations in both Trinidad and Tobago and Oman. The National Gas Company of Trinidad and Tobago and Atlantic LNG are both OGMP 2.0 members with Gold Standard reporting for 2024. Around 90% of the National Gas Company's operated assets achieved Level 4 reporting but Atlantic LNG's Level 3 reporting was incomplete.[193] Petroleum Development Oman (PDO) and Oman LNG are both OGMP members, PDO's 2023 Level 4 methane emissions were estimated at 15.4kt and Oman LNG's Level 3 emissions at 3.3Mt. Oman LNG achieved Gold Standard reporting in 2024 with the majority of its operated assets at Level 3.[194]

8.3 Emissions from LNG Supply Chains: lifecycle analysis, liquefaction and shipping

The previous section focussed mainly on emissions from specific sources of production in individual LNG exporting countries. But more layers of detail are needed to specify emissions from a specific project – and a specific cargo from that project – especially where a country has multiple export terminals in geographically distant locations served by different sources of gas.[195]

Analysis of LNG delivered to a specific location will need to specify emissions not just from the source of gas production but also from:

[184] Heath and Ong (2022), Table 8, p.25.
[185] Australia's National Greenhouse Gas Accounts (2024); Kayrros (2024), p.10.
[186] Petronas (2023), p.117.
[187] OGMP (2024), p.103.
[188] Petronas (2023), p.120.
[189] Sustainability Performance Data | PETRONAS Global
[190] OGMP (2024).
[191] Pertamina (2023), p.105.
[192] Ibid, p.106. Fugitive emissions fell from 2021-22, but increased significantly in 2023.
[193] OGMP (2024), p 27 and 48.
[194] Ibid, p.102 and 53.
[195] As noted above, only the production segment is relevant in the context of the EU Methane Regulation.

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- the route from the well head to the liquefaction terminal including: pipelines (gathering and transmission), compressors, processing plant and storages;
- the specific liquefaction plant and (if there are multiple trains) the specific train;
- the length of the tanker voyage which will depend on the engine characteristics of the tanker;
- unloading from the LNG tanker into the regasification terminal.

Lifecycle analysis is complex and requires comprehensive data availability and transparency. A US National Petroleum Council study of emissions from natural gas and LNG assessed more than 2000 lifecycle studies and found that differences in system boundaries, modelled stages of the supply chain, units of published results and other technical decisions such as global warming potential, made comparisons of results very difficult.[196]

As noted earlier, the vast majority of peer-reviewed studies with detailed public domain data and methodologies come from the US and the main focus of these studies is upstream – exploration and production – where the majority of emissions in the supply chain prior to export take place. But there are an increasing number of studies dealing with emissions from midstream (gas gathering and boosting, transmission, compression, processing and storage) [197] and more recently liquefaction plants.[198] These are extremely technical papers, but their common elements are:

- the complexity of such estimates – particularly the number of data points which need to be measured which, in the case of liquefaction plants run into several thousands;
- the difficulty of reconciling source- and site-level estimates (which can be more complex than for upstream emissions);
- and the fact that generally emissions from mid-stream and liquefaction assets are larger (in many cases significantly larger) than those assumed by regulatory authorities typically using engineering emission standards.

Detailed technical studies demonstrate the problems of measuring emissions from a supply chain and the limitations of using a single figure for LNG emissions from countries with complex supply chains, with assets of different vintages. The `pause' in US government approvals for LNG projects introduced in January 2024 (and subsequently lifted) was at least partly based on the need to reappraise the environmental impact of these projects.[199]

Liquefaction

Appendix 13 shows the liquefaction plants, number of trains and start-up dates of the ten largest LNG exporters. The efficiency and hence emissions from plants, and also individual trains, will be strongly related to their dates of construction. All the US, and most of the Australian and Russian, plants were built in the 2010s and 2020s, compared to countries where the majority of the trains date from earlier decades, in some cases 20-30 years ago. Two studies carried out at the Sabine Pass and Corpus Christi liquefaction terminals - which accounted for around half of US LNG exports in 2023 - over significant time periods using multiscale measurements, showed substantial variations in emissions over time.[200] This shows that `snapshot' measurements from complex facilities can produce results which are not representative of average emissions. This may account for the substantial differences between the emissions intensities of liquefaction plants in the US Department of Energy's assessment of LNG exports.[201]

[196] National Petroleum Council (2024a), Chapter 4, p.5.
[197] Subramanian et al (2015), Vaughn et al (2017), Yu et al (2022), Brown et al (2023), Ravikumar et al (2024).
[198] Zhu et al (2025), Khaliukova et al (2024).
[199] Fulwood (2024). The wording of the US Department of Energy Statement was that projects: `…must use the most complete, updated, and robust analysis possible on market, economic, national security, environmental considerations, including current authorized exports compared to domestic supply, energy security, greenhouse gas emissions including carbon dioxide and methane'.
[200] Zhu et al (2025) which was carried out over 16 months, and Khaliukova et al (2024) over 9-15 months.
[201] US Department of Energy (2024), Appendix C, Consequential Greenhouse Gas Analysis of US LNG Exports, Tables 5 and 12, pages C12 and C17.

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IMEO's survey of OGMP2.0 data from its member companies reports flaring from LNG liquefaction, shipping and regasification accounted for 40% of midstream emissions in 2023, transmission systems over 50%, and underground storage the remaining 7%.[202]

Shipping

Table 6: Sea Distances Between Main LNG Export locations in Australia, Qatar and the US, and main Importing Locations in North West Europe (nautical miles)

AUSTRALIA	
DAMPIER to ASIAN PORTS:	DARWIN to ASIAN PORTS
Shanghai 3306	Shanghai 2765
Tokyo 3679	Tokyo 3033
Incheon 3633	Incheon 3068
Yun-An LNG 2715	Yun-An LNG 2249
Cochin 3042	Cochin 3598
	GLADSTONE to ASIAN PORTS
	Shanghai 4134
	Tokyo 3860
	Incheon 4313
	Yun-An LNG 3586
	Cochin 5336
UNITED STATES	
SABINE PASS to ASIAN PORTS: via Panama Canal (Suez Canal) {Cape of Good Hope}:	SABINE PASS to EUROPEAN PORTS:
Shanghai 10081 (13854) {15098}	Le Havre 4787
Tokyo 9202 (14521) {15762}	Wilhelmshaven 5137
Incheon 9998 (14169) {15416}	Milford Haven 4588
Yun-An LNG 10459 (13238) {14485)	
Cochin 13858 (9840) {11761}	
NORFOLK to ASIAN PORTS: via Panama Canal (Suez Canal) {Cape of Good Hope}:	NORFOLK to EUROPEAN PORTS
Shanghai 10391 (12526) {14466}	Le Havre 3360
Tokyo 9519 (13193) {155130}	Wilhelmshaven 3737
Incheon 10308 (12841) {14784}	Milford Haven 3156
Yun-An LNG 10769 (11910) {13853}	
Cochin 14168 (8512) {11129}	
QATAR	
DOHA to ASIAN PORTS:	DOHA to EUROPEAN PORTS via Suez Canal (Cape of Good Hope):
Shanghai 5845	Le Havre 6138 (10871)
Tokyo 6512	Wilhelmshaven 6540 (11273)
Incheon 6160	Milford Haven 6091 (10824)
Yun-An 5229	
Cochin 1776	

Source: https://sea-distances.org/

[202] UNEP (2024a), Figure 5, p.5.

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Liquefaction plants in Qatar, Malaysia, Oman, Algeria, Nigeria and Trinidad and Tobago, are located within a relatively small geographical area. By contrast in the United States, Australia and Russia, liquefaction plants are hundreds, and sometimes thousands, of kilometres apart.[203] Similarly, the distance between liquefaction plants in the same country and a specific market can be very different. Table 6 shows shipping distances between liquefaction plants in the three largest global LNG exporters – Australia, the US and Qatar - and major import locations in Europe and Asia. For Australia, distances are shown for liquefaction plants on the west, north and east coasts; and for the US plants on the Gulf and east coasts.

From Australian terminals, the distance to Asian markets (where more than 90% of Australian LNG is sold) varies from 2000-4500 miles, compared with Qatar 1800-6500 miles and the US 9000-15000 miles (depending on whether the route is via the Panama Canal, the Suez Canal or the Cape of Good Hope). For US LNG delivered to European markets distances are 3000-5000 miles (depending on whether the liquefaction terminal is located on the east or the Gulf coast. For Qatari LNG delivered to European markets the distances are 6000-6500 miles via the Suez Canal but an additional 5000 miles if the route is via the Cape of Good Hope. Australian LNG cargoes are very rarely delivered to Europe because the distance via any possible route is in excess of 11000 miles.[204]

In 2023-24 the Panama Canal restricted numbers of LNG ships due to low water levels and even when these restrictions had been lifted vessel numbers remained low.[205] During the same period, LNG shipping via the Suez Canal was severely restricted due to hostilities against shipping in the Bab al Mandab Straits forcing them to use the Cape route.[206] These problems had a significant impact on the shipping distance for US LNG deliveries to Asia and Qatari deliveries to Europe (shown in Table 6). Therefore, in terms of emissions from shipping, US LNG has an advantage delivering to Europe, particularly if Qatari LNG has to travel via the Cape route. Australian LNG has a substantial advantage over the US, and a significant advantage over Qatar for all Asian destinations other than India (and the rest of South Asia) where Qatari cargoes have the shortest route.

The extra distance which a ship needs to travel raises the issue of the different emission profiles of ship engines. There are relatively few studies of emissions from LNG shipping based on actual measurements.[207] The most important are fugitive emissions when the LNG is being unloaded from the ship, and `methane slip' – the percentage of methane in fuel which is emitted unburned from the engine. Of the total LNG tanker fleet of 772 ships in 2023, nearly 90% are estimated to be powered by LNG (dual-fuel engines) and the rest by liquid fuels.[208] In 2023, the European Commission issued a Regulation giving default emission factors for all types of ship including four types of LNG carrier engines.[209] These factors are similar but not identical to those of the International Maritime Organisation (IMO).[210] A previous OIES publication noted potential inconsistences between EU and IMO standards and uncertainties over which will prevail in the longer term.[211] An independent study of measured emissions from a large LNG-powered ferry and unloading emissions from three LNG carriers recommended that both the EU and the IMO should consider increasing the default methane slip for the low pressure dual fuel engine from 3.1% (EU) and 3.5% (IMO) to `at least 6%'.[212]

[203] US plants are located on the Gulf and east coasts. Australian plants are located on the west, north and east coasts. Russian plants are located on the north and east coasts.
[204] https://sea-distances.org/
[205] Financial Times (2024).
[206] Sharples (2024),
[207] Balcombe et al (2022) is the first academic study of which this author is aware.
[208] GIIGNL (2024), p.26. DNV (2024), pp.19-20. In 2024, an additional 339 LNG-fuelled LNG carriers were on order.
[209] European Commission (2023), Annex 1. The emissions factors (% of the mass of the fuel used by the emissions source) for each engine are: LNG Otto dual fuel medium speed (3.1), LNG Otto dual fuel slow speed (1.7), LNG diesel dual fuel slow speed (0.2), Lean burn spark ignited (2.6).
[210] IMO (2023). p.51. This source includes an additional engine type: Steam turbines and boilers (0.01).
[211] Olczak and Piebalgs (2023).
[212] ICCT (2024), p.v.

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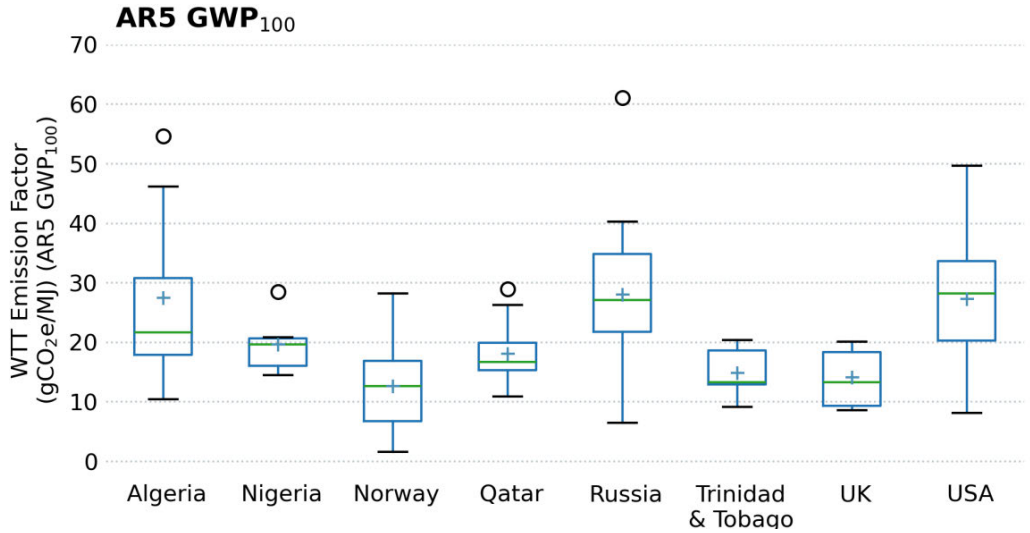
From 2024, EU regulations required GHG emissions from shipping to be measured and reported under the EU emissions trading scheme (ETS). Thus emissions charges for shipping of all fossil fuels will be measured and paid for separately from the Methane Regulation.[213]

8.4 Estimates of greenhouse gas emissions from LNG supply chains from specific exporting countries to specific markets

Results from a literature review of greenhouse gas intensity of European LNG imports, which includes assessments of six of the ten largest global LNG exporters, are shown in Figure 9.

Figure 9: Greenhouse Gas Intensity of LNG Exporters to Europe

Well-to-Tank carbon intensity (gCO_2e/MJ, AR5, GWP_{100})



Notes: – Upstream to Liquefaction stages only, the rectangle encompasses the first to third quartile of the data collected, + = mean values, horizontal line = median values, o = maximum recorded values
Source: Carr et al (2024), Figure 3 and Table 8, p. 22

Despite some of the literature having been published several years ago, Figure 9 makes points which are relevant to all observations of LNG emissions:

- There is substantial variation in the results from different studies, particularly for Algeria, Russia and the US.
- Absolute data are very dependent on which GWP time horizons and which IPCC Assessment Report (ARs) values are used. The study gives data for GWP 20-year and GWP 100-year time horizons and values from AR4, 5 and 6 (see Metrics Section 3).
- Considerably more studies use AR5 metrics than AR4 or AR6, and many more use GWP100 than GWP20. For six of the ten largest LNG exporters there were 98 observations for AR5 GWP100 but only 26 for GWP20. There are also significant variations in literature on individual countries, with 47 studies of US emissions using AR5/GWP100, compared with 5/6 for Nigeria and Trinidad.[214]

This illustrates the uncertainty factors which are involved in any estimate of emissions and the possibility of substantial differences between estimates depending on when and how the studies were carried out.

[213] For a detailed discussion of EU emissions from shipping see Olczak and Piebalgs (2023).
[214] Ibid, Table 6.11, pp. 20-24.

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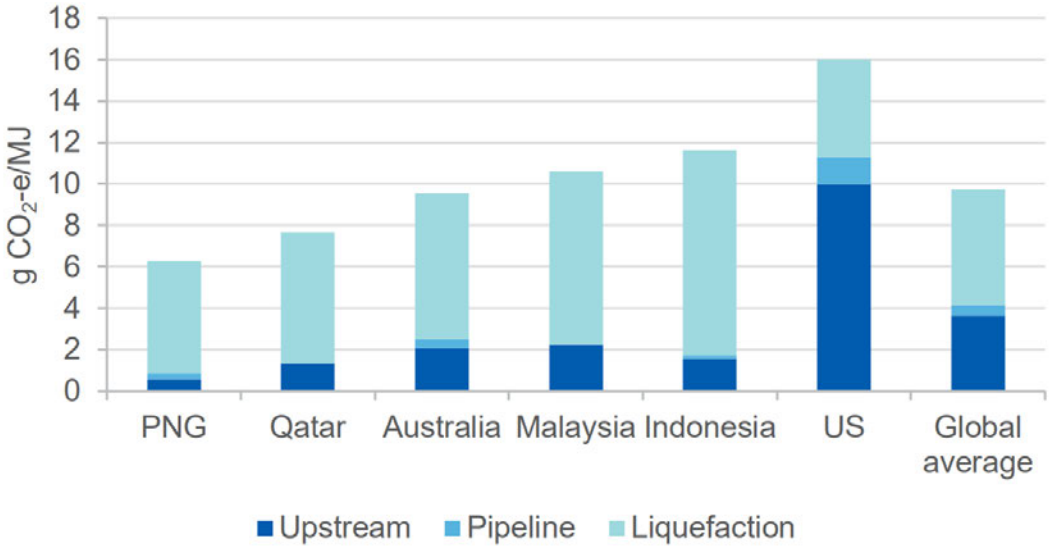
Figure 10: GHG Emissions Intensity of Selected LNG Exporters



Notes: Shown as the emissions under normal operating conditions. Measured for LNG loaded onto vessels. Includes operational and under construction projects.
Source: Department of Industry, Science and Resources (2024), Figure 2.6, p.27. Data from Wood Mackenzie LNG Emissions Benchmarking (data tool), December 10, 2023.

A limited number of public domain estimates are available for greenhouse gas emissions from LNG exports from different countries, both in general and delivered to specific locations. Unfortunately these are mostly not comparable because of different units and different stages of the supply chain but it is possible to compare Figure 10 and Table 7.[215]

Table 7: Global Warming Potential for LNG Delivered to Germany (GWP100)

	GWP 100 [gCO2e/MJ] according to IPCC 2013						GWP 100 [gCO2e/MJ] according to IPCC 2021
	Production and processing	Pipeline transport	Liquefaction	Ship transport	Regasification	Total	Total
Algeria	19.2	1.0	6.3	0.8	0.1	**27.5**	**27.3**
Qatar	6.9	0.2	8.0	2.6	0.1	**17.7**	**17.7**
Malaysia	8.2	0.9	7.6	3.7	0.1	**20.6**	**20.5**
Nigeria	11.2	0.4	7.2	1.9	0.1	**20.8**	**20.7**
Indonesia	7.7	0.1	7.3	3.5	0.1	**18.8**	**18.7**
USA	12.4	0.9	7.2	2.1	0.1	**22.7**	**22.6**

Source: Munter and Leibich, (2023), Table 13, p.27

[215] Figure 10 data are only for the production to liquefaction segment, so that for comparison ship transport and regasification have to be subtracted from Table 7.

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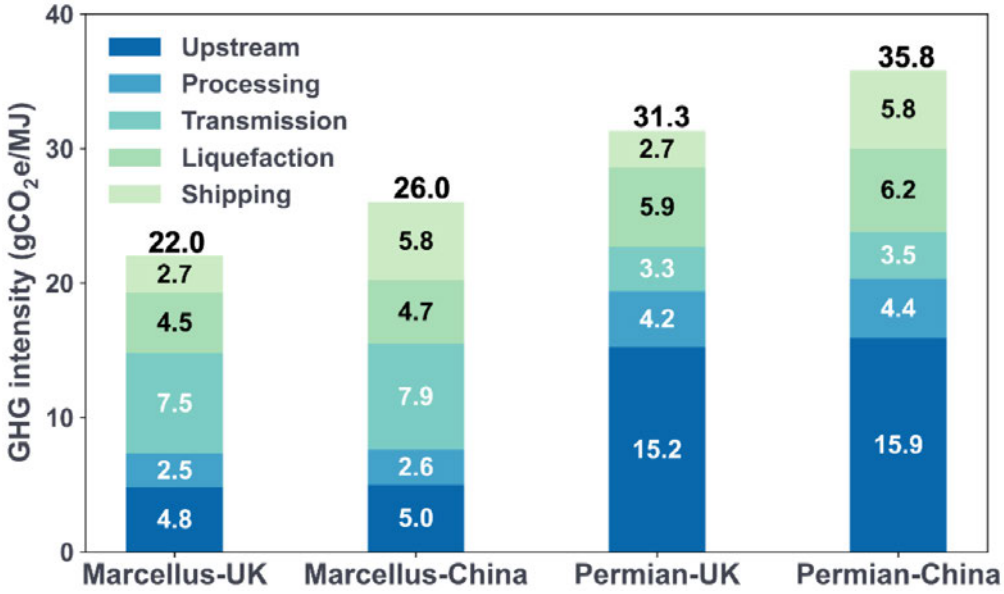
For countries common to both sets of data, Table 7 data are 20-40% higher than Figure 10, with Qatari emissions nearly twice the Figure 10 estimate. Table 7 also shows Algerian emissions by far the highest due to production and processing figures far above all other countries, possibly due to the country's flaring intensity shown in Table 4. In all cases other than the US, Figure 10 data have a much higher share of emissions from liquefaction than Table 7 which corresponds well to data from Rystad Energy (although the two sources have very few countries in common).[216] Of the 10 largest LNG exporters the only country for which these sources provided no estimate is Oman. which corresponds to the observation above of a complete lack of official data.

Figures 10 and 11 make different points about emissions from US LNG exports which are particularly important given the country is, and will increasingly be, the largest global exporter. Figure 11 shows measurement-informed GHG emissions intensity from two US basins – Permian and Marcellus – exported to the UK and China from a liquefaction terminal in Louisiana, showing upstream and processing emissions from the Permian Basin around 50% higher than the Marcellus.[217] This emphasises the problem of studies (such as those in Table 7) which only provide a single figure for US emissions from production to liquefaction. A smaller but still significant disparity is the difference in shipping emissions which are twice as large for China compared with the UK.

Figure 11: Lifecycle Assessment of GHG Emission Intensity of US LNG Exported to the UK and China (CN) Studies (100 year GWP)



Source: Zhu et al (2024), Figure 2

Figure 12 shows emissions from US LNG exported to a much larger range of countries but specific to the supply chains leading to Sabine Pass and Corpus Christi liquefaction terminals in 2022 using `gas pathing' methodology to achieve enhanced life cycle analysis.[218] A feature of this data is the very large upstream addition caused by the measurement of emissions. By comparison, measurement adjustments for liquefaction and shipping are minimal. The differences in intensity for different countries are mostly what would be expected with Asian markets greater than Europe (reflecting the differences in Figure 11 between China and the UK). But aside from East Asian destinations, intensity is surprisingly uniform for much of Europe, south and south East Asia and Latin America (with Brazil [high] and Columbia [low] as outliers).

[216] NSTA (2023), all data sourced from Rystad Energy's Gas and LNG trade emissions analysis dashboard (July 2023).
[217] Zhu et al (2024) takes data from a range of studies from 2017-22.
[218] See Roman-White et al (2024) for an explanation of the methodology and how it differs from previous estimation estimates.

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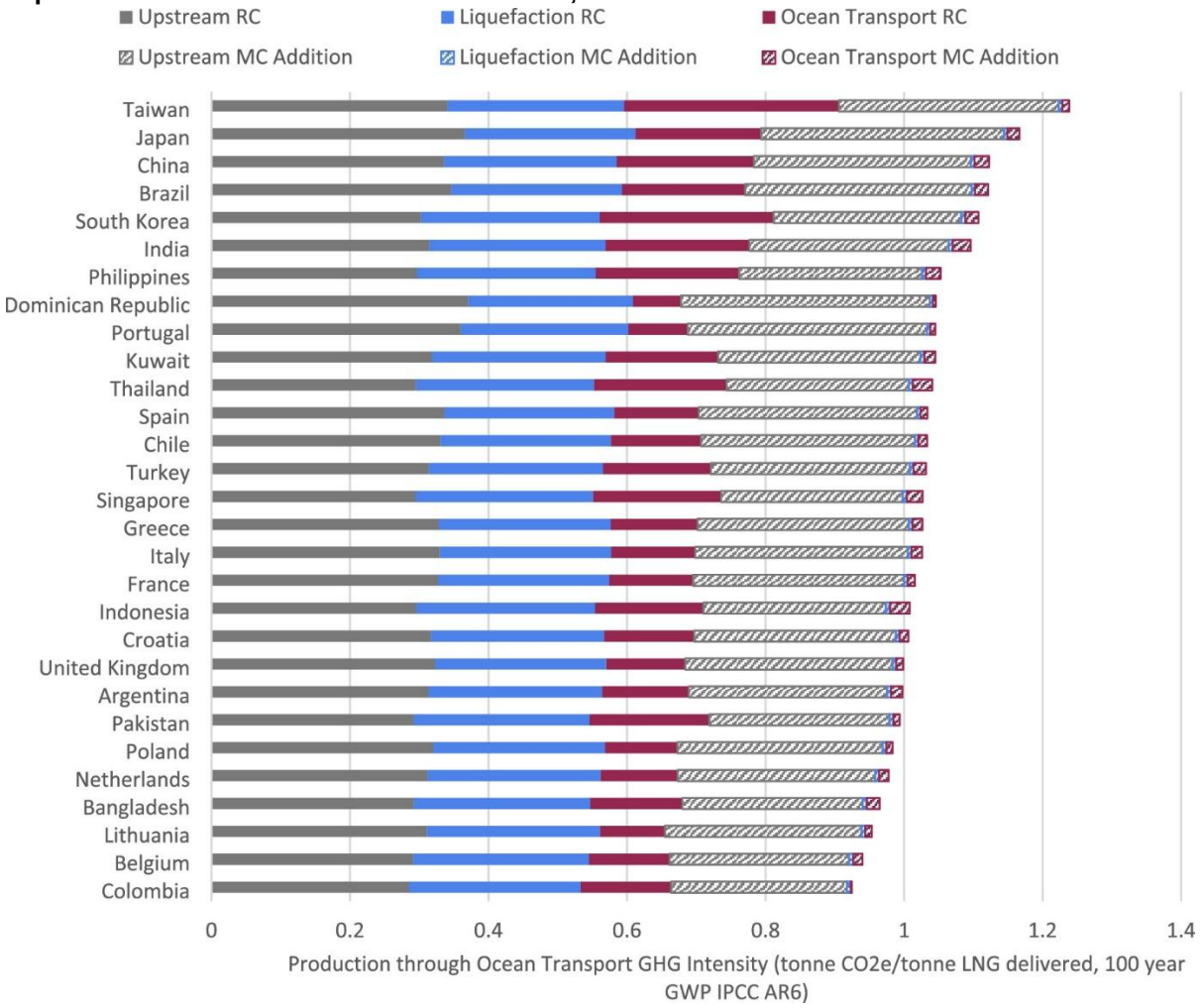
Figure 12: Greenhouse Gas Intensity of US LNG Exports from Sabine Pass and Corpus Christi Liquefaction Terminals to Selected Countries, 2022



Notes: RC: Reference case : activity and emissions data from EPA's 2022 Subpart C and Subpart W production through liquefaction, augmented by upstream supply chain data from Cheniere where available.
MC: Measurement informed case study data. MC provides an assessment of the impact of higher methane emissions from the production through shipping cycle but is less specific to Cheniere's supply chain and limited to a regional understanding of the upstream
Source: Roman-White et al (2024), Figure 5. Page G

This section has underlined the need for granular detail for estimates of emissions attributed to supply chains. The most important of these are clarity on measurement versus estimation of emissions for each part of the supply chain, and the date and frequency of measurements. This is particularly important for exporting countries where different liquefaction terminals can be supplied from a range of different production locations, through complex supply chains. For estimates of emissions from LNG cargos delivered to different markets, shipping distances and details of the type of ship delivering a cargo are also very important. To summarise, without such granular detail generalisations of greenhouse gas emissions of LNG exports from a specific country are at best misleading. The problem for researchers is how to obtain such detail, which will require the asset-holders to provide it voluntarily or be required to do so by regulators, and be subject to verification by accredited experts.

What these studies show is that comparisons of deliveries from different LNG suppliers to different markets need accurate measurement and reporting of emissions from individual supply chain stages:

- For production through liquefaction (i.e. before the LNG is shipped) comparisons need to take into account the complexity of supply chains and liquefaction plants in widely different locations.

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- For production through shipping (i.e. landed LNG prior to regasification) comparisons are additionally required for shipping distances and the emission characteristics of individual ships.
- For full supply chain comparisons including end-use in the importing country, emissions from the fuel or energy source which the importer is currently using which LNG would replace (or would use in the absence of LNG) need to be calculated and compared with LNG. In the widely cited case of LNG replacing coal in Asia, full LNG supply chain emissions need to be compared with full coal (domestic or imported) supply chain emissions including methane emissions from the coal supply chain. In addition, assumptions that LNG will always be replacing coal in power generation may not be correct as in many Asian countries, industrial and transport sectors may be more likely end users.

For comparisons between projects, an important additional factor which needs to be taken into account is the age and efficiency of assets in the supply chain.

9. Transparency and Confidentiality

One of the major problems arising from any study of methane emissions, and any attempt to verify data or methodology, is a lack of transparency. The most usual cause, or reason given, for this absence of transparency is confidentiality. Natural gas and LNG contracts tend to include `blanket' confidentiality clauses as standard, an example of which is:

> *`Each party shall treat and keep all terms and conditions of this Agreement, any information disclosed to it by the other Party…(collectively referred to herein as "**Confidential Information**")…and shall not transmit, reveal, disclose or otherwise communicate Confidential Information in whole or in part to any Third party..'.*[219]

9.1 The EU Methane Regulation

Transparency requirements are stated in Article 1 of the EU Methane Regulation on subject matter and Scope. Section 6 already laid out the provisions for establishing a Methane Transparency Database and the publication of Methane Performance Profiles (Articles 30 and 31). However, three articles of the Regulation refer specifically to confidentiality provisions.

Use and sharing of information: `in performing their tasks..the Commission, the Competent Authorities and Verifiers shall consider the information made publicly available by the IMEO or OGMP 2.0..in particular information on.. d) publication of aggregated reported data by core source and by level of reporting, classified by, where available, operated and non-operated assets, in compliance with competition and confidentiality requirements'.[220]

Monitoring, reporting and verification measures: `The competent authorities of the Member States shall protect the confidentiality of the information received from importers under this Article, in accordance with Union law..[and] shall provide that information to the Commission which shall protect the confidentiality of such information, in accordance with Union law.'[221] The same wording applied to methane intensity.[222]

Subsequent to the publication of the Regulation, the Commission replied to the question: `What information will be published? How will commercial confidentiality be maintained?' as follows:

> *`A key objective of the EU Regulation is to achieve much higher levels of transparency and disclosure on the reporting and abatement of methane emissions than currently exists globally. It is considered that all the information and data which the Regulation imposes on operators and importers is of interest to the wider public and should therefore be publicly available and free of*

[219] Qatar Liquefied Gas Company Ltd and Pakistan State Oil Company (2016), Clause 25.1, p.60.
[220] European Commission (2024), Article 10(1d).
[221] Ibid, Article 28(4).
[222] Ibid, Article 29(3).

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charge. Should such information not be delivered, there is the risk that the obligated parties will be considered to not have complied with the Regulation, and may face the consequence of non-compliance. The industry should consider the possible reputational risk as such non-compliance will be reflected in the country/company Methane Performance Profiles that the Regulation tasks the Commission to adopt and make publicly available.'[223]

If disclosure of MRV of emissions is required by regulators and therefore included in contracts, these would need to be specifically excluded from confidentiality requirements, which is straightforward as long as both parties agree but may be contrary to corporate confidentiality commitments.

9.2 United Nations and corporate initiatives

OGMP 2.0 contains strict confidentiality provisions:

1. `All information and data supplied by member companies to UNEP in connection with the "OGMP 2.0 Framework" shall be kept confidential and not disclosed to third parties subject to points 2 and 3 below.
2. UNEP may publish or disclose information consolidated in accordance with Section 4.6, provided that member companies will have a reasonable opportunity to review and raise comments prior to the publication on the information intended for publication.

`UNEP may disclose information or data received by member companies to a legal entity with which it is under common control; as well as with a third party for the sole purpose of consolidating and or analysing such information or data, on conclusion of an undertaking of confidentiality from such third party at least as strict as the provisions of this Section.'[224]

The reporting framework of the Oil and Gas Climate Initiative (OGCI) confirms that its members collect this data individually and have it verified but only publish it in an aggregated form.[225]

`Since 2016, OGCI has been working.. [with] an independent 3rd party, to collect and check data consistency, and guarantee the confidentiality of member companies' data. In 2019, we developed…information about the level of third-party assurance that member companies apply individually into OGCI data reporting..Our process confirms that OGCI data, as well as information about third-party data assurance are consolidated, reviewed and challenged in order to increase the reliability of the aggregate data we publish.'

Following this template, OGCI emissions data is reported as an aggregate of 12 companies, defeating one of the aims of the EU Methane Regulation which is to allow buyers to base purchases on the emissions profile of individual suppliers.[226]

The aims of the Oil and Gas Decarbonisation Charter (OGDC) were discussed in Section 5 but its aims in relation to MRV are also very important:[227]

`Make public their 2030 target for Scope 1 and 2 emissions by 2025, and update that target by 2028. Aim to implement current best practices by 2030 to reduce global average emissions intensity of the oil and gas industry. Facilitate cooperation and transparency across the sector and commit to publish emissions performance annually through the OGDC platform. Measure, monitor, publicly report and independently verify GHG emissions and progress in reducing emissions, and to support continuous improvement in data quality, in accordance with internationally-recognized frameworks.'

[223] European Commission (2024c), Answer A12.
[224] OGMP 2.0 (2020), p.18.
[225] OGCI (2024), para 3.1.
[226] OGCI applied the same principle to its satellite monitoring work with external companies stressing that: `Trust and confidentiality is critical for effective collaboration', and `The confidentiality provided throughout the campaign helped to establish a collaborative and dynamic environment'. OGCI (2024), p.6 and 22.
[227] OGDC (2023). Continuous Improvement and Interim Ambitions, Transparency, Measuring and Reporting Progress.

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It is important to stress that these are aims and ambitions and that the commitment to publish emissions performance is qualified by being `subject to applicable laws of respective operations and jurisdictions'. Nevertheless these go significantly further than similar commitments from other initiatives, and are subject to monitoring once the 2030 targets have been announced.

In 2024, OGDC launched a baseline survey - `a self-reported data collection process among signatories'. This survey `and its iterations in the years to come will be the primary source of data for OGDC as it monitors the progress of signatories toward Charter goals'.[228] OGDC's 2024 Baseline Survey suggests significant problems in achieving these aims. Somewhat surprisingly, the Survey used Rystad Energy estimates of production levels and GHG emissions, rather than data from Charter signatories themselves. The Survey noted that:

> *`Rystad Energy leverages its proprietary methodology to provide the above estimates …there is some unavoidable uncertainty around upstream GHG emissions – particularly regarding methane. As a result, its numbers should be considered ballpark figures only. Rystad Energy's estimates are based on a different methodology and dataset to those used by many companies. Neither the OGDC not its signatories are in a position to validate or confirm Rystad's data or estimates'.*[229]

These comments are not confidence-inspiring in relation to either transparency or quality of data and raise the question of whether OGDC members will be required to submit corporate data for future surveys.

The OGDC Baseline Survey posed a series of questions to signatories in relation to its major aims. In relation to its near-zero upstream methane emissions ambition, around one third of responses were partially or fully consistent with the text of the Charter and partially or fully substantiated with public information; the figure for eliminating routine flaring was slightly higher at 41%. This means that between 41% and two thirds of responses to these questions were either not supported by public information or not consistent with the Charter text.[230]

Certifying companies (see Section 3 and Appendix 2) provide little or no transparency of their operations with public disclosure ranging between `none', `list of participants only' and `list of consenting participants'.[231]

The lack of public domain data and insistence on confidentiality of emissions data, leads to questions as to why this data should be considered confidential. This author has received the following explanations from several LNG suppliers:

- Company policy is not to make this data public.
- Our contracts do not allow us to disclose this data.
- We would be willing to make our data public but our (joint venture) partners will not agree.
- If we make emissions from specific assets public, competitors will be able to estimate our production levels or other commercially sensitive data.

In relation to any usual definition of commercial confidentiality - which is information that would impact the commercial or financial position of a company - none of these explanations is convincing. Critics therefore assume that the real explanation for lack of transparency is potential embarrassment for companies with very high levels of emissions. Public confidence is not helped by mainstream business reporting which suggests that oil and gas companies `regularly hide leakages of methane'.[232] Unwillingness of companies to make asset level and supply chain emissions data and methodologies publicly available, contributes both to cynicism of their motives and assumptions of much higher

[228] OGDC (2024), p.06.
[229] OGDC (2024), p.16.
[230] Ibid, pp.30-31.
[231] Highwood Emissions Management (2023), pp.35-36.
[232] Financial Times (2024a).

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estimates by NGOs and academics which media and civil society tend to regard as credible. There is little attempt by the industry to engage with published studies showing very high emissions from gas and LNG exports, presumably because of a reluctance to reveal any of its own data.[233]

Perhaps surprisingly, public disclosure of emissions has not thus far proved to be a major issue in US gas and LNG supply chains. Section 15.10 of the North American Energy Standards Board (NAESB) Base Contract for the Sale and Purchase of Natural Gas does not specifically mention environmental data in relation to what parties may disclose.[234] No cases have been recorded involving confidentiality of emissions data and should these arise they would need to be argued in court by the parties.

Transparency of emissions will be key to what is often referred to as `gas advocacy'. A leading gas consultancy making the case for natural gas's role as a transitional energy source, concludes that:

> *`The industry must do more to convince stakeholders of the benefits of gas through clear, consistent and coordinated advocacy and messaging. Policymakers, lenders, consumers and the wider population must all be persuaded of gas's environmental credentials, reliability and flexibility as a transition fuel'.*[235]

Without transparency of MRV data at both corporate and supply chain level, any such advocacy and messaging are likely to fail.

10. Summary and Conclusions:

There is general agreement that reducing methane emissions from the oil and gas sector is one of the easiest and lowest cost measures which can have a significant impact on global warming prior to 2050. Since 2022, there have been many announcements and documents signed both by governments and oil and gas companies targeting methane emissions reduction both in general and specifically in the oil and gas sector. Available data suggests that in the 2020s emissions have continued to increase globally and from the oil and gas sector, but at a slower pace. Detailed analysis is difficult due to lack of granular national and sectoral data. Global methane emissions from the energy sector, having fallen in 2020 (due to the Covid-19 pandemic), increased slowly in the 2020s back to the peak level of 2019. At the same time, significant progress has been made in creating systems for more accurate measurement, reporting and verification of methane emissions.

Initiatives and Commitments

The Global Methane Pledge signed in 2021, covering emissions from agriculture and waste as well as energy, has grown to 160 signatories. But despite being strongly endorsed by successive G7 meetings, there is no way to judge either the overall progress of the Pledge towards its collective goal of reducing emissions by 30% from 2020 levels by 2030, or the progress of individual countries. Industry initiatives such as the Oil and Gas Climate Initiative (OGCI) have reported substantial reductions of emissions from a group of 12 companies which have achieved their commitments (aggregate upstream operated methane intensity target of well below 0.2% reached in 2021, four years ahead of the 2025 deadline), but with no granularity of either individual company results or how these were reached. The Oil and Gas Decarbonisation Charter (OGDC) launched a baseline survey of emissions which will inform its targets for 2030, but not using data provided by its member companies.

The Oil and Gas Methane Partnership (OGMP) 2.0, a voluntary methane measurement and reporting framework, has 140 corporate members in 70 countries, but with 80% of the membership concentrated in Europe and North America. The International Methane Emissions Observatory (IMEO) collects and publishes OGMP data as well as the reporting levels reached by its members. Significant progress has been made in that 46% of companies achieved Level 5 (Gold Standard) reporting in 2024 but the actual volume of emissions at that level remains small.

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[233] An exception is Al-Attiyah Foundation (2025) which challenges the assumptions in Howarth (2024) in relation to emissions from coal and US LNG.
[234] cs012102w4.PDF
[235] Wood Mackenzie (2025), p.9.

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No additional inter-governmental or multinational corporate initiatives seem necessary but three major problems are that:

- Signatories to these initiatives have not sufficiently documented their progress towards the targets contained therein, so that it is difficult to judge the credibility of their commitments.
- None of these initiatives meets the needs of all stakeholders: governments, regulators, investors, energy companies and customers.
- Signatories to corporate measurement initiatives are dominated by European and North American companies, probably because of their complexity and a lack of available technology elsewhere. Geopolitical considerations may account for the absence of China, Russia and India from government initiatives, and very few of their companies are signatories to corporate initiatives.

Regulation and Legislation

US and EU regulation and legislation in the process of being implemented, require companies to switch reporting of emissions from engineering estimates or default factors to actual measurements. EU regulation also requires third party verification by accredited companies. The Biden Administration's Inflation Reduction Act introduced methane fees charged on emissions which exceed defined limits, but with the arrival of the Trump Administration these have been rescinded. It remains to be seen how much of the Biden Administration's methane reduction programme and engagement in international initiatives will survive, although its removal is procedurally complex and may take time.

The EU Methane Regulation which entered into force in 2024 can be considered both a great achievement and a great disappointment. The achievement is that it was adopted despite many member states being unenthusiastic; the disappointment is that it is far less ambitious than was promised in the 2020 Methane Strategy. The Regulation is restricted to emissions from the production segment which may miss the 60-70% of emissions from other segments of long and complex supply chains. It does not become fully operational for imports until 2030 and key metrics such as intensity and equivalence have yet to be defined, including eligibility for country-level as opposed to producer-level equivalence. Imports which exceed intensity thresholds will not be banned from the EU, but will be subject to penalties determined by Competent Authorities which will require consistent interpretation across member states. While the Regulation applies to all fossil fuels, the initial focus has been on natural gas and particularly liquefied natural gas (LNG) possibly because of the substantial increase in European imports post-2022.

Liquefied Natural Gas (LNG): measurement, reporting and verification

LNG-related Initiatives

Attributing GHG emissions to a specific cargo of LNG is a complex process. In 2021, SGE and GIIGNL created LNG MRV initiatives but neither has been widely adopted. Trade in `carbon neutral' LNG cargos, concentrated on China and Japan, peaked in 2021 and by 2024 reports of trades had virtually ceased due to cost issues and uncertainties about both the calculation of emissions and the quality of offsets.

The Coalition for LNG Emission Abatement towards Net Zero (CLEAN) was launched in 2023 focusing on Japan and South Korea, with a mainly Japanese utility membership. CLEAN is a voluntary capacity-building initiative which cannot be compared with regulation or legislation, and does not (yet) include Chinese, South or South East Asian importers. But it is very important because around three quarters of global LNG cargos are delivered to Asian countries.

MRV technologies

Evolving regulatory frameworks have led to a substantial improvement of measurement technologies, particularly satellites which are able to identify smaller emissions releases with increasing geographical accuracy. Where conditions do not allow satellite observations, aircraft overflights are being used. Both of these techniques need to be reconciled with site- and source-level measurements at ground or low altitude level. In the US, which has the most complex LNG supply chains, studies are combining measured data supplied by asset holders – producers, marketers, transmission, processing and storage companies - along supply chains using `gas pathing' algorithms which allow data gaps to be more accurately estimated, albeit with considerably complex calculations.

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For a country such as Qatar, where gas can be traced from a specific gas field through a specific pipeline to one liquefaction terminal (or terminals within a limited geographical area), a country-level estimate of LNG emissions may be considered representative. But for US and Australian exports cargos can be sourced from completely different gas fields, (or in the case of the US different oil and gas basins), through different export terminals which may be hundreds or thousands of miles apart. For cargos delivered to a specific market or region, the location of the export terminal determines the distance from the source of the gas, as well as the distance from the specific market to which a cargo is delivered (including the specifications of the ship in which it is delivered), which will significantly impact the emissions from the total supply chain. Changes in all these parameters over time mean that data for a specific year may not be representative and studies have revealed how supply chain emissions can change significantly over time, requiring MRV observations on a periodic (ideally quarterly) basis. Since 2022, the US company Cheniere has included a confidential `cargo emission tag' for each delivered cargo, which includes a calculation of its life cycle GHG emissions, which suggests that such calculations are possible.

Studies seeking to demonstrate whether GHG emissions can be reduced by substituting other fossil fuels (most often coal) with LNG are required to compare emissions from a *specific* LNG supply chain with emissions from the energy supply chain which it is replacing, in addition to the GWP metrics which have been used and the date(s) of the estimates. This may not be possible unless detailed emissions data across both supply chains is available.

Confidentiality and transparency

A great deal more information is available about emissions for US LNG than for any of the other 10 largest global LNG exporters in Table 8. For many of these countries current data is either partial or completely absent. All of the current and future sources of methane emissions data – such as OGMP 2.0, IMEO, OGCI, the EU Methane Regulation - include confidentiality provisions which allow stakeholders to withhold information, except from parent organisations or governments.

Similar confidentiality provisions will apply to information gathered by accredited verifiers reporting to regulatory authorities, resulting in a serious transparency deficit. Certification companies mainly operating in North America present similar problems of transparency. These limitations strain the willingness of civil society to accept the accuracy and credibility of emissions data. One of the keys to acceptance will be a credible explanation of why MRV methodologies and data should be considered confidential.

Consequences for EU LNG Imports

By 2030, the EU Methane Regulation promises to have a significant impact on emissions from LNG trade. This will substantially impact companies which send the greatest percentage of their LNG to EU destinations.

Table 8: Regional Exports of 10 Largest LNG Exporters 2023 (Mt)

	EU	Other Europe*	Asia	Asia Pacific	Latin America	Middle East	North America	Total
United States	35.6	21	6.66	14.44	5.6	0.75	0.46	84.51
Australia	0.01	0	24.7	54.8	0.04	0	0.07	79.62
Qatar	12.98	2	37.74	21.28	0.14	4.07	0	78.21
Russia	13.07	1.2	8.64	8.23	0.06	0.07	0	31.27
Malaysia	0	0	6.87	19.74	0	0.14	0	26.75
Indonesia	0.07	0	4.36	10.91	0	0	0.25	15.59
Oman	0.59	0.06	2.03	8.45	0	0.4	0	11.53
Algeria	7.09	4.63	0.83	0.33	0.07	0.08	0	13.03
Nigeria	6.23	0.7	2.53	1.51	0.81	0.87	0.33	12.98
Trinidad	2.52	0.57	0.81	0.39	2.32	0.13	0.92	7.66
	78.16	30.16	95.17	140.08	9.04	6.51	2.03	361.15

*UK and Turkey
Source: GIIGNL (2024), pp.12-13

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Table 8 shows that, in 2023, on a national basis the share of exports delivered to EU member states was Algeria (54%), Nigeria (48%), Russia (45%), the US (42%), Trinidad (33%) and to a lesser extent Qatar (17%). Adding in exports to the UK and Turkey raises these percentages for Atlantic Basin exporters, especially the US where the figure rises to two thirds of its exports.

The fact that US exporters provided nearly half EU LNG imports in 2023 and 2024 demonstrates the importance of finding a regulatory accommodation between exporter(s) and importer at a country or company level. The Trump Administration has linked commitments to increased LNG imports to the imposition of tariffs on EU countries, but it remains to be seen how this plays out in negotiations. It is at least possible that the Administration will demand a relaxation of EU Methane Regulation rules which, for security of supply reasons, the EU may feel obliged to grant. However, the full impact of the Regulation on imports – including possible penalties for failing to meet intensity targets – will not come into force until 2030, beyond the term of both the current US Administration and the current European Commission and Parliament.

10.1 Progress since 2022 and the focus on LNG - the `four As': awareness, agreements, aims and achievements

Summarising progress on methane emissions since 2022 the evidence assembled in this paper shows that since 2022:

- There is a much greater degree of awareness of the problem and agreements about its importance.
- Substantial numbers of governments and oil and gas companies have signed documents and joined initiatives with aims and targets to substantially reduce emissions, which have been reflected in much stronger regulation in Europe and North America compared with other parts of the world.
- But the extent to which awareness, agreements and aims have led to achievements in terms of verified reductions of methane emissions is not clear.

To return to the propositions in the introduction to this paper, methane emissions are the potential Achilles Heel of any claim for gas and LNG to act as a transition or bridge fuel. For this reason far more transparency on the part of governments in relation to their Global Methane Pledge and national commitments is urgently needed. Similar transparency from the oil and gas sector is required in the form of statements from companies of emissions data and measurement methodology at asset level. Because of its projected expansion in the period up to 2030, attention is currently focussed on emissions from LNG. The LNG community therefore has the challenge to lead the way on providing publicly available detail of measurement, reporting and verification of emissions. The entire oil and gas sector may be judged by its ability and willingness to demonstrate and document significant progress in meeting that challenge as part of its license to operate.

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Appendices

Appendix 1: IEA Methane Tracker Methodology

Table A1: Categories of Methane Emission Sources and Emission Intensities in the United States

HYDROCARBON	SEGMENT	PRODUCTION TYPE	EMISSIONS TYPE	INTENSITY (mass methane/ mass oil or gas)
OIL	Upstream	Onshore Conventional	Vented	0.36%
OIL	Upstream	Offshore Conventional	Fugitive	0.09%
OIL	Upstream	Offshore	Vented	0.36%
OIL	Upstream	Offshore	Fugitive	0.09%
OIL	Upstream	Unconventional oil	Vented	0.72%
OIL	Upstream	Unconventional oil	Fugitive	0.18%
OIL	Downstream		Vented	0.004%
OIL	Downstream		Fugitive	0.001%
OIL		Onshore Conventional	Incomplete-flare	0.06%
OIL		Offshore	Incomplete-flare	0.01%
OIL		Unconventional	Incomplete-flare	0.04%
NATURAL GAS	Upstream	Onshore Conventional	Vented	0.29%
NATURAL GAS	Upstream	Onshore Conventional	Fugitive	0.11%
NATURAL GAS	Upstream	Offshore	Vented	0.29%
NATURAL GAS	Upstream	Offshore	Fugitive	0.11%
NATURAL GAS	Upstream	Unconventional gas	Vented	0.43%
NATURAL GAS	Upstream	Unconventional gas	Fugitive	0.17%
NATURAL GAS	Downstream		Vented	0.15%
NATURAL GAS	Downstream		Fugitive	0.10%

Source: IEA (2024) Table 1, p.5-6

Table B1: Scaling Factors Applied to US Emissions Intensities for Major LNG Exporters

	Oil		Gas	
	Upstream	Downstream	Upstream	Downstream
United States	1	1	1	1
Australia	0.8	0.5	0.6	0.5
Qatar	1.1	0.6	1	0.6
Russia	2.3	1.3	1.7	1.1
Malaysia	2.2	1.1	1.5	1.1
Indonesia	3.2	1.5	2.1	1.5
Oman	1.6	0.7	1	0.7
Algeria	4.7	1.4	2.1	1.4
Nigeria	3.8	1.8	2.4	1.8
Trinidad	nd			

Source: IEA (2024), Table 2, p.7

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Appendix 2: Comparison of Natural Gas Certification Schemes: supply chain coverage and grade levels

Table A2: A Comparison of Natural Gas Certification Programs: supply chain coverage, certification process level, certification and GHG quantification

Segment	Equitable Origin	MiQ	Project Canary
Offshore Production		✓	
Onshore Production	✓	✓	✓
Gathering & Boosting	✓	✓	✓
Processing	✓	✓	✓
Transmission & Storage	✓	✓	✓
LNG Import/Export		✓	
Distribution			

Category	Equitable Origin	MiQ	Project Canary
Public Standard	✓	✓	✓
Third-Party Assessment	✓	✓	
Certification Scope (production)	Site to basin level	Basin or sub basin level	Well to basin level
Certification Period	3 years, annual verification assessment	Annual	Annual, dynamic for certain elements

Category	Equitable Origin	MiQ	Project Canary
Methane Intensity	✓	✓	✓[1]
Methane Intensity Methodology[2]	NGSI	MiQ Standard[3]	Project Canary's Low Methane Rating (LMR)
Requires Direct Measurement		✓[4]	
Allows Direct Measurement	✓	✓	✓
GHG Intensity	✓	✓[1]	✓

[1] Voluntary add-on to the certification program.

[2] The Natural Gas Sustainability Initiative (NGSI) methane intensity protocol was developed to calculate intensity for each segment of the natural gas supply chain. NGSI calculates methane intensity as methane emissions associated with natural gas divided by methane throughput. ONE Future uses a similar calculation for methane intensity as NGSI, although the specific sources, emissions factors, and emissions allocation approach varies for certain segments. While both the NGSI and ONE Future protocols include quantification procedures, emissions estimates from direct measurement can be incorporated into the identical intensity equation used by both approaches. The Low Methane Rating (LMR) was developed to capture methane intensity at the basin and site level. LMR also uses a similar calculation for methane intensity as NGSI. Methane emissions calculations may also incorporate estimates from direct measurements, USEPA emission factors, emissions modelling, and other data sources for a higher level of data integrity.

[3] MiQ's methane intensity methodology is most closely aligned with the ONE Future protocol where certain emissions from sources are energy-allocated while others are allocated to an individual product. However, the allocation methodology for each source does not exactly align with the latest ONE Future protocol.

[4] Most MiQ-certified operators employ a direct measurement technology to meet their facility-scale monitoring requirements, and as such, most operators are required to directly measure emissions and amend their methane emission inventories.

Source: ERM (2023), Tables 2,3 and 4, pages 7,8 and 11

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Table B2: Natural Gas Certification Schemes – grade levels

Equitable Origin

Grade	Performance Target (PT) Level
A+	100% PT1, 75% PT2, 50% PT3
A	98% PT1, 50% PT2, 25% PT3
A-	95% PT1, 25% PT2, 10% PT3
B+	90% PT1
B	85% PT1
B-	80% PT1
C+	75% PT1
C	70% PT1

Performance Indicator	Disclosure Metric	Methodology
Methane Intensity by Segment	Percentage	NGSI intensity with description of methane quantification methodology
GHG Intensity by Segment	gCO_2e/MJ	EO100™ intensity with description of GHG quantification methodology
Zero Routine Flaring	Yes/No	No routine flaring within the asset during the full calendar year preceding certification date
Net-Zero Corporate Commitment	Yes/No	Publicly announced corporate commitment to achieving net-zero emissions by 2050
Water Recycle Rate	Percentage	Water recycled / total water usage
Freshwater Use Intensity	Percentage	Freshwater usage / total water usage

Notes: gCO2e/MJ = grams of carbon dioxide equivalent per megajoule; GHG = greenhouse gas; NGSI = Natural Gas Sustainability Institute

MIQ

Grade	Methane Intensity	Company Practices[1]	Monitoring Technology Deployment
A	≤ 0.05%	≥ 12	12
B	≤ 0.10%	≥ 8	8
C	≤ 0.20%	≥ 4	4
D	≤ 0.50%	0	0
E	≤ 1.00%	0	0
F	≤ 2.00%	0	0

[1] Point thresholds are based on the individual segment standard

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Project Canary

Grade	Score	Meaning
Platinum	> 125	Top 10% of peers
Gold	100-125	First quartile performance
Silver	75-100	Second quartile performance
Rated	< 75	Dedicated to continuous improvement

Table C2: Project Canary Low Methane Intensity Rating (LMR) Criteria

Rating	Methane Intensity	Company Practices	Scoring Requirements
LMR Minimum Qualification	≤ 0.20%	Minimum Requirements	≥ 0
LMR A	≤ 0.20%	Minimum Requirements + Further Differentiated Practices	≥ 5
LMR AA	≤ 0.10%	Minimum Requirements + Further Differentiated Practices	≥ 10
LMR AAA	≤ 0.05%	Minimum Requirements + Further Differentiated Practices	≥ 15

Source: ERM (2023), Tables 5,6,7,8 and 9. Pages 13-15

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Appendix 3: Initiatives for Reducing Methane Emissions

Name	Secretariat/Conveyor	Primary Participants	Main objective	Numerical target	Support activities
Advancing Global Methane Reduction (AGMR)	Methane Guiding Principles (MGP)	Companies	Instigate and accelerate country-level methane emissions reductions		Best-practice, support policy development, MMRV
Aiming for Zero	Oil and Gas Climate Initiative (OGCI)	Companies	Aims for companies to eliminate the oil and gas industry's methane footprint	Companies strive to reach "near zero" methane emissions from operated oil and gas assets by 2030	
Coalition for LNG Emission Abatement toward Net-zero (CLEAN)	Korea Gas Corporation and Jera	Companies	For LNG buyers and producers to reduce methane emissions in the LNG value chain by increasing the visibility of emissions through dialogue with producers, and by developing and disseminating best practices for reduction		Best practices, coordination

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Name	Secretariat/Conveyor	Primary Participants	Main objective	Numerical target	Support activities
China Oil and Gas Methane Alliance	China National Petroleum Corporation (CNPC), China Petrochemical Corporation (Sinopec) and China National Offshore Oil Company (CNOOC)	Companies	Comprehensively improve the standard of methane emissions control in China	0.25% intensity of natural gas production by 2025	
Global Flaring and Methane Reduction (GFMR) Partnership	World Bank (WB)	Countries and companies	A multi-donor trust fund focussed on helping developing countries cut carbon dioxide and methane emissions generated by the oil and gas industry; ending routine flaring at oil production sites across the world; and reducing methane emissions to the greatest extent possible		Financing, best practices, project development, policy
Global Methane Pledge (GMP)	Climate and Clean Air Coalition (CCAC), United Nations Environment Programme (UNEP)	Countries	To take voluntary actions to contribute to a collective effort to reduce global methane emissions at least 30% from 2020 levels by 2030	Global 30% reduction from 2020 levels by 2030	Coordination, support policy development, financing
Methane Alert and Response System (MARS)	International Methane Emissions Observatory (IMEO)	Countries and companies	The first global satellite detection and notification system providing actionable data on very large methane emissions around the world		Satellite super-emitter detection

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Name	Secretariat/Conveyor	Primary Participants	Main objective	Numerical target	Support activities
Methane Roadmap Action Programme	Climate and Clean Air Coalition (CCAC)	Countries	Supports the development and implementation of transparent and consistent national methane roadmaps		Coordination, support policy development, best practices
Oil and Gas Decarbonisation Charter (OGDC)	To be confirmed	Companies	Dedicated to speeding up climate action and achieving high-scale impact across the oil and gas sector	0.2% methane intensity of oil and gas production by 2030	
Oil & Gas Methane Partnership (OGMP 2.0)	United Nations Environment Programme (UNEP), International Methane Emissions Observatory (IMEO)	Companies	Commits to providing a comprehensive, measurement-based reporting framework for the oil and gas industry that improves the accuracy and transparency of methane emissions reporting		MMRV
Zero Routine Flaring by 2030 (ZRF)	World Bank (WB), Global Flaring and Methane Reduction Partnership (GFMR)	Countries and companies	Commits governments and oil companies to voluntarily end routine flaring by 2030, as well as to annually report their flaring data and progress towards this target	Zero routine flaring by 2030	Financing, feasibility studies, project identification and development, policy and regulation, monitoring, best practices

Note: MMRV = Measurement, monitoring, reporting and verification
Source: IEA (2024f)

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Appendix 4: Global Methane Pledge

Recognizing that, in order to ensure that the global community meets the Paris Agreement goal of keeping warming well below 2 degrees C, while pursuing efforts to limit warming to 1.5 degrees C, significant methane emission reductions must be achieved globally by 2030;

Recognizing that the short atmospheric lifetime of methane means that taking action now can rapidly reduce the rate of global warming and that readily available cost- effective methane emission measures have the potential to avoid over 0.2 degrees C of warming by 2050 while yielding important co-benefits, including improving public health and agricultural productivity;

Recognizing that methane accounts for 17 percent of global greenhouse gas emissions from human activities, principally from the energy, agriculture, and waste sectors, and that the energy sector has the greatest potential for targeted mitigation by 2030;

Recognizing that the mitigation potential in different sectors varies between countries and regions, and that a majority of available targeted measures have low or negative cost;

Recognizing that, to keep 1.5 degrees C within reach, methane emission reductions must complement and supplement, not replace global action to reduce carbon dioxide emissions, including from the combustion of fossil fuels (coal, oil and natural gas), industrial processes, and the lands sector;

Recognizing that improvements to the transparency, accuracy, completeness, comparability, and consistency of methane emissions data assessed and validated in accordance with United Nations Framework Convention on Climate Change (UNFCCC) and Paris Agreement standards and Intergovernmental Panel on Climate Change (IPCC) good practice can promote more ambitious and credible action;

Recognizing that, while there are multiple useful international initiatives that address methane, there is a need for high-level political engagement in order to catalyze global methane action.

The Participants in the Global Methane Pledge:

Commit to work together in order to collectively reduce global anthropogenic methane emissions across all sectors by at least 30 percent below 2020 levels by 2030.

Commit to take comprehensive domestic actions to achieve that target, focusing on standards to achieve all feasible reductions in the energy and waste sectors and seeking abatement of agricultural emissions through technology innovation as well as incentives and partnerships with farmers.

Commit to moving towards using the highest tier IPCC good practice inventory methodologies, consistent with IPCC guidance, with particular focus on high emission sources, in order to quantify methane emissions; as well as working individually and cooperatively to continuously improve the accuracy, transparency,

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consistency, comparability, and completeness of national greenhouse gas inventory reporting under the UNFCCC and Paris Agreement, and to provide greater transparency in key sectors.

Commit to maintaining up-to-date, transparent, and publicly available information on our policies and commitments.

Commit to support existing international methane emission reduction initiatives, such as those of the Climate and Clean Air Coalition, the Global Methane Initiative, and the relevant work of the United Nations Environment Programme, including the International Methane Emissions Observatory, to advance technical and policy work that will serve to underpin Participants' domestic actions.

Welcome and encourage announcements of further parallel specific domestic actions by Participants and commitments taken by the private sector, development banks, financial institutions and philanthropy to support global methane abatement.

Resolve to review progress towards the target of the Global Methane Pledge on an annual basis until 2030 by means of a dedicated ministerial meeting.

Call on other states to join the Global Methane Pledge.

Source: Global Methane Pledge.pdf

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Appendix 5: 2024 G7 Energy and Environment Ministers' Meeting Communique[236]

h) Methane emissions – Noting with concern that methane concentration in the atmosphere is still increasing, we underline that reducing methane emissions that account for about a third of the warming we experience today, is key to keep a limit of warming of 1.5°C within reach and avoid climate tipping points and limit temperature overshoot. We therefore recognise that methane emissions need to be reduced in all emitting sectors. We also underline that according to IEA's net-zero scenario reductions in the emission intensity and consumption of oil and gas results in a 60 percent reduction in GHG emissions from oil and gas operations from 2030 to limit warming to 1.5°C. We highlight that oil, coal and gas demand reduction is essential to reduce overall CO2 and methane emissions to limit warming to 1.5°C. Considering the high potential of the fossil energy sector to lead towards tangible methane emission reductions in the short and mid-term, we recognize that cutting methane emissions from fossil fuel operations by means of already existing technologies is largely feasible and cost-effective for oil and gas operations, and it should play a central role in national efforts to reduce such emissions along with the development of a global market for hydrocarbons associated with lower methane emissions. We also note the need to improve measurement and reporting of methane emissions from oil and gas industry operations using globally recognised frameworks such as Oil and Gas Methane Partnership OGMP 2.0 and call on the private sector to take effective voluntary measures by strengthening international frameworks on measurement and reporting. We highlight that G7 countries are putting in place measures to collectively deliver reductions in methane emissions across all sectors, including energy, waste, and agriculture, aligned with the Global Methane Pledge's collective goal of at least 30 percent reduction by 2030. We acknowledge the importance of taking practical actions to reach this goal with a view to identifying best practices, regulatory options and measures. We call on the IEA to further monitor the methane mitigation efforts and results at country level and develop concrete recommendations for reaching the 2030 collective global methane pledge. To further accelerate these efforts,

We commit to

I. pursue collective effort towards a 75 per cent reduction in global methane emissions from fossil fuels, including by reducing methane emissions intensity of oil and gas operations by 2030, through developing a robust methodology and use of measured data, and work with non G7 producing countries to reduce the methane emission intensity of imported fuels recognizing the IEA's emission reduction scenario;

II. accelerate methane measures in line with the global reduction level of at least 35 per cent in methane emissions by 2035 reflected in 1.5°C IPCC scenarios;

III. iii. accelerate methane emission measures as well as support developing countries in reducing methane emissions from waste sector including through advancing resource efficiency and circular economy 10 approaches, and improving landfill management, to contribute to achieving the available global methane emission reduction potential estimated from waste sector by 30-35 per cent by 2030;

IV. explore options for regulatory approaches and market-based instruments to support methane emission reduction actions;

V. enhance data transparency and accuracy, by utilizing satellite observation data, and supporting the work of the UNEP's International Methane Emissions Observatory;

VI. significantly reducing all domestic routine flaring and venting by 2030; and call G7 gas suppliers to do so.

[236] G7 (2024), p.9 and 16.

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13. Reducing methane emissions in third countries oil and gas producing economies – In order to promote the cooperation with third country oil and gas producing economies, we underline the need of targeted measures to reduce methane emissions and data consistency and comparability. We support international initiatives to improve methane emissions detection, measurement, monitoring and verification 17 across oil and gas supply chains, such as UNEP's International Methane Emissions Observatory, to facilitate the rapid methane reductions needed to achieve the objective of the Global Methane Pledge. We highlight the potential of working with development finance partners and the private sector to increase support for methane abatement in oil and gas producing economies, including developing countries, and emerging economies. We underline the importance of implementing national frameworks and associated NDCs that are conducive to long-term planning and investments in methane abatements.

We commit to:

i. in collaboration with IEA and UNEP IMEO and CCAC, work with interested oil and gas producing countries to deliver deep cuts to methane emissions, including through technical cooperation and transfer of enabling technologies, on voluntary and mutually agreed terms, and to identify best practices, regulatory options and measures and enhance transparency of emissions;

ii. promote actions to reduce methane emissions along natural gas, LNG and oil supply chains and enhance data transparency, improve methane emissions detection, quantification, source location;

iii. collectively explore actions to improve the measurement, monitoring, reporting and verification of methane emissions, including through the EU and US-led MMRV International Working Group and the Oil and Gas Methane Partnership 2.0, with a particular focus on the natural gas supply chain.

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Appendix 6: International Working Group to Establish Universal Approach to Measuring, Monitoring, Reporting, and Verifying Greenhouse Gas Emissions Across the Natural Gas Supply Chain [237]

Natural gas producers and exporters, importers and end users, governments, and other key stakeholders have made significant progress towards addressing this challenge through various measurement, reporting and verification protocols at local and international levels. A number of well-established domestic and international emissions reporting approaches already exist, our efforts are aimed at building on these existing approaches. This includes, but is not limited to, the United Nations Environmental Program's Oil and Gas Methane Partnership 2.0 (OGMP 2.0).

The MMRV Working Group will advance comparability by reviewing and building upon existing standards and protocols to provide a consistent set of technical criteria for reporting emissions and operating data at various levels of data availability. The approach will encourage and prefer measured data over modeled data and estimation of emissions, while balancing economic and technical feasibility. The MMRV Framework will also be technology neutral with respect to approaches for measurement of emissions. These actions will improve the accuracy and representativeness of the reported data. Comparability will be further supported by using transparent and consistent tools for estimating GHG supply chain emissions and data quality from pre-production through final delivery of the natural gas.

To provide comparable and reliable information, the MMRV Working Group will support independent third-party verification of the accuracy and representativeness of the emissions data and the aggregate supply chain GHG emissions intensity. It will also support accreditation to ensure that certifiers are independent of the reporting entity and are technically qualified to conduct reviews.

The MMRV Working Group's deliberations and recommendations are informed by a diverse group of global and local industry, environmental and technical stakeholders with broad expertise and technical knowledge related to MMRV and the oil and natural gas industry. With input from these stakeholders, the international MMRV Working Group will work collaboratively through 2024 to develop, where appropriate, guidance, protocols, and tools for voluntary use in natural gas markets. The MMRV Working Group may expand in the future to include additional hydrocarbons.

The MMRV Working Group will address methodological aspects of MMRV and will not agree to or prescribe performance-based emission reduction targets. Participants in the MMRV Working Group are not committed to, nor restricted from, the use or inclusion of the work products in any regulatory process, policy measures, or commitments.

Working group to advance credible information about greenhouse gas emissions

In October 2024, an international (GHG) across the natural gas supply chain to drive emissions reductions in the global marketplace. This working group, which began collaboration last year, is developing a consistent framework for the measurement, monitoring, reporting, and verification (MMRV) of methane, carbon dioxide, and other GHG emissions that occur during the production, processing, transmission, liquefaction, transport, and distribution of natural gas.

Currently, natural gas buyers lack the ability to compare claims being made about the GHG performance of different natural gas supply options. This is due to widely varying approaches for quantifying and reporting

[237] MMRV Framework (2023). The text and signatories can be found at https://thedocs.worldbank.org/en/doc/a903b5e6456991faf3b5e079bba0391a-0400072021/related/ZRF-Initiative-text-list-map-104.pdf

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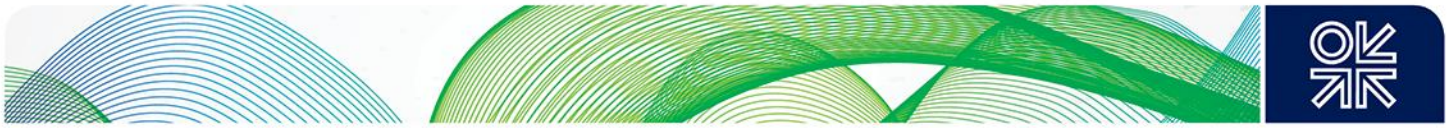

aggregated natural gas supply chain emissions and a lack of clear metrics for valuing and fostering higher quality data. The absence of an agreed framework for MMRV limits the ability of buyers to use purchasing decisions to incentivize greenhouse gas emissions reductions.

Comparability and reliability are critical for buyers to have confidence in the GHG supply chain emissions intensity data reported by natural gas suppliers. Buyers need a globally accepted approach for quantifying and aggregating emissions across the supply chain and assessing data quality that ensures comparability and reliability. The MMRV Framework is developing this approach and working to enhance credibility of reported information by establishing expectations for engaging accredited entities to conduct rigorous independent third-party reviews.

The International MMRV Working Group has reached the following key milestones in its effort to develop and deliver this framework for comparing natural gas supply chain GHG emissions from different suppliers in the global market, starting in 2025:

- Developed a consensus-based design architecture to guide the current technical development of the various elements of a future MMRV system
- Established multiple technical sub-groups consisting of a diverse mix of international government technical experts to guide the development process

The ongoing work of the MMRV Working Group includes:

- Leveraging internationally recognized principles for assessing the quality of data used to quantify the greenhouse gas intensity of natural gas delivered to buyers
- Building upon existing technical protocols for measuring and estimating methane and carbon dioxide emissions to establish a performance-based data quality approach that ensures comparability and values accuracy through consistent verification requirements
- Assessing international approaches to provide reliability and confidence in measures of supply chain GHG intensity using accredited independent third-party verification bodies
- Defining requirements and expectations for long-term management of the MMRV Framework to enable trust and confidence in the marketplace
- Seeking and incorporating technical input from industry, academia, non-governmental organizations, and other stakeholders to guide the development process and ensure future market acceptance of the MMRV framework once implemented.

Policy and technical experts from the governments of Argentina, Australia, Brazil, Canada, Colombia, Egypt, France, Germany, India, Italy, Japan, Malaysia, Mozambique, Nigeria, Norway, the Republic of Korea, the United Kingdom, the United Arab Emirates, and the United States, as well as the European Commission and the East Mediterranean Gas Forum, provide overall direction and technical input for the International MMRV Working Group. The group also receives input from experts in industry, non-governmental organizations, and academia from global and nationally-focused entities.

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Appendix 7: The Oil & Gas Decarbonization Charter[238]

The following Charter lays out the aims of the Oil & Gas Decarbonization Charter:

I. **Mission:** This initiative aims to continue motivating oil and gas companies to join the decarbonization effort, achieving broad geographical coverage and high scale of impact, and to help speed up actions and to encourage learning. This Charter reflects the principles that the Oil & Gas sector believes will contribute to supporting the aims of the Paris Agreement.

II. **Scope 1 and 2 CO2eq Ambitions**. The following reflect the ambitions that the Oil & Gas sector believes will have positive impacts in support of the aims of the Paris Agreement and deliver substantive reductions in greenhouse gases, and which we aim to work together as an industry to achieve:

1. Net Zero Operations by or before 2050: We aim to reach net-zero CO2eq emissions (Scope 1 and 2) for operations under our control and, as applicable, engage with joint operating partners towards net-zero CO2eq emissions (Scope 1 and 2), by or before 2050. The priority for greenhouse gas emissions mitigation is the avoidance and reduction of operational GHG emissions.

2. Aiming for Near-Zero Upstream Methane Emissions by 2030: We believe that virtually all methane emissions can be avoided. We aim to implement the actions and practices needed to achieve near- zero methane emissions by 2030 on upstream operations under our control and, as applicable, engage with joint operating partners to achieve near-zero methane emissions.[239]

3. Zero Routine Flaring by 2030: We aim to implement the actions and practices needed to eliminate routine flaring by 2030 on all operations under our control and will leverage our influence to achieve the same in our non-operated portfolio.[240]

III. **Continuous improvement and interim ambitions:** If not already shared publicly, by 2025, we shall set and share publicly, the aspiration for 2030 of Scope 1 and 2 CO2eq emissions (absolute and/or intensity) in support of the ambitions set out herein. We will share publicly an update of this aspiration again by 2028 (with potential increase in ambition).

IV. **Accelerated decarbonization:** Implementation of the above ambitions will need increasing alignment with industry best practices to accelerate the decarbonization of the industry's operations. Reducing methane emissions and stopping routine flaring will provide the largest reductions in emissions from oil and gas operations by 2030. Increasing alignment with broader industry best practices would mean, for example, additional reductions from electrification of upstream operations, deployment of CCUS, and use of low-carbon hydrogen.

We aim to bring the whole sector together to join this effort. The success of this overall effort will depend on the implementation from almost all, if not all, private Oil Gas companies and national Oil & Gas companies along with the policy support of governments to join the challenge and create an effective enabling environment.

[238] This is an abbreviated version of the Charter text. The full text can be found at: COP28 O&G Charter (ogdc.org)
[239] "Near-zero methane" is defined as below 0.2% methane intensity as per the formulation identified by OGCI
[240] As defined by the World Bank

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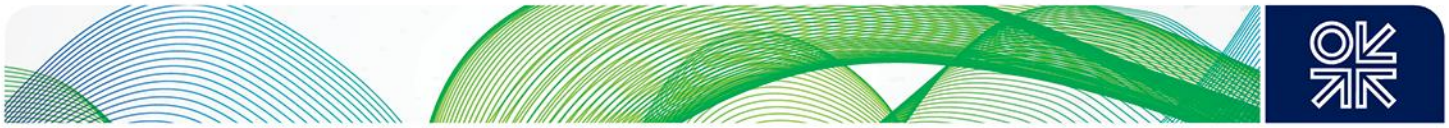

Recognizing that Oil & Gas producers currently have varied emission intensities within their operations, we will aspire to implement current best practices by 2030 to collectively reduce the global average emission intensity for the Oil & Gas industry.

V. **An Inclusive and Dynamic Approach to Achieving our Ambitions:**

1. National Policies to Accelerate Net Zero Delivery. Our commitment to help industry decarbonization towards the aspiration outlined above will require government policies that support the commercialization of new decarbonization and low and zero-carbon investments, create a stable and balanced framework to achieve the energy transition, and expedite permitting to streamline project implementation and infrastructure. We are ready to accelerate the ambition of our decarbonization efforts and will seek to cooperate with governments to identify the means to facilitate such acceleration.

2. Partnering with Other Sectors**.** This Charter is intended to mobilize and drive holistic decarbonization and energy transition outcomes, and we will seek to achieve this through a concerted partnership with key enabling sectors including technology and service providers, as well as the financial services sector.

3. Engaging to Reduce GHG Emissions. We are ready to engage with our customers, policy makers, partners, and other energy-intensive industries to reduce greenhouse gas emissions and help accelerate the transition to a net-zero society.

4. Energy Security and Affordability. To support the UN's Sustainable Development Goals, the industry remains committed to the reduction of energy poverty and providing secure and affordable energy to all our customers. We recognize the nexus between energy access and poverty and are focused on providing accessible energy to support the development of all economies.

VI. **Transparency and Collaboration**. The following activities reflect the Oil & Gas sector's desire to transparently collaborate towards the achievement of the specific ambitions identified in (II) above, in each case in accordance with applicable laws and practices. We recognize that the ambitions set out herein are voluntary in nature, and that each of us is subject to the applicable laws of our respective operations and jurisdictions.

1. Organizational Setup. In furtherance of our Mission, the Oil & Gas sector will develop an organizational setup with required mechanisms to facilitate cooperation and transparency amongst the sector in accordance with the objectives and tasks identified in this Charter. Through such organization, we will remain action-oriented and commit to annually publish emissions performance designed to achieve the decarbonization goals outlined herein.

2. Measure and Report Progress. We aim to measure, monitor, publicly report and independently verify (MMRV) GHG emissions and our performance and progress in reducing our emissions, and to support continuous improvement in data quality, all aligned in accordance with internationally recognized frameworks, and to publish the same within our respective sustainability reports.

3. Evolving Best Practices. We will work with Oil & Gas sector entities and other credible industry bodies and partners to evolve further best practices and transition pathways.

4. Sector Collaboration and Best Practices. We will advocate, influence and share Oil & Gas decarbonization best practices and insights related to ambition setting and transition planning.

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Appendix 8: Global Initiative to Reduce Gas Flaring: "Zero Routine Flaring by 2030"[241]

During oil production, associated gas is produced from the reservoir together with the oil. Much of this gas is utilized or conserved because governments and oil companies have made substantial investments to capture it; nevertheless, some of it is flared because of technical, regulatory, or economic constraints. As a result, thousands of gas flares at oil production sites around the globe burn approximately 140 billion cubic meters of natural gas annually, causing more than 300 million tons of CO_2 to be emitted to the atmosphere.

Flaring of gas contributes to climate change and impacts the environment through emission of CO_2, black carbon and other pollutants. It also wastes a valuable energy resource that could be used to advance the sustainable development of producing countries. For example, if this amount of gas were used for power generation, it could provide about 750 billion kWh of electricity, or more than the African continent's current annual electricity consumption. While associated gas cannot always be used to produce power, it can often be utilized in a number of other productive ways or conserved (re-injected into an underground formation).

This "Zero Routine Flaring by 2030" initiative (the Initiative), introduced by the World Bank, brings together governments, oil companies, and development institutions who recognize the flaring situation described above is unsustainable from a resource management and environmental perspective, and who agree to cooperate to eliminate routine flaring no later than 2030.

The Initiative pertains to routine flaring and not to flaring for safety reasons or non-routine flaring, which nevertheless should be minimized. Routine flaring of gas is flaring during normal oil production operations in the absence of sufficient facilities or amenable geology to re-inject the produced gas, utilize it on-site, or dispatch it to a market. Venting is not an acceptable substitute for flaring.

Governments that endorse the Initiative will provide a legal, regulatory, investment, and operating environment that is conducive to upstream investments and to the development of viable markets for utilization of the gas and the infrastructure necessary to deliver the gas to these markets. This will provide companies the confidence and incentive as a basis for investing in flare elimination solutions. Governments will require, and stipulate in their new prospect offers, that field development plans for new oil fields incorporate sustainable utilization or conservation of the field's associated gas without routine flaring. Furthermore, governments will make every effort to ensure that routine flaring at existing oil fields ends as soon as possible, and no later than 2030.

Oil companies that endorse the Initiative will develop new oil fields they operate according to plans that incorporate sustainable utilization or conservation of the field's associated gas without routine flaring. Oil companies with routine flaring at existing oil fields they operate will seek to implement economically viable solutions to eliminate this legacy flaring as soon as possible, and no later than 2030.

Development institutions that endorse the Initiative will facilitate cooperation and implementation, and consider the use of financial instruments and other measures, particularly in their client countries. They will endeavor to do so also in client countries that have not endorsed the Initiative.

Governments and oil companies that endorse the Initiative will publicly report their flaring and progress towards the Initiative on an annual basis. They also agree to the World Bank aggregating and reporting the same.

The parties that endorse the Initiative acknowledge that its success requires all involved – governments and oil companies, with the support of development institutions – to fully cooperate and take the action described herein to eliminate routine flaring no later than 2030.

[241] World Bank (2024a)

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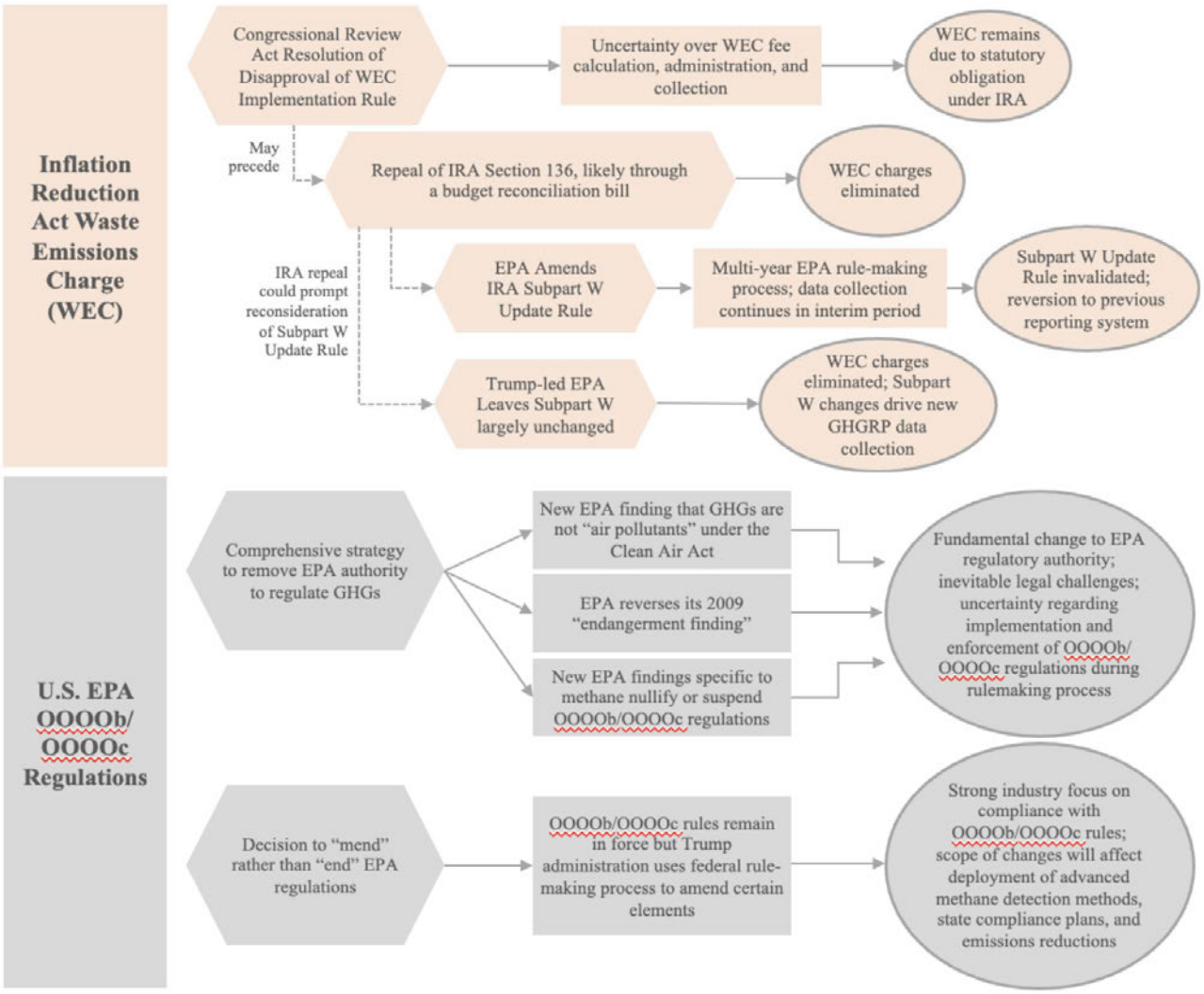
Appendix 9: `Reconsideration' of US Methane Regulation by the Trump Administration: Potential Policy Pathways and Complexities



Source: Book et al (2025)

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Appendix 10: Annex IX of the EU Methane Regulation

ANNEX IX

Information to be provided by importers in accordance with Article 27(1), Article 28(1), (2) and (3), and Article 29(1)

Importers shall provide the following information:

(1) name and address of the exporter and, if different from the exporter, name and address of the producer;

(2) exporting third countries and regions, as classified in the Union nomenclature of territorial units for statistics (NUTS) level 1, where the products were produced, and countries and regions, as classified in the NUTS level 1, through which the products were transported before they were placed on the Union market;

(3) as regards crude oil and natural gas, information whether the producer or the exporter, as applicable, is carrying out source- and site-level measurement and quantification, whether that data are subject to independent third-party verification, whether its methane emissions are reported, either independently or as part of commitments to report national greenhouse gas inventories in line with UNFCCC requirements, and whether they are in compliance with UNFCCC reporting requirements or with OGMP 2.0 standards; a copy of the latest report on methane emissions, including, where available, the information referred to in Article 12(4), where provided in such report; and the method of quantification (such as UNFCCC tiers or OGMP 2.0 levels) used in the report for each type of methane emission;

(4) as regards crude oil and natural gas, information whether the producer or the exporter, as applicable, applies regulatory or voluntary measures to control its methane emissions, including measures such as LDAR surveys or measures to control and restrict venting events and flaring events, including a description of those measures, together with, where available, relevant reports from LDAR surveys and from venting events and flaring events with respect to the last available calendar year;

(5) as regards coal, information whether the producer or the exporter, as applicable, carries out source-level methane emissions measurement and quantification, whether those methane emissions are calculated and quantified in accordance with Annex VI, whether that data are subject to independent third-party verification, whether its methane emissions are reported, either independently or as part of commitments to report national greenhouse gas inventories in line with UNFCCC requirements, and whether they are in compliance with UNFCCC reporting requirements or in compliance with a European or other international standard for monitoring, reporting and verification of methane emissions; a copy of the latest report on methane emissions, including, where available the information referred to in Article 20(6); and the method of quantification (such as UNFCCC tiers) used in the report for each type of methane emission;

(6) as regards coal, whether the producer or the exporter applies regulatory or voluntary measures to control its methane emissions, including measures to control and restrict venting events and flaring events; and, where available, the volumes of vented and flared methane calculated for each coal mine at least during the last calendar year and the existing mitigation plans for each coal mine, together with a description of those measures, including, where available, reports from venting events and flaring events with respect to the last available calendar year;

(7) name of the entity that carried out the independent third-party verification of the reports referred to in points (3) and (5), if any;

(8) information under Article 28(1) or (2), as applicable, showing that the crude oil, natural gas or coal is subject to monitoring, reporting and verification measures at producer level that are equivalent to those set out in this Regulation for contracts concluded or renewed on or after 4 August 2024 and information on the efforts undertaken to ensure that crude oil, natural gas or coal supplied under contracts concluded before 4 August 2024 is subject to monitoring, reporting and verification measures at producer level that are equivalent to those set out in this Regulation;

(9) information whether the model clauses referred to in Article 28(3) are used in the supply contracts, specifying which model clauses;

(10) information under Article 29(1) on the methane intensity of the production of crude oil, natural gas and coal placed on the Union market under the relevant supply contracts.

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Appendix 11: Statement of Methane Abatement Partnership Roadmap[242]

The European Commission, with support from Canada, Germany, Italy, Japan, the United Kingdom, and the United States, as well as Carbon Limits, Clean Air Taskforce, Environmental Action Germany, Environmental Defense Fund, Environmental Investigation Agency, European Bank for Reconstruction and Development, Global Methane Hub, ICA Finance, International Energy Agency, Methane Matters Coalition, and the Organisation for Economic Co-operation and Development, present at the 29th UN Climate Change Conference (COP29), gathered under the presidency of the Government of Azerbaijan, launches the Methane Abatement Partnership Roadmap.

Recognizing the need to ensure that the global community meets the collective goal of the Paris Agreement to keep warming well below 2°C while pursuing efforts to limit warming to 1.5°C;

Recalling the decision on the first Global Stocktake under the Paris Agreement, including for the first time a reference to transitioning away from fossil fuels in energy systems, in a just, orderly and equitable manner, as well as to tripling renewable energy capacity globally and doubling the average annual rate of energy efficiencyimprovementsby 2030;

Recalling the Global Methane Pledge target of cutting anthropogenic methane emissions at least 30% by 2030 from 2020 levels and the strong international engagement on its implementation;

Noting that the 2024 Global Methane Tracker estimates that in the last years methane emissions have not decreased but, on the contrary, increased;

Recalling the launch at COP28 of the Oil and Gas Decarbonisation Charter with 53 signatory companies, with more than half being National Oil Companies, committing to net-zero operations by 2050 at the latest, and ending routine flaring by 2030, and near-zero upstream methane emissions by 2030;

Welcoming the launch of the Methane Finance Sprint at COP28 with more than USD 1 billion commitments and the World Bank Global Flaring and Methane Reduction Partnership with USD 255 million, mobilising new financing to effectively reduce methane emissions;

Recalling the G7 commitment to pursue a collective effort towards a 75 per cent reduction in global methane emissions from fossil fuels, including by reducing the methane emissions intensity of oil and gas operations by 2030;

Recalling the importance of importer-exporter cooperation, as outlined in the joint statement on 'Accelerating methane mitigation from the LNG value chain' by the European Commission, Japan, the United States, the Republic of Korea and Australia at the 2023 LNG Producer-Consumer Conference, as well as in the 'Joint Declaration from Energy Importers and Exporters on Reducing Greenhouse Gas Emissions from Fossil Fuels' by the United States, the European Union, Japan, Canada, Norway, Singapore, and the United Kingdom at COP27;

Noting the need to support oil and gas developing producing countries in pursuing structural transformation and systemic change, including as outlined in the OECD's Equitable Framework and Finance for Extractive-based Countries in Transition (EFFECT);

Noting that the development and implementation of policies and regulations, such as the EU Methane Regulation, the U.S. oil and gas methane mitigation regulations under the Clean Air Act, as well as international initiatives such as the Coalition for LNG Emission Abatement toward Net-zero (CLEAN) and the UNEP-convened Climate and Clean Air Coalition's (CCAC) Fossil Fuel Regulatory Programme, are urgently needed to reduce methane emissions in the energy sector;

[242] https://energy.ec.europa.eu/document/download/1978e73b-0158-4593-87a5-c051bc0ec714_en?filename=Methane%20Abatement%20Partnership%20Roadmap.pdf

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Noting UNEP's International Methane Emissions Observatory 2023 Annual Report's reflections on harnessing the methane data revolution as well as recommendations to advance further to deliver transparency needed for rapid climate action and accelerate methane reduction on a global scale;

Recognizing that supporting the immediate reduction of emissions from existing fossil fuel operations can in the short term both contribute to security of supply of fossil fuels and provide financial incentives to importing and exporting/producing countries, while contributing to the decarbonisation of the energy system and the transition away from fossil fuels in energy systems by 2050;

We urgently call for collaboration among countries, both fossil fuel importers and exporters, to accelerate the reduction of methane emissions associated with fossil energy production and consumption, by collaborating and aiming to implement a Methane Abatement Partnership roadmap. The objective of this roadmap is to minimize emissions of methane throughout the oil and natural gas supply chain. This roadmap would strive to achieve the following:

1. Establish cooperation frameworks between fossil fuel importing and exporting countries to strengthen support for the initiative of reducing emissions from existing assets in the relevant supply chains.
2. Support the adoption of systems to enhance transparency of measurement-based data on the methane emissions associated with the full supply chain of internationally traded fossil fuels, recognising the importance of data quality in the journey towards lower emissions.
3. Encourage strengthening or development of relevant policies and measures, including a robust Monitoring, Reporting and Verification (M RV) system. These approaches could include robust data collection through regulation, building on the Oil and Gas Methane Partnership 2.0(OGMP 2.0) principles as well as using satellite, aerial, and drone data to ensure reliable baseline information on existing emissions. Other frameworks, such as that under development by the international GHG Supply Chain Emissions MMRV Working Group, may also be used. These policies and measures could be complemented by setting up dialogues with other jurisdictions, sharing knowledge and best practices.
4. Encourage and work with relevant operators to build a sound project plan to abate methane emissions from existing fossil fuel assets. This would strive to provide a clear timeline, investment plan and human resources needed, as well as the amount of emissions to be abated, to the extent possible. In order to ensure the effectiveness and rapidity of this step, the producing country could utilise existing tools and frameworks, partnering with relevant organizations such as the International Energy Agency, the Organisation for Economic Cooperation and Development, UNEP's International Methane Emissions Observatory and the UNEP-convened Climate and Clean Air Coalition, as well as with other relevant organisations and operators. At the same time, companies and private investors would work towards creating suitable financial conditions able to mobilise the investments needed.
5. Secure the investments needed for emissions reduction projects in producing countries, together with relevant operators, utilising measurement and reporting to target abatement measures. The World Bank could be one of the key financial partners for developing countries through the new Global Flaring and Methane Reduction trust fund, and private investors may provide capital through sustainability instruments.
6. Follow up on the implementation of the cooperation framework, transparently ensuring that the emission reductions were delivered and sustained, thus contributing to global decarbonisation and increased security of supply. Relevant organisations, such as UNEP's International Methane Emissions Observatory, could provide overall global reporting and progress reports to ensure robust emissions reductions.

We call on other countries and stakeholders to support the Methane Abatement Partnership Roadmap and to showcase examples of implementation at COP30.

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Appendix 12: Comparison of flaring rates for six out of the ten LNG exporting countries, 2019 and 2023 (Bcm)

	2019		2023	
	GECF	GFMR	GECF	GFMR
Qatar	0.7	0.9	1.3	1.2
Russia	16.5	23.2	14	28.4
Malaysia	1.2	2.1	0.9	1.5
Algeria	2.7	9	2.2	8.2
Nigeria	8.8	7.8	5.1	5.8
Trinidad	0.08	0.19	0.06	0.14

Sources: World Bank (2024) GECF 2024, Tables 4.1.2.2, 4.7.2.2, 4.8.2.2, 4.9.2.2, 4.10.2.2 and 5.4.2.2, pages 60,84,88,92,96 and 122

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Appendix 13: Date of Commissioning Liquefaction Plants and Trains for the 10 Largest LNG Exporters

United States	Australia	Qatar	Russia	Malaysia	Indonesia	Oman	Algeria	Nigeria	Trinidad and Tobago
Calcasieu Pass (18) 2022	NWS (5) 1989-2008	QatarEnergy LNG N1 (3) 1996-98	Portovaya (2) 2022	MLNG Satu (3) 1983	Bontang 4 trains: 1990, 1994, 2x1998	Oman1+2 (2) 2000	Arzew GL1Z (6) 1978	NLNG 1/2 (2) 1999/2000	Atlantic LNG 1/2 (2) 2002-03
Cameron LNG1 (1) 2019	Darwin (1) 2006	QatarEnergy LNG N2 (1) 2009	Vysotsk (1) 2019	MLNG Dua (3) 1995	Tangguh 1+2 (2) 2009	Qalhat (1) 2005	Arzew GL2Z (6) 1981	NLNG 3 (1) 2003	Atlantic LNG 4 (1) 2006
Cameron LNG2 (1) 2020	Pluto (1) 2012	QatarEnergy LNG N2 (1) 2009	Yamal (4) 2017-21	MLNG Tiga (2) 2003	Tangguh 3 (2) 2023		Arzew GL3Z (2) 2014	NLNG 4/5 (2) 2006	
Cameron LNG3 (1) 2020	QCLNG 1 (1) 2015	QatarEnergy LNG N3 (1) 2010	Sakhalin 2 (2) 2009	MLNG T9 (1) 2016	Donggi-Senoro (1) 2015		Skikda GL1K (1) 2013	NLNG 6 (1) 2008	
Corpus Christi (1) 2018	QCLNG 2 (1) 2015	QatarEnergy LNG N4 (1) 2011		PFLNG Dua (1) 2021)					
Corpus Christi (1) 2018	GLNG 1+2 (2) 2015-16	QatarEnergy LNG S1 (2) 1999-2000		PFLNG Satu (1) 2017					
Corpus Christi (1) 2019	APLNG1 (1) 2016	QatarEnergy LNG S2 (1) 2004							
Corpus Christi (1) 2020	APLNG2 (1) 2016	QatarEnergy LNG S2 (1) 2005							
Cove Point (1) 2018	Gorgon (3) 2016-17	QatarEnergy LNG S2 (1) 2007							
Elba Island (10) 2019	Wheatstone (2) 2017-18	QatarEnergy LNG S3 (1) 2009							
Freeport LNG 1 (1) 2019	Ichthys (2) 2018	QatarEnergy LNG S3 (1) 2010							
Freeport LNG 2 (1) 2020	Prelude (1) 2019								
Freeport LNG 3 (1) 2020									
Sabine Pass 1 (1) 2016									
Sabine Pass 2 (1) 2016									
Sabine Pass 3 (1) 2017									
Sabine Pass 4 (1) 2017									
Sabine Pass 5 (1) 2018									
Sabine Pass 6 (1) 2021									

Source: GIIGNL 2024, pp. 36-39

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