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Greenhouse Gas Emissions from LNG Trade: from carbon neutral to GHG-verified

Introduction

When reports of carbon-neutral LNG cargos began in 2019, public attention was drawn for the first time to greenhouse gas (GHG) emissions specifically from LNG trade. The concept of the transaction is that equivalent emissions from an LNG cargo are offset by the purchase of credits in the voluntary carbon market from a recognised registry. It should therefore involve two principal elements: the estimation and/or measurement of emissions from the cargo, and the purchase of an equivalent offset. But there has never been a rigorous definition of how emissions from a cargo have been, and should be, estimated or measured. Nor has there been sufficient transparency (and in many cases any transparency) to provide credibility to the claim that carbon, or more accurately GHG, emissions from these LNG cargos have been offset.

By 2021, the number of these cargos had increased substantially, and the concept seemed to be taking off. But in 2022 reports of cargos had declined with Japanese city gas companies being the only new buyers. Some attribute this to the reluctance of buyers to pay an additional premium for LNG cargos which had risen to historically high prices. Others suggest that the entire concept was flawed due to lack of accurate definition and transparency. In discussions at the 2022 World Gas Conference one speaker referred to the phenomenon as a `publicity stunt'. This insight follows up issues raised in a detailed paper published earlier this year on the more general issue of methane emissions from natural gas and LNG trade.[1]

The Growing Importance of LNG: estimated and measured emissions

In Europe, the issue of GHG emissions from LNG has increased in importance since the Russian invasion of Ukraine which has provided a major impetus for LNG imports to replace Russian pipeline gas in Europe, and was included as a key element of the European Union's REpowerEU Plan.[2] The EU objective to phase out Russian gas imports entirely by 2027 may be achieved much sooner given the dramatic fall in imports and the strong possibility of a complete interruption by the end of 2022. Around twelve state-backed and privately-owned floating storage and regasification units (FSRUs) have been ordered by European companies in Germany, Netherlands, France, Poland, Greece, and Finland/Estonia (jointly) which are scheduled to start operations before the end of 2023. Two larger

[1] Stern, J. (2022), Measurement, Reporting and Verification of Methane Emissions from Natural Gas and LNG Trade, OIES Paper ET06.

[2] Brussels, 18.5.2022, COM (2022) 230 final, European LNG imports increased by 41 bcm in the first 8 months of 2022 compared with the same period of the previous year. REPowerEU has a 2022 target of 50 bcm for the EU which will probably not be met by direct imports but rather using LNG imported by the UK and exported by pipelines to Belgium and the Netherlands.

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land-based regasification terminals are under construction in Germany, which has never previously imported LNG, to be commissioned in 2025/26.

Substantial additional European LNG requirements may potentially conflict with expectations of rapidly rising demand in Asia, partly to replace coal use for both climate and air quality reasons. Asian countries have traditionally imported more than 70 per cent of globally traded LNG.

These developments raise questions about compatibility with European climate targets and whether such new facilities may be locking in fossil fuel emissions for the next two decades, which raises the question about how such emissions are measured. Governments of Asian LNG importing countries have also set net zero targets (albeit with time horizons beyond 2050 in some cases), as have many of their utilities which accounts for the latter's interest in carbon-neutral LNG. For these reasons it is very important to clarify whether emissions have been estimated or measured. Estimation is a desktop exercise using engineering or statistical tools to obtain a figure for emissions. This is particularly important in respect of methane emissions which are much harder to measure and more important in relation to short-term climate warming than CO2 emissions.[3] The majority of publicly available historical data are drawn from estimates, but recent studies have shown this usually leads to under-reporting compared to measurement which physically employs ground level and aerial technologies to monitor and quantify the emissions.[4] In addition to existing charges for carbon dioxide emissions, a proposed EU regulation will set a standard for methane emissions from imported natural gas and LNG by the end of 2025.[5]

Carbon-Neutral LNG Cargos

Table 1 shows some of the detail for around 50 carbon-neutral LNG trades which had been publicly announced up to July 2022. There are many uncertainties in relation to Table 1 including: whether some of the cargos have been or are yet to be delivered, the country where the cargo originated, and its seller and buyer.

Credits associated with the transaction are shown for offsets recorded in the Verra Registry.[6] Cargos with no recorded credits may have used other registries or may not have been recorded as an LNG trade (there is no obligation for registrants to state the nature of the transaction on which the offset is based). It has not been possible to obtain details for many of the earlier trades but more information has become available since late 2021. Most recent contracts have been signed with Japanese city gas companies which provide the LNG to their customers.[7]

[3] IPCC 6th Assessment Report, Working Group III, April 2022, Figure SPM1, p. SPM 6.

[4] Alvarez, R. A. (and nine additional authors) (2018), 'Assessment of Methane Emissions from the US Oil and Gas Supply Chain', Science 361: 186–8. Environmental Defense Fund (2021), Flaring: Aerial Survey Results, https://www.permianmap.org/flaring-emissions/ showed similar under-reporting of emissions from flared gas. Satellite observations strongly support claims that emissions have been under-reported. For more detail see Stern (2022) pp. 23-25.

[5] European Commission, Proposal for a Regulation of the European Parliament and of the Council on Methane Emissions Reduction in the Energy Sector and amending Regulation (EU) 2019/942, COM (2021) 805 final, Brussels, 15.12.2021. The Regulation will apply to methane emissions from all imported fossil fuels.

[6] Verified Carbon Standard Registry https://verra.org/project/vcs-program/registry-system/

[7] In addition to those listed in Table 1, Inpex signed an agreement with Sakata Natural Gas in July 2022. https://www.inpex.co.jp/english/news/assets/pdf/20220715.pdf

Table 1: Carbon Neutral LNG Cargos 2019-22

DATE	SELLER	BUYER	DELIVERY	Credits*	Vintage Dates**	CCB *** Standard
Jun-19	Shell	Tokyo Gas	Japan			
Jun-19	Shell	GS Energy	South Korea			
Jun-19	Jera	Not Known	India			
Mar-20	Shell	CPC	Taiwan			
Oct-20	Total	CNOOC	China			
Nov-20	Shell	CPC	Taiwan			
Nov-20	Shell	CNOOC	China	238239	2008-19	Gold Silver
Jan-21	Shell	CNOOC	China	217694	2010-20	Gold Silver
Mar-21	Mitsui	Hokkaido Gas	Japan			
Mar-21	Gazprom	Shell	U.K.	246320	2012-18	Gold
Mar-21	RWE	POSCO	South Korea			
Apr-21	Mitsubishi/DGI	Toho Gas	Japan	230000	2016-18	Gold
Apr-21	Not known	Pavilion Energy	Singapore			
May-21	Cheniere	Shell	Europe			
Jun-21	not known	TotalEnergies/OMV	Japan			
Jun-21	Oman LNG	Shell	Japan	220149	2010-15	
Jun-21	ADNOC LNG	ATPL	Not Known	106604	2020	
Jul-21	Shell	Osaka Gas	Japan	232672	2010-15	Gold
Jul-21	Novatek	Saibu Gas	Japan			
Jul-21	Shell	Petrochina	China	220548	2012-19	Gold
Jul-21	TotalEnergies	Atlantic Basin Services	Dominican Republic	134512	2020	
Jul-21	Ichthys LNG	Inpex	Japan	188260		
Jul-21	BP	Sempra	Mexico			
Aug-21	Petronas	Shikoku Electric	Japan	52198		
Aug-21	ENI	CPC	Taiwan	204342		
Aug-21	Inpex	Iruma Gas	Japan			
Sep-21	Inpex	Shizuoka Gas	Japan	243963	2011-13	
Sep-21	Inpex	Toho Gas	Japan	250061		
Sep-21	Qatar Petroleum	Naturgy	Spain	134512		
Sep-21	Petronas	Shenergy	China	19041	2011	
Sep-21	Shell	CPC	Taiwan	206180	2017	
Sep-21	Shell	Petrochina	China	223828		Gold
Sep-21	Sakhalin Energy	Toho Gas	Japan	201595	2017-20	
Oct-21	Diamond Gas	Japex	Japan	5	2017	

Oct-21	Shell	Petrochina	China	237777	2008-19	Gold
Nov-21	Shell	Petrochina	China	217156	2008-20	Gold
Dec-21	Shell	Petrochina	China	203003	2010-20	Gold
Dec-21	Not Known	CNOOC	Hong Kong	216462	2008-19	
Jan-22	Petronas	Hiroshima Gas	Japan	30000	2011	
Jan/Feb 22	Tokyo Gas	Saibu Gas	Japan	225102	2008-12	
Jan/Feb 22	Tokyo Gas	Customers****	Japan	225102	2008-15	
Feb-22	Petronas	Shenergy	China	19042	2013	
Mar-22	Petronas	Shenergy	China	19042	2013	
Mar-22	Tokyo Gas	Customers****	Japan	231225	2008-19	
Jun-22	Osaka Gas	Customers****	Japan	251070	2012-15	
Jun-22	Inpex	Toho Gas	Japan	250061	2014-16	
Jun-22	Tokyo Gas	Customers****	Japan	215574	2010-15	
Jun-22	Shell	Petrochina	China	188217	2008-19	Gold
Jul-22	Shell	Petrochina	China	189570	2012-20	Gold

*Offsets in tonnes of CO2 equivalent **vintages of offset (start-date to end-date) ***Climate Community and Biodiversity Standard ****customers of the buyer
Sources: Stern (2022), Verra Registry.

Immediately obvious from Table 1 is that the CO2-equivalent volumes for individual cargos are substantially different in size, although the majority are in the range of 200,000-250,000 tonnes. Most public announcements stated that the emissions included all greenhouse gases, and encompassed the full supply chain from production to end use.[8] But there has been no indication of how emissions from these trades have been empirically measured or estimated. Some may assume a standard volume of emissions from a cargo of a certain size. Some of the cargos delivered by Shell used a UK government methodology which assumed that a 70,000 tonnes cargo emits approximately 240,000 tonnes of carbon dioxide equivalent (CO2e) across the supply chain from exploration to end-use. Of this, 25.7 per cent of the emissions (61,680 tons CO2e) are assumed to be from exploration, production, transportation, and regasification, and the remaining 74.3 per cent from end-use combustion.[9] AES assumes that the supply chain of an LNG cargo emits 180,000 tonnes of carbon dioxide but with no explanation of this figure.[10]

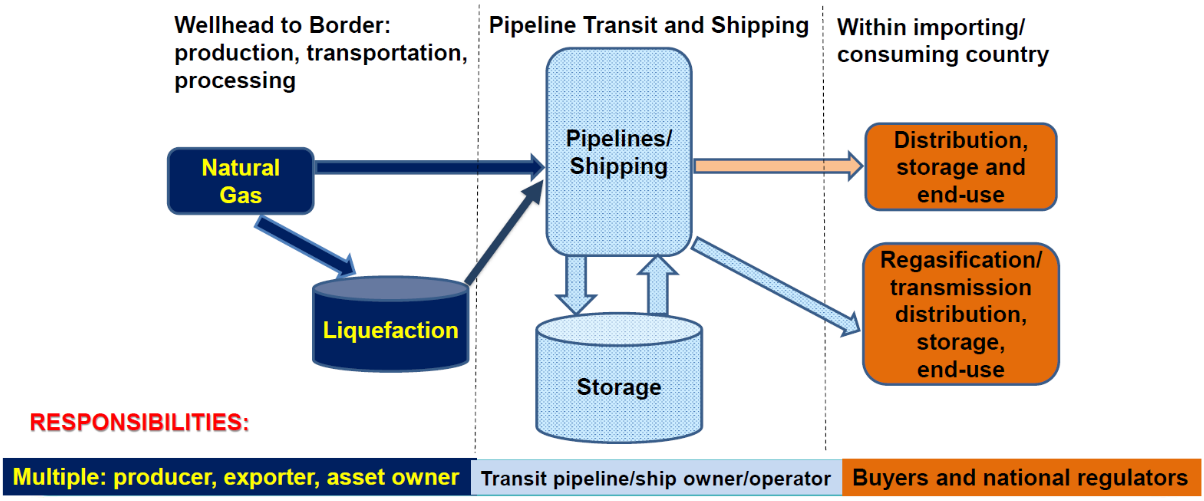
[8] The June 2019 Jera cargo offset only Scope 3 emissions ie those from within the importing country.
[9] Stern (2022), Appendix 6.
[10] https://www.aes.com/carbon-neutral-lng (accessed August 22, 2022). The size of the cargo and how this volume of emissions was derived is not specified.

The credit vintages (some of which are shown in Table 1) which represent the years when the offsets were registered also vary significantly between cargos. It is difficult to make judgements about the quality of the credits as older vintages may not necessarily be inferior to newer but, having not been sold previously, can trade at a discount. Credits which the registry has labelled `Gold' or `Silver' have been verified to meet Climate, Community and Biodiversity (CCB) Standards.

Responsibilities and Methodologies for Measurement, Reporting and Verification (MRV) of Emissions from Supply Chain Segments

Figure 1 is a representation of an export supply chain for pipeline gas and LNG. It is used here to clarify the location of the physical assets for which MRV of emissions are required, and therefore the corporate bodies and regulatory authorities which have responsibilities for emissions from those assets. Rather than stages, boundaries, or scopes[11] we refer to 'segments' of the supply chain which provides a specific designation of responsibilities for assets.

Figure 1. Segments of a Gas and LNG Export Supply Chain: responsibilities for measurement, reporting and verification



Source: OIES

In many studies, cargo sellers make generic assumptions across the supply chain without addressing the discrete assets in each segment. Owners and operators of assets from the wellhead to the loading arm of the LNG ship should take responsibility for MRV of emissions from those assets. Shipping will be a segment requiring discrete measurement as emissions will depend on the type of ship and the duration of the voyages (both loaded and ballast).[12] The buyer(s) of the LNG and their regulators have the most accurate information, and are therefore in the best position to make the calculation of emissions for the segment from the import border to the end user. Unless one company has responsibility for the entire supply chain from production to end user(s), studies attempting to estimate emissions from the total chain are probably unrealistic.[13]

[11] Using the definition of Scopes 1, 2 and 3 from the Greenhouse Gas Protocol, (https://ghgprotocol.org/) does not work well for (oil and) gas supply chains because of the lack of precision on boundaries.

[12] For details of emissions from different types of ship see: Balcombe, P. and 5 additional authors (2021), 'How can LNG-fuelled ships meet decarbonisation targets? An environmental and economic analysis', Science, 227, 15 July, 120462, https://doi.org/10.1016/j.energy.2021.120462

[13] Exceptions could be where LNG is delivered to power stations located at the point where the LNG is landed, as is sometimes the case in Japan.

MRV of emissions from US gas and LNG

The US is the world's largest gas producer and one of the largest global LNG exporters.[14] The country has a long history of regulation by federal and state institutions, and interactions between companies and regulators. The US Environmental Protection Agency (EPA) has developed a substantial body of emissions regulation over many decades to which companies must comply, but academic and NGO research has found that EPA data substantially under-estimate carbon dioxide and methane emissions from venting, flaring, and fugitive emissions.[15]

The US Inflation Reduction Act of August 2022 introduced a methane fee for oil and gas companies. From 2024, the fee will be $900/tonne rising to $1500/tonne in 2026. There are a significant number of exemptions depending on the production level and whether there is already compliance under EPA rules.[16] The Act directly raises the question of how emissions will be measured and reported, and whether they will require independent verification.

Literature on methane emissions is overwhelmingly concentrated on US standards and practices, and evolving certification mechanisms for gas are similarly based on these systems. Two prominent initiatives are those established by MiQ[17] and Project Canary.[18] Both are aimed at the differentiation of gas products in terms of methane emissions (although Project Canary includes a wider range of environmental issues).

MiQ: `Independently Certified Gas'

MiQ has detailed, publicly available documentation on procedures for certifying onshore and offshore production. For each of these, there is a main document and three subsidiary documents dealing with: methane intensity, company practices, and monitoring technology deployment, and two procedures: certification and non-compliance. Certificates are lodged in the organisation's registry.[19] MiQ is developing an LNG Standard Module and a Transmission and Storage Standard which, when finalised, will provide certification of emissions from the wellhead to the regasification terminal.[20]

Project Canary: `Responsibly Sourced Gas' (RSG)

Project Canary defines Certified or RSG as:

> `natural gas that has undergone independent third-party certification that the molecules were produced under standard best practices for methane mitigation (eg certified low methane gas) as well as other best practices around minimising other environmental and community impacts.'[21]

Project Canary states that it differentiates from other standards by providing measured, continuous monitoring of methane emissions and `establishing the highest bar for validating ESG commitments for air, water, land and community'.[22] It provides these services for both upstream and midstream operators.[23] But apart from the general statement that RSG gas has been measured and monitored continuously through many (often hundreds of) data points, there is very little information about how

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[14] In the first half of 2022 the US was the largest global LNG exporter.
[15] US EPA data are reported in Greenhouse Gas Reporting Program (GHGRP) | US EPA For under-reporting of methane emissions by EPA see op. cit. Alvarez et al. (2018) and Environmental Defense Fund (2021).
[16] For a summary see McKormick, M. `Oil Industry condemns first US fee on greenhouse gases amid energy crisis', Financial Times, September 2, 2022.
[17] https://miq.org/
[18] https://www.projectcanary.com/
[19] https://miq.org/documents/
[20] Drafts of the LNG and transmission and storage documents have been seen by the author.
[21] https://www.projectcanary.com/
[22] https://www.projectcanary.com/
[23] Project Canary's certification separates midstream operations into: transmission and storage, gathering and boosting, processing and fractionation.

such monitoring is carried out, other than that it is on a company-by-company basis and further detail is regarded as confidential.[24]

GTI Energy: `Veritas'

GTI Energy is developing Veritas, which it describes as a differentiated gas measurement and verification initiative, designed to accelerate actions that reduce methane leakage from natural gas systems. Veritas (which at the time of writing had 25 supporters) is developing a number of protocols: methane intensity, measurement, reconciliation, supply chain summation, audit, and insurance. It is not intended to be a certification body but plans to be complementary to schemes such as MiQ and Project Canary. The goal is 'to develop a standardized approach to measuring and verifying methane emissions intensities as a flexible, foundational tool that can be used to inform company certification programs, ESG disclosures, regulatory reporting, and investor transparency'.[25]

It is important to say that all these initiatives are still being developed. At mid-2022, MiQ stated that it was certifying `over 4 per cent of global gas supply', and Project Canary quoted an estimate that RSG gas volumes could `grow from 8.7 Bcf/d in 2021 to more than 20 Bcf/d by the end of 2022 based on announced projects, or roughly 18 per cent of the North American market'.[26] From a public information perspective, the most important difference between MiQ and Project Canary is transparency and detail. But further explanation and clarity is needed in relation to both grading systems:

- both give grades equating to different methane (and other) emissions criteria, neither provides a specific figure for methane emissions from either supply chain segments or assets.[27] MiQ does not specifically require measurement; its grades are a combination of methane intensity, company practices, and technology deployment.
- grades seem largely based on ground level emission measurements or estimates, despite recognition of the importance of reconciling bottom-up and top-down emission estimates.[28]

The Cheniere study and its wider relevance

In 2021, an extensive study of emissions from Cheniere's 2018 LNG cargos was published in an academic journal.[29] This is the only detailed attempt to trace emissions from each of the segments of the LNG supply chain using operational data from the US's biggest exporter. It provides a transparent account of the measurement methodologies used and the resulting data, reported using different time horizons. There is clarity about what has been estimated and what has been measured. A problem highlighted by the Cheniere study is that because of the number of production locations (well pads), gathering and boosting networks, processing plants, and transmission and storage assets, it is

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[24] Communication with Project Canary.

[25] https://www.gti.energy/veritas-a-gti-methane-emissions-measurement-and-verification-initiative/

[26] https://miq.org/ ; https://www.projectcanary.com/blog/why-responsibly-sourced-gas-is-getting-the-green-light-from-companies/?utm_source=ActiveCampaign&utm_medium=email&utm_content=Are+your+assets+future-proof%3F&utm_campaign=July+Newsletter+%232%3A+General&vgo_ee=ba5V3MbdPDZDvHg3kttW3pnfYHPCppgfknc5DFQzaQ8%3D

[27] MiQ standards are A-F, which range from 0.02-2 per cent intensity of methane emitted per unit of gas produced, with a frequency of assessment from quarterly to annually. https://miq.org/the-technical-standard/ Project Canary's Trustwell Certification minimum requirements for Silver, Gold and Platinum grades (as of January 2021) comprised: a minimum 10 per cent of certified wells visited during site visit, a commitment to environmental stewardship, qualification for the low methane verified attribute, qualification for freshwater-friendly attributes, a documented spill prevention program, a waste management program, an emergency response program, and successfully addressing well integrity issues. Trustwell scoring and certification targets are: Platinum to be more responsible than 90 per cent of other operators; Gold to be more responsible than 75 per cent of other operators; Silver to be more responsible than 50 per cent of other operators. https://www.projectcanary.com/private/trustwell-and-rsg-definitional-document/

[28] Project Canary relies on measurements, MiQ on a combination of measurements and estimates. For definitions and importance of bottom-up and top-down emissions see Stern (2022), pp.7-8 and Appendix 2.

[29] Roman-White, S. and 8 additional authors, 2021, 'LNG Supply Chains: a Supplier-Specific Life Cycle Assessment for Improved Emission Accounting', ACS Sustainable Chemistry Engineering (2021) 9 (32), 10857–67. Roman-White, S. and 8 additional authors, 2021, 'LNG Supply Chains: a Supplier-Specific Life Cycle Assessment for Improved Emission Accounting', ACS Sustainable Chemistry Engineering, https://pubs.acs.org/doi/10.1021/acssuschemeng.1c03307.

impossible to identify the origin of gas molecules and the *exact* path they have taken through the network before arriving at a liquefaction plant.[30]

In a US context, certification of emissions will apply to different asset holders: producers, gathering and boosting networks, processing, transmission, storage, liquefaction, shipping, and (potentially) regasification. Buyers of LNG can be provided with certificates which show emissions from different stages of the supply chain equivalent to the volume of the cargo which they have purchased. The key word here is *equivalent*, because these will not be the same molecules exported from a specific liquefaction plant. For these reasons, there can be no general figure for emissions from US LNG cargos as their origins and supply chain pathways can (and probably will) be significantly different, and this is a problem for the MiQ and Project Canary initiatives summarised above. Verification of US emissions will also be substantially more complicated because of the very large numbers of wells and well pads from which gas has been produced, and the transportation assets through which gas has (or could) pass before it reaches a liquefaction plant.

Therefore, as important as the US has undoubtedly become in relation to global LNG trade, and despite the fact that US organisations are leading efforts to measure GHG emissions from (oil and) gas operations, there are substantial problems associated with using US practice as an international benchmark because of the degree of complexity of the (oil and) gas supply chain, and the long-established regulatory framework, neither of which exist in other LNG exporting countries to anything like the same extent. For all LNG exporters the issue will be whether emissions from a specific cargo have been measured and with what degree of accuracy, or whether they have been estimated and if so, what assumptions have informed those estimates.

Emissions frameworks for non-US LNG exporters

In most other countries, the task of measuring emissions from LNG exports should be much simpler because:

- the gas generally comes from a single field - or a limited number of fields - to a specific liquefaction plant;
- the number of gathering/transmission pipelines, processing plants and storages, through which gas needs to pass before reaching the liquefaction plant, is limited and can therefore be more easily traced.

Aside from the US, the three largest LNG exporters in 2021 were Qatar, Australia, and Russia. The vast majority of Qatar's gas comes from one major field through short pipelines to a number of different liquefaction plants located within a limited geographical area.[31] Gas which feeds Australian LNG plants comes from a limited number of offshore fields through dedicated pipelines.[32] The two operating Russian LNG export projects likewise are supplied by offshore fields through dedicated pipelines.[33] Other major exporters have more complex supply chain configurations, particularly Nigeria, where the vast majority of the gas is associated with oil and has to pass through multiple pipelines and processing plants before reaching Bonny Island. In Algeria, where gas is collected from multiple fields and piped to a common processing plant at Hassi R'Mel, the problems are similar.[34] For non-US exporters, more general problems are a lack of information and data and in some countries not even any official recognition of the importance of these issues.

[30] For a more detailed review of the Cheniere study see Stern (2022), pp.34-35. With contractual detail it may be possible to identify a limited number of paths which the molecules may have taken to a liquefaction plant.

[31] Rogers, H. (2019), 'Qatar: LNG expansion following the ending of the North Field moratorium', in Stern, J.P. ed. The Future of Gas in the Gulf: continuity and change, Oxford Institute for Energy Studies.

[32] Ledesma, D. Henderson, J. and Palmer, N. (2014): The Future of Australian LNG Exports, OIES Paper, NG90. This is the case for the western and northern LNG projects. Coal seam gas (coal bed methane) projects on the east coast have a different and potentially much larger methane and GHG footprint.

[33] Henderson, J. and Yermakov, V. (2019): Russian LNG – becoming a global force, OIES Paper, NG 154.

[34] For more detail and maps of the Nigerian and Algerian gas and LNG facilities see Stern (2022).

For many (possibly most) LNG exporters, tracking the gas molecules from wellhead to liquefaction plant is much simpler, and therefore it should be possible to measure emissions more accurately than for US exports. But thus far no other major LNG exporters have proposed a MRV framework for emissions, which may put them at a disadvantage when regulation is introduced in importing countries as it will be in Europe.[35] However, in November 2021, two frameworks for MRV of emissions were published by GIIGNL and the Statement of Gas Emissions (SGE) partners.[36]

The GIIGNL Framework[37]

This framework has been 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.[38] There are two levels of assurance which must be agreed with verifiers (certifiers):[39]

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

At the time of writing, there was no confirmation that the GIIGNL framework had been adopted in any LNG trades.

Methane emission charges: the GWP and time horizon problems

CO2 prices have long been established in European countries, but by the end of 2025, the proposed European methane regulation will establish standards and charges for imports of all fossil fuels – oil, gas (including LNG), and coal.[40] Not only will methane charges require buyers to establish MRV for the

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[35] Emission estimates from the sole Norwegian liquefaction plant on Melkoya Island which is supplied from a single field can be found in: Diskos Reports: https://portal.diskos.cgg.com/prod-report-module/

[36] GIIGNL MRV and GHG Neutral Framework, https://giignl.org/framework/ SGE (2021), The SGE Methodology: GHG Methodology for Delivered LNG Cargoes, First Edition 2021. SGE-Methodology.pdf (pavilionenergy.com) The SGE framework is specific to contracts signed by the Singaporean company Pavilion, for more details see Stern (2022), pp.32-3.

[37] GIIGNL is an organisation representing companies active in the import and regasification of LNG. It has 84 members representing the LNG import industry from around the world in the Americas, Asia, and Europe.

[38] The options are: GHG Offset, GHG Offset with Reduction Plan" and GHG Neutral Cargo. GIIGNL (2021), p.2.

[39] Ibid, p.38.

[40] European Commission, Proposal for a Regulation of the European Parliament and of the Council on Methane Emissions Reduction in the Energy Sector and amending Regulation (EU) 2019/942, COM (2021) 805 final, Brussels, 15.12.2021.

LNG they import but assuming these charges will be based on CO2 prices, the factor used for converting methane emissions to CO2 equivalent units will have extremely important commercial consequences.[41] For the second commitment of the Kyoto Protocol (2013-20) it was decided to use a Global Warming Potential (GWP) metric over a 100-year time horizon.[42] In the IPCC's Fourth Assessment Report (AR4) methane emissions were assigned a GWP of 25 in CO2e units; the Sixth Assessment report published in 2022 raised this figure to 29.8 for fossil methane and 27.2 for non-fossil methane.[43] The 100-year horizon was established before governments adopted the Paris targets and subsequent net zero targets for 2050.[44] By the time the EU methane proposal is adopted, many governments will be required to achieve net zero within 25 years. Using a time horizon of 25 years, the GWP of methane is roughly 75 and emissions would therefore be priced at two and a half times the 100-year horizon figure. Therefore by 2025, an LNG cargo landed in a country with net zero 2050 targets might be required to pay a much higher CO2-related price.[45] It will be interesting to see which time horizon the EU methane standard uses, given the logic of correlation with net zero targets, or alternatively whether the problem is avoided by imposing a specific methane fee, which US legislation will impose on its domestic oil and gas production from 2024. Whatever standard is adopted will be influential in determining standards in Asia.

Conclusions and Recommendations

All measures by fossil fuel companies to quantify and compensate for their GHG emissions are to be welcomed. But with increasing pressure on companies to achieve emission reductions, and fossil fuel importers to present documented and verified statements of emissions to governments and regulators, the LNG community needs to make a radical improvement in this aspect of its environmental performance.

Although `carbon neutral' has been used as a label attached to LNG cargos where some volume of GHGs has been subject to the purchase of equivalent credits, there has been no transparency around whether and how these have been estimated and/or measured. Therefore while `publicity stunt' could be considered a harsh judgement, these trades fall short of a required standard of environmental credibility. Methodologies and certification of emissions for individual segments and assets in the supply chain are in the process of development in the US, but not so far in other major LNG exporting countries. But given the need to comply with a proposed EU standard by end-2025, taking steps to create credible MRV of emissions would seem to be a necessary step for all exporters.

Recommendations – MRV and transparency

There are several steps which companies and the LNG community as a whole must take to achieve environmental credibility in respect of GHG emissions:

[41] An alternative option would be a methane fee as in the August 2022 US Inflation Act (see above).

[42] Reporting, accounting, and review requirements relating to the second commitment period of the Kyoto Protocol, Version 01.10, p.49. The guidelines to implement the Kyoto Protocol: the Marrakesh Accords and the 5,7&8 implications | UNFCCC However, the report noted that: `GWP is a well-defined metric based on radiative forcing that continues to be useful in a multigas approach; however the GWP was not designed with a particular policy goal in mind and, depending on specific policy goals, alternative metrics may be preferable.'

[43] IPCC Assessment Report 6, Working Group 1. Table 7.15, p.7-125. The corresponding figures for a 20-year horizon ie GWP20 are 82.5 and 80.8. Many governments and their companies are still using a GWP factor of 25 from AR4 for the 100-year time horizon.

[44] But the guidelines (op. cit.) also noted: `the limitations in the use of GWP based on the 100-year time horizon in evaluating the contribution to climate change of emissions of greenhouse gases with short lifetimes.'

[45] Or the purchase of a correspondingly higher volume of offsets in order to claim carbon neutrality, taking into account that SBTI's corporate net zero standard criteria state: `The use of carbon credits must not be counted as emission reductions towards the progress of companies' near-term or long-term science-based targets. Carbon credits may only be considered an option for neutralising residual emissions or to finance additional climate mitigation beyond their science-based emission reduction targets'. SBTI Corporate Net-Zero Standard, Version 1.0, October 20211, C12, p.42. https://sciencebasedtargets.org/resources/files/Net-Zero-Standard.pdf

- Measurement of emissions, including a statement of:
    - whether these have been measured or estimated and if estimated by which protocol (eg NGSI and API)
    - the methods which were used, whether these included both bottom-up (ground level) and top-down (aerial) measurements and the extent to which the two forms of measurement were reconciled;
    - the segment(s) or asset(s) of the supply chain to which these measurements were applied;
    - how frequently these measurements were carried out and whether continuous monitors were employed providing a flux rate[46] in units per hour
- Reporting of emissions including:
    - which greenhouse gases are included
    - reporting in original units of measurement, the GWP factors used if the data have been converted into CO2 equivalent (CO2e), and the conversion of CO2e units to kgCO2e/cargo
- Verification of measurement and reporting including:
    - whether verification has been carried out by a company independent of the owners and operators of the supply chain
    - whether the verifying company has carried out sampling of emissions from a supply chain segment or asset, independent of the emission data provided by owner(s) and operator(s)
    - the technical qualifications of the verifying company including the ability to model the measurements to develop independent verification of the flux algorithms

Offsets should be treated as a transaction separate from MRV of emissions. But if carbon – or more correctly greenhouse gas – neutrality is being claimed for the cargo, the volume, vintage, quality, and registration detail of the credits needs to be stated.

The measurement methodologies together with the resulting data, frequency of measurement, units (and conversion factors) of emissions, and by which organisations methodologies and data were verified, should be regarded as minimum transparency requirements. Failing to provide this information risks the continuation of statements from academic and NGO sources that emissions are several times higher than company declarations, creating ongoing credibility problems for the LNG industry.

In 2021, more than 90 per cent of LNG cargos were imported by European and Asian buyers. The EU emissions trading scheme already imposes charges for carbon dioxide and is proposing to introduce charges for methane emissions from imported fossil fuels by the end of 2025. But Asia accounts for around 70 per cent of global LNG imports and will therefore be key to achieving emission reductions. Asian buyers should request their suppliers to provide a detailed assessment of emissions from LNG cargos which they purchase; how these were measured and reported and whether the results were verified by independent third parties. The request from buyers could specify a methodology for MRV of a cargo, with the proposed EU Regulation and GIIGNL providing available examples. Failure to provide information which is sufficient to make an accurate assessment of emissions, could increasingly impact

[46] Emissions are measured in concentrations of gases at a specific location. These need to be converted to fluxes ie emissions from a specific asset, principally by the use of algorithms.

the value of cargos. Because of nationally determined contribution statements and targets, such assessments and requirements will increasingly involve governments as well as LNG buyers.

Conclusions

In conclusion, `carbon-neutral' LNG has become progressively limited to a relatively small number of trades in Asia and cannot be considered a credible or relevant environmental standard. Cargos should be `greenhouse gas verified' and should set out the methodologies used to measure, report, and verify emissions. These methodologies should distinguish between assumptions and models for estimating emissions, and empirical measurement of emissions. Owners and operators of assets in the different segments of the supply chain should take responsibility for MRV of emissions from those assets. For sellers this would include emissions from the wellhead to the loading arm of the LNG ship (ie all upstream segments plus liquefaction), and this may also include shipping depending on ownership of that segment. Buyers would normally take responsibility of emissions from regasification, distribution and end-use. Reporting should focus on the degree of accuracy which has been achieved in tracking gas molecules from production through different segments of the supply chain to liquefaction, shipping and end-use. This will be especially important where emissions have been estimated rather than empirically measured. Measurement and reporting should be subject to verification by technically qualified companies which should have the capability to replicate a sample of emissions from the different assets in the supply chain. If offsets are used to claim GHG neutrality, these should be reported in detail along with the MRV of emissions.

In 2022, the attention of the gas and LNG world has been diverted by the security crisis in Europe and by global price levels. However, when this crisis passes, attention will return to climate targets and emission reductions. At that time, the LNG community must be able to credibly document its emissions which will become an increasingly critical part of its social license to operate.

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