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Voluntary markets for carbon offsets: Evolution and lessons for the LNG market

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1. Introduction

National commitments to cut greenhouse gas (GHG) emissions currently fall far short of what is needed to meet the goal of the 2015 Paris Agreement to limit global warming to 1.5^0 C and no more than 2^0 C[1]. Meeting this goal will require an estimated 45% reduction in global emissions by 2030, reaching net-zero emissions by 2050[2] with a continuing decline beyond that date. In response to this imperative, companies in every economic sector, along with national and regional governments, cities, universities, and investors are making their own commitments to reach net-zero emissions. As of March 2021, net-zero pledges covered 68% of the global economy[3], supported by a growing public consensus that climate change represents the most significant threat to current and future generations[4].

Of the 1,500 companies that have made net-zero commitments, it can be assumed that a substantial number are considering purchase of carbon offsets for at least some portion of their emission reduction targets[5]. This is consistent with the surge in demand for voluntary carbon offsets. Since the first carbon offset project in 1989, global markets for carbon offsets have become valued at more than $5 billion annually, doubling each year since 2018, and are projected to increase by as much as a factor of 15 or more by 2030 as companies and countries set ambitious goals for net-zero CO2 emissions.[6] [7]

In parallel, carbon offsets are attracting elevated scrutiny for their role in meeting climate goals[8]. While there has been considerable progress in establishing standards for rigorous monitoring, verification and reporting protocols, there has also been a legitimate debate regarding the role and efficacy of offsets in meeting science-based targets. For example, offsets have been criticized as not consistently delivering climate and other environmental benefits, or as providing a relatively cheap way for companies to meet “net-zero” goals, substituting for, and possibly disincentivizing core investments in operational efficiencies, renewable energy, technology innovations, or procurement of low-carbon inputs into supply chains[9].

A number of public-private initiatives have been organized recently to increase transparency and rigor in the voluntary carbon markets. For example, the Taskforce on Scaling Voluntary Carbon Markets (TSVCM) initiated by Mark Carney, the former Governor of the Bank of England, chaired by Bill Winters

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[1] United Nations Framework Convention on Climate Change (UNFCCC), Nationally determined contributions (NDCs) under the Paris Agreement, Synthesis report by the secretariat, September 2021, https://unfccc.int/sites/default/files/resource/cma2021_08_adv_1.pdf. The report notes that global GHG emission level after accounting for the implementation of all the latest NDCs will be 16.3 per cent higher in 2030 when compared to the 2010 level.
[2] IPCC. 2018. IPCC Special Report on the Impacts of Global Warming of 1.5 °C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. V Masson-Delmotte, P Zhai, H-O Pörtner, et al. (eds.). Geneva: World Meteorological Organization.
[3] See Black, R., Cullen, K., Fay, B., Hale, T., Lang, J., Mahmood, S., Smith, S.M. (2021). Taking Stock: A global assessment of net zero targets, Energy & Climate Intelligence Unit and Oxford Net Zero
[4] See for instance, UN Security Council Press Release, ‘Climate Change ‘Biggest Threat Modern Humans Have Ever Faced’, World-Renowned Naturalist Tells Security Council, Calls for Greater Global Cooperation.
[5] See Black, R., Cullen, K., Fay, B., Hale, T., Lang, J., Mahmood, S., Smith, S.M. (2021). Taking Stock: A global assessment of net zero targets, Energy & Climate Intelligence Unit and Oxford Net Zero
[6] Donofrio, S., Maguire, P., Zwick, S., and Merry, W. Ecosystem Marketplace Insights Brief: Voluntary Carbon and the Post-Pandemic Recovery, Forest Trends’ Ecosystem Marketplace: September 2020. Available at: https://www.ecosystemmarketplace.com/carbon-markets/
[7] Taskforce on Scaling Voluntary Carbon Markets, Final Report. https://www.iif.com/Portals/1/Files/TSVCM_Report.pdf
[8] See for instance, Jess Shankelman and Akshat Rathi ,2021. ‘Wall Street’s Favorite Climate Solution Is Mired in Disagreements’, Bloomberg June 3; Camila Hidgson, 2021, ‘Carbon offset transactions surge despite environmental concerns’, Financial Times, 16 September 2021; Black, R., Cullen, K., Fay, B., Hale, T., Lang, J., Mahmood, S., Smith, S.M. (2021). Taking Stock: A global assessment of net zero targets, Energy & Climate Intelligence Unit and Oxford Net Zero
[9] For instance, a recent Greenpeace report notes that ‘biggest problem with carbon offsetting is that it doesn’t really work’ arguing that ‘Offsetting schemes provide a good story that allows companies to swerve away from taking meaningful action on their carbon emissions. https://www.greenpeace.org.uk/news/the-biggest-problem-with-carbon-offsetting-is-that-it-doesnt-really-work/

the CEO of Standard Chartered and sponsored by the Institute of International Finance (IIF), is ‘predicated upon the principle that voluntary carbon markets must not disincentivize companies’ own emissions reduction efforts’[10]. The Voluntary Carbon Markets Initiative (VCMI), a multi-stakeholder platform sponsored by the UK Government and the Children’s Investment Fund Foundation, lays out principles to ensure high integrity offsets and their legitimate use in making net-zero claims.[11]

This paper aims to complement the TVSCM and the VCMI by providing an overview of key trends in carbon offset markets along with recommendations for buyers and sellers on how to participate effectively in an evolving market landscape. The focus here is on the development of exchanges and spot and futures contracts tradable on these marketplaces to generate reliable price signals and liquidity, drawing on examples from the LNG industry. While ‘bundling’ LNG cargoes or other commodity transactions with carbon offsets can be relatively straightforward via exchanges and spot and futures contracts, the use of carbon offsets in these types of commodity transactions are attracting elevated scrutiny regarding their contribution to meeting climate change targets[12].

The paper is divided into five sections. Section 2 provides the basics of carbon offsets. Section 3 provides some guidelines in optimizing procurement strategies. Section 4 discusses the evolution of carbon offset markets and the development of spot and derivatives markets and the increasing role these markets are playing in the price discovery process and attracting liquidity and new players and managing risk. Section 5 reviews how the LNG industry is using carbon offsets to structure ‘carbon neutral’ cargoes and looks at opportunities to strengthen the associated environmental claims.

2. Carbon offsets mechanics

The idea behind offsetting pollution has its roots in the U.S. acid rain program whereby electric utilities, unable to meet mandated sulphur dioxide emission caps through internal controls, are given flexibility to acquire emission allowances from other utilities with more cost-effective abatement technologies. This concept has been extended to carbon offset credits[13] - transferable instruments that each represents a reduction, avoidance, or removal of one metric tonne of carbon dioxide (tCO2e) or an equivalent amount of other greenhouse gases (GHGs). Buyers can retire carbon offset credits to claim the underlying reduction towards mitigating or neutralizing their own carbon footprints.

The first large-scale, compliance carbon offset market was a ‘flexibility mechanism’ that allowed industrialized nations, and by extension regulated emission sources, participating in the Kyoto Protocol (now expired) to meet part of their emission quotas by investing in approved GHG projects in developing countries[14]. Emission reduction units (ERUs) generated by joint implementation (JI) projects and certified emission reduction (CERs) generated from the Clean Development Mechanism (CDM) allowed countries committed to achieving emission reduction targets to carry emissions reduction projects in other countries (in developing countries with no targets under the Kyoto protocol) and count these towards their own targets. A key feature of the CDM and JI is that they are administered by United Nations Framework Convention on Climate Change (UNFCCC) committees which determine the eligibility of emissions reduction projects and record transfers in a central registry.

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[10] Taskforce on Scaling Voluntary Carbon Markets, Final Report. https://www.iif.com/Portals/1/Files/TSVCM_Report.pdf

[11] https://vcmintegrity.org/

[12] See for instance, Argus Media, 2021. ‘Oil firms struggle with 'carbon offset' messaging’, September 13.

[13] A carbon credit is issued by carbon crediting body and represents a unit of emission reduction or removal of CO2. These credits are tagged and tracked and the holder or purchaser of the carbon credit can surrender it or retire it to meet carbon neutrality or emission reduction goal. See Voluntary Carbon Markets Integrity Initiative (VCMI), 2021. ‘Aligning Voluntary Carbon Markets with the 1.5^0 C Paris Agreement Ambition’, Global Consultation Report of the Voluntary Carbon Markets Integrity Initiative (VCMI).

[14] A compliance market refers to one in which carbon offsets are created in order to comply with an imposed regulation or regulatory act. In contrast, the voluntary carbon market (VCM) is a market where carbon offsets are not purchased to be used in an active regulated market. See Voluntary Carbon Markets Integrity Initiative (VCMI), 2021. ‘Aligning Voluntary Carbon Markets with the 1.5oC Paris Agreement Ambition’, Global Consultation Report of the Voluntary Carbon Markets Integrity Initiative (VCMI).

Any future international carbon market remains to be negotiated as part of implementing Article 6 of the Paris Agreement on climate change and is likely to be the source of lively debate at COP26 in Glasgow in November 2021. However, as the EU has pointed out, 'the absence of rules to operationalise Article 6 does not prevent parties from having carbon markets'[15]. In fact, over 60 compliance carbon markets are operating at regional[16], national[17], sub-national, and sectoral[18] levels, many of which allow utilities and other large emission sources to buy carbon offsets to comply with mandatory caps on the total amount of GHGs they are permitted to emit each year.

To compensate for the emissions of a new coal-fired power plant in Connecticut, an American electric power company financed the first *voluntary* carbon offset project in 1989 with $2 million to help farmers in Guatemala implement agroforestry practices and reduce the need to expand into forests.[19] Voluntary carbon offset programs began to develop after 2005, as businesses, municipalities, non-profit organizations, universities, and individuals recognized the value of offsets in making GHG emission reduction claims outside a regulatory regime. Voluntary programs have not only originated standardized protocols for dozens of new project categories and spurred GHG abatement innovations around the world, they have also been instrumental in developing a number of compliance markets. In California, for example, several voluntary offset protocols published by the Climate Action Reserve (CAR) were later adopted (with some modification) in the California Compliance Carbon Offset Program. Offset credits issued by CAR under these protocols prior to the start of California's cap-and-trade program provided early liquidity and market acceptance for credits that subsequently became eligible for compliance. Mexico and South Africa have also recognized offset credits issued by voluntary programs for compliance with carbon tax obligations[20].

Figure 1 illustrates the general steps in the lifecycle of carbon offsets and offset credits.[21]

Methodology development

GHG reductions can be certified for use as carbon offsets only if they meet monitoring, reporting and verification (MRV) requirements and other criteria established in a methodology or a protocol, approved by an independent standards body. Individual MRV protocols specify requirements for:

- project eligibility
- eligible technologies and other practices to reduce, avoid or remove GHG emissions
- geographic and project boundaries
- crediting periods
- additionality criteria
- provisions for buffer pools where needed

[15] IISD, 2021. 'Delivering Climate Ambition Through Market Mechanisms: Capitalizing on Article 6 Piloting Activities, 24 March, https://sdg.iisd.org/commentary/policy-briefs/delivering-climate-ambition-through-market-mechanisms-capitalizing-on-article-6-piloting-activities/

[16] Most notably, the EU Emission Trading System, the Western Climate Initiative with California plus several Canadian provinces, the Regional Greenhouse Gas Initiative with 8 eastern U.S. states, and the China's provinces "Subnational Compliance Program". All of these regional programs accept the use of approved offsets to meet a portion (typically 3-5%) of compliance obligations. China's national Emission Trading Scheme immediately became the world's largest carbon market when it launched in July 2021, although carbon offsets will likely not be a part of the program during its initial stage due to a plentiful supply of emission allocations.

[17] For example, the South Korea Emission Trading Scheme allows regulated companies to use forestry and agricultural-based offsets for up to 10% of their compliance obligations.

[18] For example, the Carbon Offsetting and Reduction Scheme for International Aviation administered by the United Nations Internal Civil Aviation Organization.

[19] Applied Energy Services (AES) financed the project, in partnership with the World Resources Institute and the humanitarian aid organization CARE; ; Trent, M. (1992) The Choice: The Guatemala Reforestation Project, World Resources Institute. http://pdf.wri.org/bell/case_1-56973-123-3_full_version_b_english.pdf

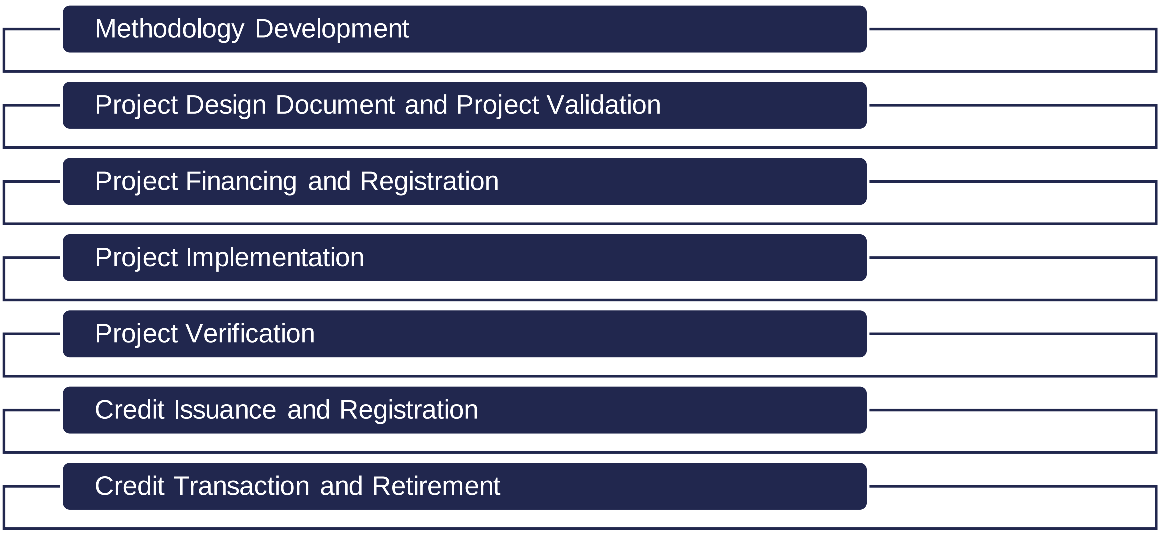
[20] See Carbon Offset Guide, 'Mandatory and Voluntary Offset Markets', https://www.offsetguide.org/understanding-carbon-offsets/carbon-offset-programs/mandatory-voluntary-offset-markets/

[21] For more details, see Kollmuss, A., Zink, H., and Polycarp. C. (2008), 'Making Sense of the Voluntary Carbon Market: A Comparison of Carbon Offset Standards, March, the Stockholm Environment Institute and Tricorona.

- monitoring and analytical technologies; and
- verification accreditation.

Hundreds of methodologies covering a wide range of project types have already been approved by existing carbon offset programs, also referred to as 'registries'[22]. The Verified Carbon Standard (Verra), Climate Action Reserve (CAR), American Carbon Registry (ACR), Gold Standard (GS) are the most established independent, voluntary carbon offset programs, each with high market credibility. A new methodology can be sponsored, proposed, originated, and shepherded through a peer review/public review process by a project developer, a prospective offset credit buyer, or a carbon offset program itself. Each registry has their own rules and standards; so far, there has not been a unifying body to harmonize these rules.

Figure 1: General Steps in the Lifecycle of Carbon Offsets and Offset Credits



Source: Authors

Project design document and project validation

For a Project Developer that will operate the project (may be a private company, a non-profit, or other non-government organization), once a project is determined to be viable, a first step in creating a carbon offset credit is the Project Design Document (PDD) that describes how the project meets the legal and performance requirements of an accepted MRV protocol. The PDD also provides a business plan that details the project mission, the implementation schedule, project boundaries, baselines conditions, processes for data collection, data management and quality control, personnel expertise and competencies, and estimated emission reductions. The developer submits the PDD to an accredited validation and verification body (VVB) that is approved by the carbon offset program/registry. The VVB will typically conduct on-site evaluations to determine project eligibility and the viability of the implementation plan.

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[22] These are also sometimes referred to as standards which are entities that develop methodologies, protocols and requirements that project developers should adhere to. These should be verified and validated by third parties (often referred to as Validation and Verification Bodies) duly approved under a carbon standard. There is a wide range of standards for different projects, but currently three standards account for the bulk of verification: Verified Carbon Standard (VCS), The Climate, Community and Biodiversity Standards (CCBS) and Gold Standard. The VCS and the CCBS are developed and managed by Verra, a non-profit organisation in Washington. The VCS issues tradeable credits called Verified Carbon Units (VCUs) that can be sold in the open market. See HSBC, 2020. 'Building a Voluntary Carbon Offsets market: Supporting Net-Zero Ambition', September, HSBC Centre of Sustainable Finance.

Project financing and registration

Prior to any project launch, the project developer should identify the source of funds to execute the project. Advance financing can come directly from prospective buyers of the offsets. In other cases, the developer may have a business model and enough reserves for self-financing. In this way, the project developer maintains ownership of the credits and maximum flexibility to wait for the best pricing opportunity. A more common approach is an Emission Reduction Purchase Agreement (ERPA) that contracts for future delivery of offset credits (or in some cases, options) as they are issued. Upon approval of the PDD as meeting eligibility criteria in an applicable protocol, a carbon offset program would officially register the project, allowing it to proceed.

Project implementation, verification, and offset credit insurance

The actual work to execute the project involves coordination of multiple activities that can include technology deployment, insuring that monitoring systems are calibrated and meet Quality Assurance / Quality Control (QA/QC) requirements in the protocol, conducting the required monitoring, data collection, analysis, and reporting, computing GHG emission reductions based on comparison of baseline and project emissions in conformance to the quantification methodology in the applicable protocol, and identifying any data gaps or other issues that could impact the project outcomes.

Project verification

Once a project is implemented, a project developer hires an independent third party, accredited by the carbon offset program, to verify that the carbon reduction claims are accurate and that all aspects of the project protocol and offset program requirements have been met. Verification is often done by the same VVB that conducted the initial validation assessment. Verifications often include audits, in-person site visits, as well as a thorough analysis of all project-related data. Verifiers submit a final report to the carbon offset program that, if applicable, attests to the project meeting the requirements in the protocol.

Offset credit issuance and credit registration

Once a verification report is approved, the carbon offset program issues the number of carbon offset credits equal to the quantity of verified CO2-equivalent GHG reductions. Each verified credit is given a unique identifying serial number that enables traceability and auditing. Offset credits are typically deposited into the project developer’s account in a registry system administered by the offset program.

Offset credit transaction and retirement

Once issued, carbon offset credits can be purchased and transferred from the project developer in a registry operated by an offset program, or into buyer-owned accounts operated by an open exchange. (see Section 4 for more in depth review of market dynamics). Credits can change hands multiple times before they are permanently retired on the carbon offset program registry. Buyers that retire the credits can claim the GHG emission reductions towards a net-zero goal or other GHG commitment. Once retired, the credit serial number is stored in an independent database and is taken out of circulation and cannot be transferred or used.

3. Optimizing offset outcomes

All registered offsets in voluntary markets are certified by independent standards bodies, and verified by third parties in conformance with rigorous, published offset protocols. However, unlike compliance markets where certified offsets are effectively commodified with identical pricing, liabilities, and other contractual elements, voluntary offsets are intangible offsets that can be highly variable in terms of project type, location, vintage, sustainable development credentials, and other factors. Buyers of voluntary credits therefore have more options compared to compliance offset buyers, but at the same time need to conduct due diligence to ensure that the particular credits and underlying projects meet their own organization’s standards.

3.1. Quality of the offsets

One of the challenges highlighted by the TSVCM is the ability of buyers to identify what constitutes a high-quality credit. The following summarizes some of the key decision elements for prospective buyers to consider in comparing the merits of alternative carbon offset strategies.

3.1.1. Project types

Over the past three decades, more than 200 different types of projects have been approved for compliance and voluntary offset markets[23]. These can be grouped into the following categories:

- Avoided Nature Loss in which forests, grasslands, wetlands, peatlands, and other natural carbon sinks are protected.
- Technology-based avoidance/reduction, for example, transition to renewable energy in jurisdictions where renewable energy is not yet mandated, capturing methane from landfills and dairy operations, deployment of efficient cookstoves in rural households, and recovery and destruction of fluorochemical refrigerants.
- Nature-based removal which restores natural carbon sinks via, for example, reforestation, regenerative agriculture, and mangrove restoration.
- Technology-based removal and sequestration in which CO2 is separated from industrial stack emissions[24] and either injected into secure geologic formations or used in manufacture of durable materials such as carbon fiber and concrete.

3.1.2. Project strength

Voluntary and compliance markets rely on an ecosystem of standards and certification organizations, project developers, and verifiers to only recognize emission reductions that are '**real, measurable, and additional**'. Conformance to these core principals and minimum quality thresholds depends on numerous factors including the quality and accuracy of monitoring data, credibility of the crediting baseline, whether impacts are accurately quantified using conservative, transparent methodologies, accounting for **leakage**[25]), and the rigor of independent, accredited verifications. In addition, the question of the permanence of any reductions is critical.

Proving **additionality** requires a project proponent/developer to demonstrate that a given project would not otherwise occur under business as usual. For example, a solar project in a jurisdiction with an existing renewable portfolio standard or other renewable energy mandate would not qualify for carbon offset credits under a properly administered program.[26] Likewise, a landfill with a methane capture system would not be eligible for credits if state regulations mandate such technology. Concerns have been raised recently regarding forestry and other conservation projects involving lands that may already be under long-term conservancy easement with a land trust or government agency.[27]

Some offsets represent avoided GHG emissions that are inherently **permanent,** for example, destruction of recovered, phased-out fluorochemical refrigerants. For projects involving CO2 capture, permanence is more uncertain and will depend on how the CO2 is utilized (e.g., embedded in durable materials such as concrete or carbon fiber versus being used as an intermediate feedstock in alternative

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[23] Total includes protocols approved by the Clean Development Mechanism, Alberta Offset System, California cap-and-trade system, Regional Greenhouse Gas Initiative, Voluntary Carbon Standard, American Carbon Registry, and The Gold Standard.
[24] Reducing costs and scaling emerging technologies to physically remove CO2 directly from the atmosphere is viewed as critical in meeting climate goals.
[25] Leakage refers to the potential for increased emissions outside the project boundary by shifting an emissive operation or technology to another location, e.g., a forest conservation project that results in illegal logging in another location.
[26] Nevertheless, the majority of energy-related credits (renewables, waste heat recovery, fossil fuel switch, efficient lighting) in developing countries issued under the Clean Development Mechanism between 2013 and 2020 were found to be non-additional. Cames, M. et al. (2016) et al., How additional is the Clean Development Mechanism? Oeko Institut & Stockholm Environment Institute, March, 2016, infra.ch.
[27] The Nature Conservancy "Our Commitment to Carbon Credits and the Path to Net Zero" https://www.nature.org/en-us/newsroom/carbon-market-review-findings/; https://www.worldoil.com/news/2021/4/5/nature-conservancy-investigating-its-own-sales-of-potentially-meaningless-carbon-credits.

fuel synthesis). Forestry, grassland, and other nature-based offset projects are generally considered to provide multi-decade carbon sequestration, but there are risks of reversals (e.g., loss to fire, disease, or illegal logging) that must be accounted for and managed via buffer pools and other guarantees.

Carbon offset projects can have secondary ‘co-benefits’ in addition to reductions in GHG emissions. For example, use of efficient clean cookstoves reduces the amount of water needed for boiling, and reduces the amount of labor that women in small villages devote to transporting water (often from a distant river or lake) and gathering wood. Similarly, conserving forests, wetlands, grasslands, mangroves, farmland soil, or other natural carbon sinks (“bio-sequestration”) can also result in preserved habitat for wildlife, reduced runoff that pollutes surface waters, increased agricultural productivity, and preservation of traditional customs among native/indigenous populations.

Demand for nature-based offsets (also referred to as “Natural Climate Solutions”, or “Nature-Based Solutions”) is high, due in large part to their “beyond-climate” benefits. Between 2017 and 2019, nearly $400 million was transacted in buying and selling 105 MtCO2e of voluntary carbon offsets from forestry and land use activities[28]. Continuing increases in demand are forecast, in line with estimates that forests and other natural climate solutions are capable of providing up to one-third of climate mitigation by 2030.[29] Initiatives such as the Natural Climate Solutions Alliance hosted by the World Economic Forum and the World Business Council for Sustainable Development, and the International Emissions Trading Association’s Market for Natural Climate Solutions are helping to mobilize large-scale carbon finance for nature-based climate mitigation. In its recent ‘Fit for 55’ communication the EU has asserted that ‘restoring nature and enabling biodiversity to thrive again is essential to absorb and store more carbon’… and ‘therefore need to increase the capacity of the EU’s forests, soils, wetlands and peatlands, oceans and water bodies to act as carbon sinks and stocks.”[30]

3.2. Role of offsets in net-zero ambitions

Assuming that a corporate buyer was able to secure guaranteed, high-quality offsets as described above (e.g., additional, not overestimated, permanent, unique to one entity, co-benefits and not associated with significant social or environmental harms), they face two other fundamental challenges in assuring that their investments are part of an effective “net-zero” carbon strategy.

First, as noted in the Introduction, offsets have been criticized as an ‘easy-out’ for corporations to meet net-zero goals, and in some commentaries merely an accounting mechanism that transfers emissions from one place to another. The GHG Management Hierarchy[31] and recent multi-stakeholder appraisals of voluntary carbon markets emphasize that offsets should be pursued as a complimentary, rather than a primary, strategy to balance unavoidable, residual GHG emissions that cannot be reduced, prevented, or eliminated via direct measures in the near term[32].

Second, as noted by the VCMI, “the ‘net-zero’ terminology has acted as a magnet for voluntary corporate climate commitments….at the same time, stakeholders have expressed concern about the

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[28] Compliance markets financed over $2.3 Billion for forestry projects during the same time period. Ecosystem Marketplace State of the Voluntary Carbon Markets 2021.

[29] Bronsom Griscom “How Nature can get us 37 Percent of the Way to the Paris Climate Target,” Ecosystem Marketplace, October 19, 2017, https://www.ecosystemmarketplace.com/articles/nature-can-get-us-37-percent-way-paris-climate-target/

[30] European Commission, (2021), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality.

[31] https://transform.iema.net/article/ghg-management-hierarchy-updated-net-zero

[32] The report of the Task Force on Scaling Voluntary Carbon Markets states that ‘offsetting can raise climate ambitions if pursued in conjunction with a company’s efforts to reduce its own emissions’ and should not by any means disincentivise corporations from reducing their own emissions. Similarly, the Voluntary Carbon Markets Integrity Initiative states that the “imperative for overall and absolute emissions reductions globally, to keep 1.5 ℃ within reach, necessarily means the end to ‘traditional’ offsetting – where carbon credits are purchased instead of reducing avoidable emissions within the value chain of a company. It is no longer sufficient or legitimate to achieve long- term ‘equivalence’ through counterbalancing emissions with carbon credits. Instead, the use of carbon credits should be additional to abatement and should be carefully managed to avoid replacing other forms of public and private action.”

lack of clarity of those commitments, with widespread confusion linked to the discrepancy in their calculation and communication…. This is in part because there is no widely agreed-upon definition of net-zero at the corporate entity level".

In recognition of these complexities, the TSVCM[33] recently recruited an independent governance body to establish and maintain 'Core Carbon Principles' to derive a set of threshold criteria against which the quality of carbon credits and standards and methodologies can be assessed[34] and a consistent taxonomy of project attributes such as environmental co-benefits, proof of atmospheric CO2 removal, vintage, and project type.

4. Voluntary carbon market dynamics[35]

In order for carbon offsets to generate value, project developers must be able to obtain investments, either directly from end-users or other financing sources. In turn, the ultimate purchaser of a carbon offset needs to be able to claim the credit, i.e., the verified GHG emission reduction, or carbon removed/sequestered – which would be the ability to show the ownership and then retirement of the offset to create a registered benefit.

4.1. Optimized trading

Project owners have several ways that they can transact in the marketplace:

- Direct offtake agreements with an 'end-user'
- Selling to a retailer, who purchases the offsets with the intent to find a match with an end-user
- Selling into an open market exchange

4.1.1. Direct offtake

Carbon offsets could be purchased directly from project developers who coordinate all the project operations including registration, monitoring and reporting requirements, third party verification, and registering the credits once issued by the carbon offset programs.

The advantage of a direct offtake agreement is that a project owner and a buyer can agree on the value of the project and transact directly. This could be an efficient way to establish pricing and to eliminate fees and other ancillary costs when other parties are involved. Once the contract is specified, the obligations for carbon offsets transfers in the registries and the delivery of cash as payment can be executed as negotiated in the contract. However, in practice bilateral agreements can be slow to negotiate and expose counterparties to various risks. Potential issues with this type of arrangement include the risk that either counterparty might default on its obligations, or that the agreed price between the counterparties is not the 'fair value' that might have been agreed if both the buyer and the seller were to have access to a wider range of information on which to make a decision.

4.1.2. Retail providers

Retailers maintain portfolios of multiple types of projects and can customize offset packages (e.g., volumes, vintages, project types, delivery dates) to meet preferences of different customers (e.g.,

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[33] Taskforce on Scaling Voluntary Carbon Markets (2021).

[34] These core principles reinforce several concepts: (1) Reduce where companies 'should publicly disclose commitments, plans, and annual progress to decarbonize operations and value chains….using best available data, and prioritize fully implementing these commitments and plans' including 'making public (or subjecting to external audit) the basis on which claims are made'; (2) Report where companies 'should measure and report Scope 1, Scope 2, and, wherever possible, Scope 3 greenhouse gas emissions on an annual basis using accepted third-party standards for corporate greenhouse gas accounting and reporting'; (3) Offset where companies with unabated emissions are offset through the purchase and retirement of carbon credits generated under credible third-party standards.

[35] This section focuses only on voluntary carbon offset markets; in compliance carbon markets, regulated entities view offsets, once they have been approved and registered by the regulator, as commodities with equivalent pricing regardless of the underlying project type.

individuals, corporations, financial institutions). It is common for a retailer to maintain accounts on carbon offset program registries or exchanges and will retire offset credits directly on a buyer's behalf.

In the early stages of the voluntary carbon markets, retailers of carbon offsets represented a large part of overall liquidity. As with many emerging markets, retailers offered expertise and advisory services to their corporate clients, bundled along with the carbon offsets to help meet their net-zero commitments. Retailers also offered highly bespoke solutions to their clients. This is particularly valuable in offset markets because buyers often have specific preferences or mandates such as the geographic origin of the project, the technology that was utilized, whether or not the project was nature-based, and other characteristics such as the commitment to biodiversity or equal gender rights. Maintaining this database was difficult, and retailers were often able to do this more efficiently than any single participant.

Carbon offset retailers can provide other market efficiencies by taking direct ownership positions in the carbon offsets, providing cash liquidity, lowering of counterparty risk, and managing buyer needs over time, for example, by structuring contract deals with project owners where they can assure the purchase upon issuance, with cash on delivery. In this way, retailers become the single touch point for both the project owner and the buyer, providing contract terms that specify delivery of offsets at a certain 'forward price', volume, and time period (which can be as close as one month out or as long as several years). However, in practice retailers often "back-to-back" sell the underlying units to their clients and collect fees before paying the sellers of the offsets.

Although carbon offset retailers provide multiple market advantages, project owners and buyers would want to recognize that quoted prices remain the provenance of the retailers, who thereby possess significant latitude in establishing fees for matching market participants, managing counterparty risk, and insuring delivery of the offsets. This market asymmetry led many retailers, in the absence of transparent pricing, to extract significant premiums in the form of arbitrage.

4.1.3. Brokers

As with other commodities, numerous firms act as brokers for carbon offset credits. Brokers procure offset credits and then transfer (or retire) them on clients' behalf. As with retailers, brokers can help identify a mix of offset credits from different project types and facilitate large or small transactions either through bilateral contracts or via exchanges. Some brokers sell offset credits from projects they have invested in, in addition to projects developed by others. This can provide pricing efficiencies but can also affect impartiality.

4.1.4. Market exchanges

While many parties continue to trade over the counter (OTC), a natural step in voluntary carbon markets has been the development of 'environmental' commodity exchanges, which are open marketplace offering the full range of offsets. While many parties continue to trade over the counter (OTC), the TSVCM emphasises the importance of these exchanges, and of liquid spot and futures contracts tradable on these exchanges, to generate reliable price signals and allow for risk management, without which it is not possible to unlock the full benefits from carbon offset markets. Generally, a spot exchange can become a venue where contract terms become standardized, information can be shared equally among all market participants, and counterparty risks can be managed in a cost and time-efficient manner.

Several carbon exchanges have emerged to optimize the price discovery process and the management of counterparty risks. Xpansiv market CBL[36] operates the largest voluntary carbon spot market with direct linkages to the major registries, providing price transparency and enabling participants to select and transact on a project-by-project basis by making bids and offers across a wide range of carbon offset projects, varying by standard, region, technology, project methodologies, and vintage. Other exchanges include the recently launched Climate Impact X in Singapore, the Carbon Trade Exchange in London and Sydney, and the AirCarbon Exchange in Singapore. Recently, Saudi Arabia's

[36] Referred to hereafter as "CBL". CBL is a subsidiary of Xpansiv, Ltd.

Public Investment Fund and the Saudi stock exchange Tadawul announced a plan to establish a voluntary exchange in Riyadh for offsets and carbon credits within the Middle East and North Africa Region.

4.2. Pricing and Contract Efficiencies

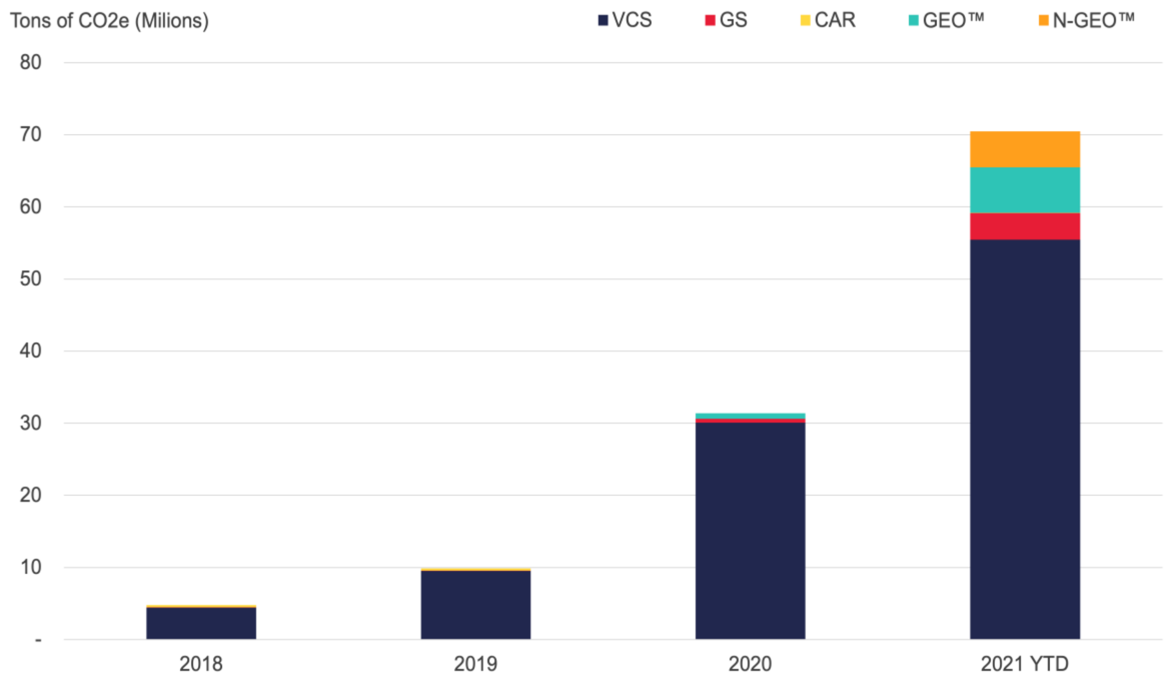
Price discovery in the carbon offset markets has transformed rapidly over the past 24 months. Up until 2019, the market primarily depended on retailers to provide pricing information on the variety of projects, and a market participant needed to have relationships with various retailers to get a good overview of how the markets were transacting. With the rise of spot market exchanges, two mechanisms for price discovery have occurred:

- Project-by-project pricing
- Standardized contracts pricing

4.2.1 Project-by-project pricing

Project-by-project pricing comprises a mechanism where a project owner can 'encumber' (escrow) their inventory of carbon offsets for sale onto the CBL exchange, for example, and display the project characteristics and the offering price as a 'firm offer'. A project owner is thus able to reach a wide variety of potential purchasers, and to be guaranteed payment if a purchaser 'lifts' their offer on the exchange. They can also validate their sale price against other sellers and adjust it based on transactions listed on the exchange and on transparent, real-time supply and demand. For both buyers and sellers, price fees per transaction are transparent and generally seen to be less expensive compared to other routes. Because of these various efficiencies, the volumes of exchange-based transactions are growing exponentially in parallel with increasing numbers of carbon offset market participants. Figure 2 illustrates the transactional volume via CBL for voluntary carbon offsets annually since 2018.

Figure 2: Annual carbon volumes traded on CBL Markets, million tonnes of CO2e



Source: CBL Markets

Prices for voluntary carbon credits are highly variable by vintage, project type, co-benefits, and verification agency[37], ranging from less than a dollar to over $50 per ton of CO2e[38 39](see Table 1). Projects that are "nature-based" and involve long-term carbon sequestration (e.g., forest conservation), and especially those with environmental and social co-benefits (e.g., wildlife habitat, biodiversity, water quality, indigenous and other community values, or worker rights) typically attract higher prices.

Table 1: Variation in offset projects prices ($ per ton of CO2 equivalent on selected registries)

Registry	Avg. Price ($)	Max	Min	Median	Range
ACR	10.19	11.70	9.34	10.00	2.36
CAR	10.39	13.18	5.00	11.00	8.18
CDM	7.83	59.17	0.45	2.15	58.72
CS	20.28	47.00	4.94	18.63	42.06
VCS	10.52	21.58	3.57	10.44	18.01

Notes: ACR: American Carbon Registry; CAR: Climate Action Reserve; GS: Gold Standard; VCS: Verified Carbon Standard; CDM: Clean Development Mechanism. Source: Allied Crowds

4.2.2. Standardized contracts

Standardized futures contracts represent another stage of market evolution. In 2020, CBL created the Global Emissions Offset™ (GEO®), a physically settled contract that allows for the delivery of CORSIA[40]-eligible voluntary carbon offsets from VCS, ACR, and CAR[41].[42] The offsets underlying GEOs adhere to the CORSIA framework for international aviation, but the carbon offsets that fall under this program appeal to a broad range of firms seeking to deliver on net-zero promises.[43]

Recognizing that Agriculture, Forestry and Other Land Use (AFOLU) projects will play a vital role in voluntary carbon markets, CBL subsequently launched the Nature-Based Global Emissions Offset (N-GEO™) to facilitate a more efficient and transparent market for AFOLU credits. The contract will follow the Verified Carbon (VCS) Standard for AFOLU projects, with an additional certification of Verra Registry's stringent Climate Community and Biodiversity (CCB) Standard.[44]

By standardising carbon offset credits, the GEO and N-GEO provide a consistent quality benchmark for offsets and eliminate the price divergence observed in spot retail markets. More recently, the CME Group partnered with CBL to originate futures contracts for both CBL GEOs and N-GEOs. These future contracts enable new trading opportunities and provide innovative risk-mitigation strategies for voluntary carbon markets. Delivery of the futures contract is facilitated through CBL, which provides connectivity to all GEO-eligible registry systems. When a GEO futures contract expires, trade

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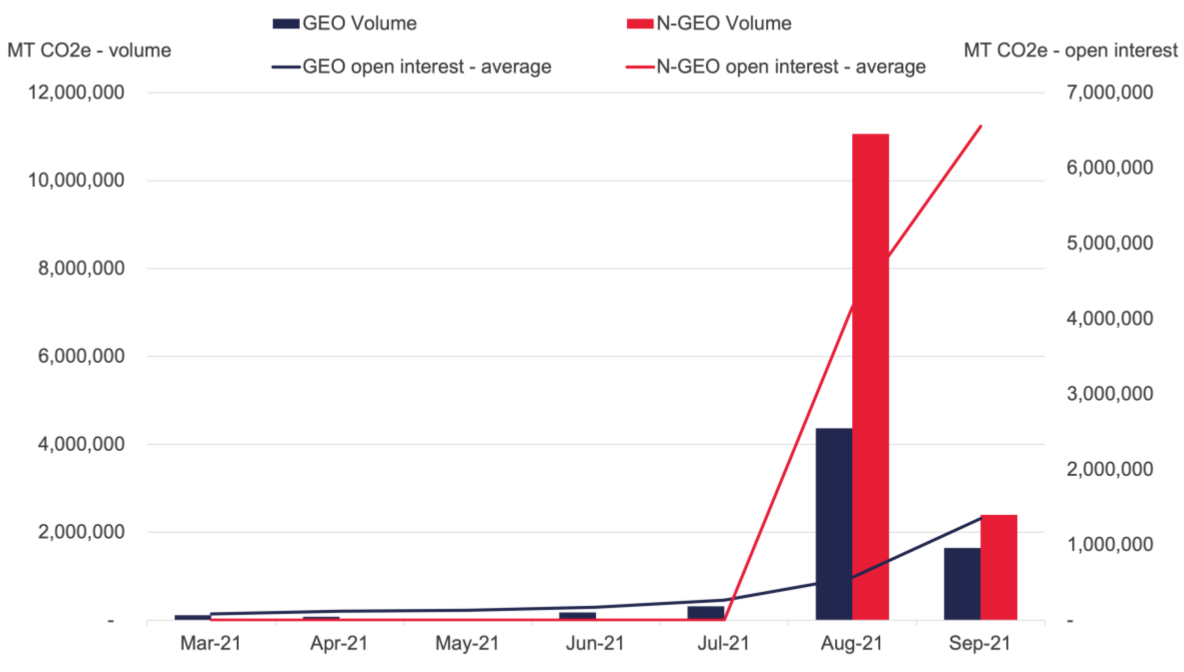
[37] https://www.cmegroup.com/education/articles-and-reports/carbon-convergence-across-the-geo-sphere.html
[38] 2021 CBL Carbon trades ranged from 0.38 to $12. Currently live offers range from $1.88 to $39 on the CBL Markets Platform
[39] Allied Crowds, 2020. 'Carbon Offsets: Pricing Data', September; Conte, M. and Kotchen, M. (2010), 'Explaining the Price of Voluntary Carbon Offsets, Climate Change Economics', Vol. 1, No. 2 (2010) 93–111
[40] CORSIA, the Carbon Offsetting and Reduction Scheme for International Aviation, is a UN mechanism developed by the International Civil Aviation Organization (ICAO) to achieve carbon neutral growth in international aviation compared to a 2020 baseline. https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx
[41] The choice of registries was based on a rigorous selection criteria and review process developed by ICAO and a group of carbon experts from 19 countries known as the Technical Advisory Body (TAB). ICAO and TAB spent years developing a stringent screening process to determine which offset registries and project types are eligible for CORSIA. The result is a set of criteria that firms across industries can use as guidance to assess the robustness of emissions offset projects and associated credits.
[42] https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx
[43] The criteria for CORSIA was chosen as it was established for over four years and verified through a standardized process under UN guidance.
[44] Many of the attributes of the N-GEO futures contract follows the same structure as the GEO futures contract, such as the expiration date, contract size, tick size, and listed trading venues. Like GEO, N-GEO utilizes the underlying CBLMarkets spot data for pricing the futures and leverages CBLMarket's connectivity to the Verra registry for delivery. Since N-GEO also includes one of the three offset registries eligible for delivery via the GEO futures contract, the GEO participant pool also has access to N-GEO futures.

participants engage in a physical delivery process. The CME GEO futures contract is a seller's option contract, meaning the seller dictates which of the three registries will be utilized to provide the offset credits required to fulfil contractual delivery obligations. Like any physically deliverable futures contract listed with CME Group, not every firm will choose to make or take delivery at expiration. Instead, many firms may either trade out of their position, roll their position to a future month, or use an Exchange for Physical (EFP) transaction to close out their futures position.

With the advent of standardized contracts, a new class of buyers has come into the market including commodity trading houses including Hartree Partners, Mercuria Energy Americas, and Vitol SA, specialized funds such as the Andurand Climate and Energy Transition Fund, as well as bank counterparties like Macquarie.[45] As the market develops and liquidity improves, the contracts may attract further participation from a broader range of corporates, financial firms, asset managers, and retail traders. Also, trading platforms and price reporting agencies are responding to market demand for more transparency. S&P Global Platts has started reporting a daily assessment for CORSIA eligible credits[46], a typical sign that a tradable asset is becoming standardized and commoditized.

Since launching in March 2021, over 6 million emissions offsets have traded through GEO futures on CME Group with over 1.5 million offsets of open interest currently held at CME Group (data as of September 21, 2021). Prices are now quoted out to December 2024 on an open, electronic marketplace. In June 2021, the first physical delivery of 21,000 carbon offset credits via GEO futures (21 contracts equivalent) took place between four market participants[47]. The N-GEO contract started trading in early August and has quickly accumulated over 13 million offsets traded, with over 6 million offsets of open interest (data as of September 21, 2021).

Figure 3: Volume traded and open interest – CME Group GEO and N-GEO futures



Notes: September 2021 data only runs through to September 21, 2021. Source: CME Group

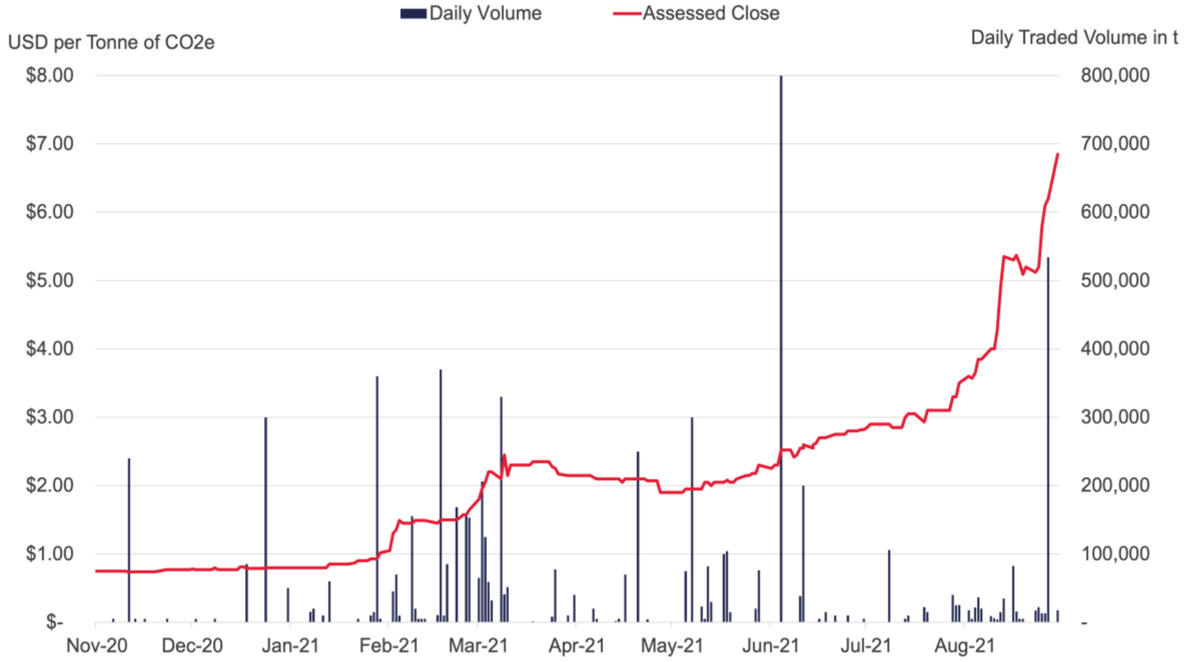
[45] https://www.cmegroup.com/media-room/press-releases/2021/3/03/cme_group_announcesfirsttradesofglobalemissionsoffsetgeofutures.html, https://www.evomarkets.com/newsroom/market_insights/evolution-brokers-first-cme-listed-carbon-offset-futures-trade

[46] https://www.spglobal.com/platts/PlattsContent/_assets/_files/en/our-methodology/methodology-specifications/platts_-cec_faq.pdf

[47] See NYMEX delivery reports https://www.cmegroup.com/delivery_reports/EnergiesIssuesAndStopsYTDReport.pdf

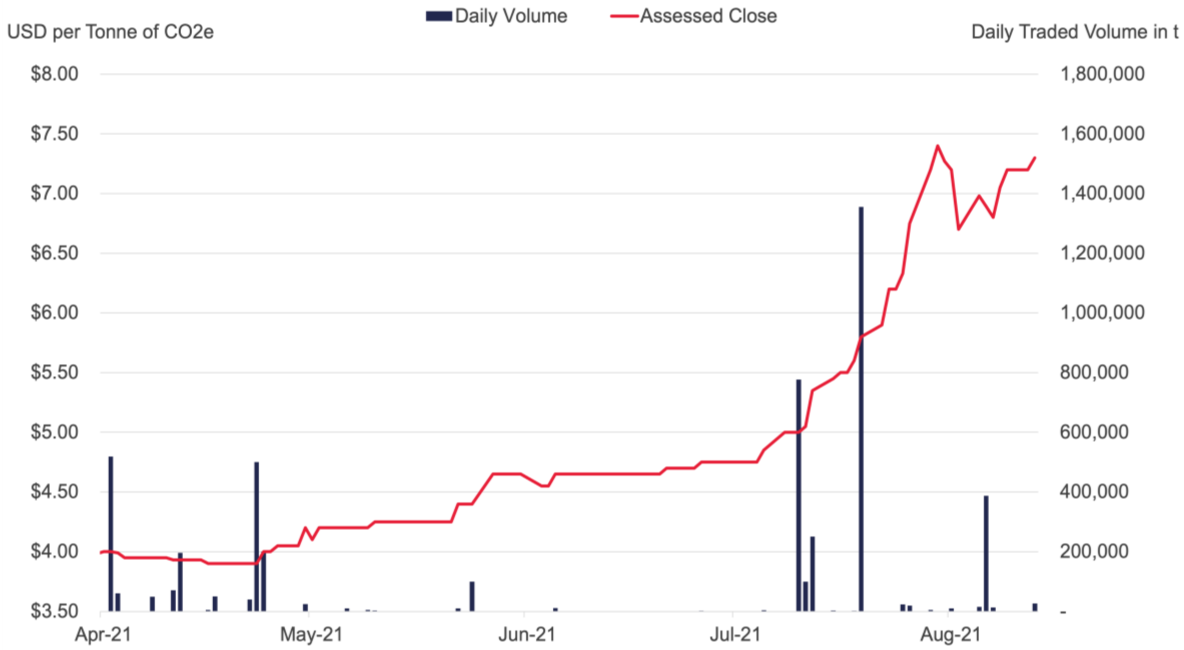
Growing activity in the CME Group GEO and N-GEO futures markets mirrors stronger participation in the spot market for CBL GEO and N-GEO offsets, tradable on CBL's spot market platform. Until late 2019, the carbon offsets market was "over-supplied" with more projects than willing investors. Since then, there has been a dramatic increase in transaction volumes and pricing, with demand driven by corporations and financial institutions seeking to meet net-zero goals (see Figure 4 and 5).

Figure 4: CBL GEO assessed prices and traded volume (year-to-date)



Source: Xpansiv market CBL

Figure 5: CBL N-GEO assessed prices and traded volume (year-to-date)



Source: CBL

5. Use of carbon offsets by the energy industry

To help respond to concerns from investors and regulators, there has been growing interest in the use of carbon offsets to create 'carbon-neutral' liquified natural gas (LNG) and crude oil cargoes. In 2020, roughly 20 'carbon-neutral' LNG cargoes traded (out of a total 5,000 LNG cargo deliveries)[48]. This section describes the main market participants and how an LNG carbon-neutral trade may be structured and optimized.

5.1. GHG emission accounting

Currently, there is no universal, standard definition of 'carbon-neutral' LNG, and reported transactions have included offsets to compensate for different segments of the LNG lifecycle.

- Gas well to loading arm
- LNG ship to regasification terminal
- Regasification terminal to combustion[49].

The gas to loading arm includes exploration and extraction per unit of output, pipeline transportation to the liquefaction terminal, and liquefaction of LNG produced and exported. The LNG ship to regasification terminal include transporting the LNG to destination. The regasification terminal to combustion includes emissions from regasifying the LNG, transporting the gas to the end user and the emissions of gas burned. This could be broadly divided into upstream (i and ii) and downstream (iii). Upstream emissions, accounts for 20-40% of LNG lifecycle emissions while downstream emissions accounts for 60-80%[50]. Given the fragmented supply chain, different certification authorities may be involved in the measurement, monitoring, verification, and certification of emissions[51].

An alternative approach is to consider the 'scope' of GHG emissions. Based on the Greenhouse Gas Protocol[52], which is the most widely used carbon accounting standard, lifecycle GHG emissions can be divided and measured according to three 'scopes' (Scope 1, 2 and 3):

- Scope 1 emissions are direct emissions from owned or controlled sources.
- Scope 2 emissions are indirect emissions from the generation of purchased energy.
- Scope 3 emissions are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions.

From the perspective of an integrated supplier selling LNG on an ex-ship DES basis, scope 1 and scope 2 encompass upstream emissions, while the consumption of natural gas will fall under scope 3, namely indirect downstream emissions. The opposite holds for the LNG importer: here, scope 1 and 2 emissions are equivalent (the direct consumption of the regasified LNG) while the upstream emissions fall under scope 3. The advantage of using upstream/downstream classification is that such classification is not dependent on a participant's position in the supply chain.

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[48] Erin Blanton and Samer Mosis, The Carbon-Neutral LNG Market: Creating a Framework for Real Emissions Reductions, Columbia Center on Global Energy Policy, July 2021.

[49] For more details, see Stern, J. 2020. 'Methane Emissions from Natural Gas and LNG Imports: an increasingly urgent issue for the future of gas in Europe', OIES Paper NG 165, Oxford: Oxford Institute for Energy Studies and Stern J., 2019. ' Challenges to the Future of LNG: decarbonisation, affordability and profitability, OIES Paper NG152, Oxford: Oxford Institute for Energy Studies.

[50] Erin Blanton and Samer Mosis, The Carbon-Neutral LNG Market: Creating a Framework for Real Emissions Reductions, Columbia Center on Global Energy Policy, July 2021, link, https://www.woodmac.com/consulting/multi-client-studies/LNG-Emissions-Tool-Carbon-Neutral-LNG/

[51] Stern J., 2019. ' Challenges to the Future of LNG: decarbonisation, affordability and profitability, OIES Paper NG152, Oxford: Oxford Institute for Energy Studies.

[52] GHG Protocol is an initiative developed by the World Resource Institute (WRI), the World Business Council for Sustainable Development (WBCSD) and a group of international companies. The initiative consists of two standards for corporate accounting and reporting and project accounting. The latter provides specific principles and methods for quantifying and reporting GHG emissions from climate change projects. See HSBC (2020).

This is a useful division because it divides responsibility for emissions between the exporter getting the cargo to the border, and the importer taking responsibility for emissions within its own country over which it should have some control.[53] Scopes 1 and 2 are regarded as wellhead to border of the importing country. Regasification and utilization are regarded as scope 3.

5.2. Measurements of emissions

The bulk of LNG lifecycle emissions occurs via combustion of the natural gas. A generally accepted "default" emission factor for natural gas combustion is an average of 117 pounds of CO2 emitted per million British thermal units[54] of natural gas, equivalent to about 2.50 kilograms of CO2 per kg of LNG.

In contrast, upstream emissions can be highly variable, driven by differences beginning at the wellhead (e.g., gas composition, flaring, venting, leak detection and repair of methane leaks), extending to differences in transmission pipelines, liquefaction processes and technologies, the carbon footprint of the shipping segment (age of the tanker, marine flaring during cooldown, miles travelled, power generation for cargo pumps, etc.), and during the regasification and transfer processes.

In the absence of widely established measurement methodologies and protocols, the industry is currently relying on benchmark values to approximate the carbon emission of an LNG cargo. Firms such as Shell and Total[55] have adopted reference values published by the UK Department of Business, Energy, and Industrial Strategy (BEIS) to allocate CO2 emissions to their carbon neutral LNG cargoes[56]:

- 0.88 kg of C02 equivalent generated for each kg of LNG for the extraction, refining, and transportation of the fuel (WTT)
- 2.54 kg of CO2 equivalent generated for each kg of LNG for the fuel combustion (TTW).

It should be noted that these emission factors values have been developed for LNG imported into the UK from (mostly) Atlantic Basin sources and therefore not directly applicable for cargos delivered to Asia. Also, although the use of industry averages to account for GHG emissions could be a useful starting point to structure carbon neutral cargoes, it can mask wide differences in GHG upstream emission activity between participants. As noted by Stern (2019),

> *'methodologies for emission standards may take several years to establish for the different elements of each LNG value chain. But cargos which do not have value chain certification by accredited authorities, or which fail to meet certain emission standards, run the risk of progressively being deemed to have a lower value (because they will require the buyer to purchase higher levels of emission offsets of various types) or eventually excluded from jurisdictions with strict regulatory standards'.*[57]

It remains to be seen how the industry will adapt and there have been some recent attempts to address this challenge. The least carbon intensive producers have most to win from more precise measurements since carbon offsetting will require the least amount of credits. Potentially, this could lead to a problem of adverse selection with less carbon intensive suppliers choosing to report their carbon footprint more precisely while other suppliers rely on industry averages.

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[53] This works well for DES trades but many (especially US) trades are fob. This means that some other entity – sometimes the importer, sometimes a trader/shipper – will take title at the exit to the LNG plant and be responsible for emissions until the cargo is landed.

[54] https://www.eia.gov/energyexplained/natural-gas/natural-gas-and-the-environment.php

[55] https://www.shell.com/business-customers/trading-and-supply/trading/news-and-media-releases/cpc-corporation-taiwan-receives-second-carbon-neutral-lng-cargo-from-shell.html, Erin Blanton and Samer Mosis, The Carbon-Neutral LNG Market: Creating a Framework for Real Emissions Reductions, Columbia Center on Global Energy Policy, July 2021, link

[56]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/891106/Conversion_Factors_2020_-_Full_set__for_advanced_users_.xlsx

[57] Stern J., 2019. 'Challenges to the Future of LNG: decarbonisation, affordability and profitability, OIES Paper NG152, Oxford: Oxford Institute for Energy Studies.

5.3. Features of recent carbon-neutral LNG transactions

Table 2 below provides an overview of trades across LNG, crude oil and condensates. A few observations are worth highlighting:

- Table 2 shows a wide range of participant suppliers and buyers. It is notable that the vast majority of carbon-neutral trades were destined to North Asian markets. In Europe, power plants that run on natural gas are covered by the mandatory carbon market for the European Union, the EU Emissions Trading System (EU ETS) which is by far the largest ETS worldwide.[58] Because EUAs are not project specific and can be used interchangeably across European jurisdictions and industries, the pricing and trading of EUA futures is highly transparent. EUA allowances currently trade around $60/ MT CO2e, significantly higher than voluntary carbon prices. The significant price difference also reflects the fact that voluntary offset credits are not fungible against EUA obligations, meaning that an entity covered by the EU ETS will not be able to retire voluntary credits to satisfy compliance under the EU ETS. Some of the Scope 3 emissions resulting from the combustion of the natural gas imported as LNG will be captured by the EU ETS, for example if natural gas is used in power stations, or in the industrial sectors which are required to buy allowances in the ETS. However, many industrial sites receive free allowances, and sectors such as heating of commercial and domestic buildings, and transport are not yet covered by the EU ETS.[59] [60]The former impacts the use of natural gas as a fuel, whilst the latter impacts the transport of LNG within the EU whether by ship or road tanker. Furthermore, the status of methane emissions associated with LNG imports (upstream production, liquefaction, transportation via ship, regasification, and transmission and distribution via pipeline) remains to be clarified in legislative proposals for later this year. As most methane emissions are associated with production of natural gas, it is not clear whether the EU will be able to impose regulations on producers outside its jurisdiction, and the EU imports most of its oil and gas.[61]
- The North Asian economies of China, Japan and South Korea account for the bulk of LNG imports into the region. Asia itself is the world's largest destination for LNG cargoes – accounting for 71% of world imports, and China, Japan, South Korea jointly representing 73% of APAC imports[62]. Those three countries do not currently run mature mandatory emissions trading systems. China is the furthest ahead, with a national ETS that started trading this year. Taking the early phase of the EU ETS as an example, however, it may take some years until pricing in China's compliance market starts to have a meaningful impact: early trading in the EU ETS was hampered by oversupply of free allowances, meaning that the price signals from EU ETS trading did not greatly influence market behaviour. This only changed in the last few years through the forced retirement of excess allowances, reducing carbon credits available to the marketplace. In the absence of mandatory compliance markets, LNG importers in North Asia may consider voluntary carbon credits an attractive proposition to demonstrate a commitment to work towards lower emissions. LNG is particularly relevant in this context since these countries seek to replace coal generation capacity at large scale. Natural gas is considered by many countries – Asian and others - as a key fuel on the road to net-zero.
- Table 2 also captures non-LNG trades–in early 2021. For instance, Occidental Petroleum delivered a carbon-neutral crude oil cargo to Reliance Industries in India. A few months later, Woodside and

[58] Unlike voluntary carbon markets, the EU ETS uses the cap & trade approach, meaning that annual allowances are allocated to market participants (either free of charge or via auctioning). Over time, the amount of allowances is reduced, increasing the price of emitting carbon into the atmosphere and incentivizing operators to reduce their emissions.

[59] See https://www.oxfordenergy.org/publications/the-challenges-and-prospects-for-carbon-pricing-in-europe/

[60] The EU Commission has recently published proposals to limit the number of free allowances and create a new ETS which will cover heating and transport. However these have yet to be agreed by the EU Parliament and the Member States. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0550

[61] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12581-Climate-change-new-rules-to-prevent-methane-leakage-in-the-energy-sector_en

[62] BP Statistical Review of World Energy 2021

Trafigura cooperated on a shipment of carbon-neutral condensate. Trafigura also delivered a carbon-neutral naphtha cargo to Braskem in Brazil. The naphtha trade is noticeable for another reason: it explicitly mentions that the chartered vessel was selected for energy efficiency, and that the vessel speed would be reduced (to reduce GHG emissions). This is a way to address criticism of "greenwashing" by structuring other aspects of the transactions to reduce GHGs. The fact that different energy products were traded on a carbon-neutral basis shows that the concept of carbon-neutral fossil fuels is applicable beyond LNG. By number of transactions, the petroleum sector is further behind the LNG market, but these initial trades provide a template how further development in the sector may play out. In fact, the underlying principles of trading commodities on a carbon-neutral basis could also be applied to other markets, such as energy-intensive industrial materials (e.g., aluminium, steel, concrete, feedstock chemicals) and agricultural commodities.

- Table 2 also shows that while most contract structures included offsetting all lifecycle emissions, some trades only covered upstream or downstream emissions, emphasizing the need for a precise and widely accepted definition of what may constitute 'carbon neutrality'. Also, of importance is what the table misses in terms of various key data points such as the quantity of emissions being offset, the prices at which the cargoes have been offset, and how the emissions have been measured and verified and what constitutes a carbon-neutral LNG. The parties must also be prepared to reveal that information to the wider public. Without taking these and other steps there is a real risk that the structuring 'carbon-neutral LNG' using existing trading instruments would be criticised as greenwashing[63].

Table 2: Overview of carbon-neutral fossil fuel transactions

Date	Seller	Buyer	Tanker	Delivery	Source of certificates	Scope covered[1]	Press release
Jun-19	Shell	Tokyo Gas	LNG	Japan	From Shell project portfolio (nature-based)	1, 2 & 3	link
Jun-19	Shell	GS Energy	LNG	South Korea	From Shell project portfolio (nature-based)	1, 2 & 3	link
Jun-19	JERA		LNG	India	CER	3	link
Mar-20 and Nov-20	Shell (2x)	CPC (2x)	LNG	Taiwan	From Shell project portfolio (nature-based)	1, 2 & 3	link
Jun-20	Shell (2x)	CNOOC (2x)	LNG	China	From Shell project portfolio (nature-based)	1, 2 & 3	link
Oct-20	Total	CNOOC	LNG	China	VCS units	1, 2 & 3	link

[63] For most of the recent 'carbon-neutral cargos' transactions, many important details including the prices paid for carbon credits are not revealed, citing factors such as confidentiality and non-disclosure clauses. As noted by Stern (2019), 'this may create difficulties for an industry where data confidentiality has been standard operating procedure, but nothing less will be acceptable (and accepted). For many environmental organisations, industry 'confidentiality' will be interpreted as hiding high levels of emissions and 'greenwash''.

Date	Seller	Buyer	Tanker	Delivery	Source of certificates	Scope covered[1]	Press release
Jan-21	Occidental	Reliance	Crude oil	India	VCU through CBL platform	1, 2 & 3	link
Mar-21	Mitsui	Hokkaido Gas	LNG	Japan	From Mitsui portfolio (nature-based)	1, 2 & 3	link
Mar-21	Gazprom	Shell	LNG	U.K.	VCS	1,2 & 3	link
Mar-21	RWE	POSCO	LNG	South Korea	VER	1, 2	link
Mar-21	Woodside	Trafigura	Condensate	N/A	Gold Standard, VCS	1, 2	link
Apr-21	Mitsubishi/DGI	Toho Gas	LNG	Japan	Unknown	Unknown	link
Apr-21	unstated	Pavillion Energy	LNG	Singapore	VCS, CCB	1, 2	link
Apr-21	Lundin	Saras	Crude oil	Italy	Nature-based projects (VCS)	1, 2	link
May-21	Cheniere	Shell	LNG	Europe	From Shell project portfolio (nature-based)	1, 2	link
Jun-21	Oman LNG	Shell	LNG	Middle East	Nature-based projects	Unknown	link
Jun-21	Lundin	GS Caltex	Crude oil	Korea	Unknown	1, 2	link
Jun-21	Shell	Astomos	LPG	Japan	From Shell project portfolio (nature-based)	1,2 & 3	link
Jul-21	Shell	Petrochina	LNG	China	From Shell project portfolio (nature-based)	1, 2, 3	link
Jul-21	Shell/ Brunei LNG	Osaka Gas	LNG	Japan	From Shell project portfolio (nature-based)	1, 2, 3	link
Jul-21	BP	Sempra	LNG	Mexico	Nature-based projetcs	1, 2	link
Jul-21	Marubeni		Ethylene	Belgium	Nature-based projects	Transport	link

Date	Seller	Buyer	Tanker	Delivery	Source of certificates	Scope covered[1]	Press release
Aug-21	ENI	CPC	LNG	Taiwan	Nature-based projects (VCS + CCB)	1, 2, 3	link
Aug-21	Petronas	Shikoku EPCo	LNG	Japan	VCS	1, 2	link
Sep-21	Ichthys LNG	Inpex	LNG	Japan	VCS	1,2 3	link
Sep-21	INPEX	Shizuoka Gas	LNG	Japan	Nature-based projects (VCS)	1,2, 3	link
Sep-21	BP	CPC	LNG	Taiwan	Unknown	1, 2	link

[1] Scope covered from seller's perspective. Sources: Blanton, E. and Mosis ,S. The Carbon-Neutral LNG Market: Creating a Framework for Real Emissions Reductions, Columbia Center on Global Energy Policy, July 2021, CME Group, Reuters, Argus Media, company websites

5.4. Structuring a carbon-neutral LNG cargo: An example

The development of spot and futures contracts does not resolve the issues raised above, but it is an essential step towards standardisation and transparency and enables a more efficient way to structure a 'carbon-neutral' LNG cargo. Assuming that the parties effectively measure, verify and report the amount of emissions, using the spot or future market to structure such a transaction is straightforward. With a wide range of offset prices (in 2020, the price range for offset credits on CBL spot markets varied from $0.24 to $9.10 per MT CO2e), the premium payable for "carbon-neutral" LNG also touches a wide range. Given most carbon-neutral LNG cargoes were delivered into Asia, we will show possible "carbon-neutrality" premiums for a typical LNG transaction priced at this destination. We estimate the LNG price at destination using Platts JKM, a DES reference price for North Asia. Since early 2020, JKM prices moved in a range from $2/MMBtu to $20/MMBtu. On average, JKM traded at $6/MMBtu. Using BEIS estimates for the sake of this example, we price a fully carbon-neutral LNG cargo with a GHG footprint of 3.42 kg CO2e / kg LNG. An LNG cargo holds approximately 70,000 tons of LNG (175,000 cubic meters LNG), equivalent to 250,000 MT CO2e. The cost of the carbon offset credits needs to be allocated to each natural gas unit procured and priced in MMBtu.

An LNG cargo of 70,000 tons will deliver approximately 3,600,000 MMBtu of natural gas. Assume an Asian LNG importer is seeking to procure a LNG cargo on a carbon neutral basis. The importer can lock in prices for the commodity using a JKM reference price of 5$/MMbtu and procure carbon offset credits at 4$/MT CO2e. The commodity cost of the cargo is $18m (5$/MMbtu * 3,600,000 MMBtu) and the carbon offset credit amounts to $1m (4$/MT CO2e * 250,000 MT CO2e). Allocating the total cost of $19m to the procured energy units, the all-in procurement cost is 5.28$/MMbtu, a premium of 6% above the pure commodity cost to offset the GHG emitting potential of the fossil fuel – noting that this includes both upstream and downstream emissions.

Table 3 below also illustrates under what circumstances the 'green premium' becomes a high cost component of the LNG cargo trade. Mechanically, for a given offset price, the lower the natural gas price, the higher the 'carbon offset' premium over the commodity cost. For a given natural gas price, the higher the offset cost, the higher the carbon offset premium. Given the wide range of prices both for LNG and offset credits witnessed over the past years, this also means that the carbon offset premium can potentially be a significant cost component of the delivered cargo, or, at the other end of the scale, a mere rounding error.

Table 3: Cost of overlaying carbon offset credits to an LNG cargo at different JKM prices

LNG Cost (JKM, $/MMBtu)	Carbon offset credit ($/MT CO2e) 1	4	8	10
2	2.07	2.28	2.56	2.69
5	5.07	5.28	5.56	5.69
10	10.07	10.28	10.56	10.69
15	15.07	15.28	15.56	15.69
20	20.07	20.28	20.56	20.69
Cost of overlaying carbon offset credits to an LNG cargo (% premium above JKM)				
LNG Cost (JKM, $/MMBtu)	Carbon offset credit ($/MT CO2e) 1	4	8	10
2	3%	14%	28%	35%
5	1%	6%	11%	14%
10	1%	3%	6%	7%
15	0%	2%	4%	5%
20	0%	1%	3%	3%

Source: CME Group – Note: ($/MMBtu – all in cost)

Notes: The top half of the table shows what the all-in cost for a carbon-neutral cargo would be depending on the commodity price (range from 2 to 20 $/MMBTu) and the price of the carbon offset credit (range from 1 to 10 $/MT CO2e). The bottom half of the table shows the percentual increase in cost of a carbon neutral cargo versus the commodity price with no carbon offsetting.

5.5. Strength of carbon-neutral LNG claims

Public confidence in the concept of "net-zero" LNG may be limited for a number of reasons, such as:

- Procurement of offsets does not negate the emissions of natural gas and LNG, and in fact can be a way to prolong dependence on fossil fuels.
- Imprecise language and/or lack of transparency into the environmental claims.
- Lack of a standardized MRV protocol to quantify lifecycle LNG emissions.
- Lack of independent certification.
- Not recording nor retiring the claims and/or certifications on an independent registry to prevent double counting.

Some LNG companies have begun to address these issues. For instance, Pavilion Energy has announced an LNG tender with an added goal of collaboration on the development of a quantification and reporting methodology for the GHG content of deliveries. Cheniere Energy has recently announced that, starting in 2022, it will quantify, monitor, report, and verify GHGs from its suppliers and production sites and supply the information to customers in the form of a certified cargo emission "tag".

While systems underlying carbon-neutral LNG claims can be expected to evolve, in the near-term participants in a carbon-neutral LNG transaction can increase both market and stakeholder acceptance through a number of measures, for example:

- Acknowledge that carbon credits do not negate the emissions from natural gas and LNG and pursue reduction in the emission intensity of these fuels to the maximum extent possible.
- Wherever possible, rather than average default values, rely on project-specific measurements of emissions for each cargo and the cargo's value chain.
- Only procure high quality carbon offset credits, with features described in Section 3, to strengthen the credibility of carbon-neutral credentials.

- Standardized carbon offset contracts provide additional assurances regarding offset quality and delivery which is especially important for large volume, real-time commodity transactions.
- Use an independent certification organization to verify the claims[64].
- Register and retire the carbon-neutral LNG certifications on an approved digital platform to prevent manipulation or unintentional double counting.

5.6. Attribute approach

To date, the carbon-neutral LNG trades have relied on procurement and retirement of carbon offsets to balance out the GHG emissions with various segments of the LNG value chain. An alternative "attribute" approach can be considered in which the GHG intensity of a specific LNG cargo is determined and "tagged" or attributed to that cargo, similar to how sulphur content or API in a specific crude oil can impact the value of that crude[65].

For example, Xpansiv's Digital Fuels Program[66] applies established standards and 3rd party certifications to continuously metered production data and environmental monitoring to register digital representations of individual mmBtus of natural gas. These digital twins, referred to as Digital Natural GasR (DNG™) are a new asset class that provides a complete and immutable environmental and energy profile, traceable back to the source. For example, natural gas produced with low methane emissions relative to a baseline, Methane Performance Certificates (MPC™) are registered, transacted, and retired similar to carbon offsets. In this case, producers and consumers (e.g., utilities) can differentiate and accurately price responsibly sourced natural gas, and convey the Scope 3 emission reductions in a transparent way based on an empirical, auditable data chain. Xpansiv is extending this same approach to digital-LNG™, designed to reward LNG companies (both upstream and midstream) with low-carbon operations and other advantages. In this way, the reductions in GHG emissions and associated claims can be conveyed to downstream consumers as part of their Scope 3 accounting and net-zero goals.

6. Conclusions

Continuing growth in the voluntary carbon market and demand for higher quality offsets and increased trading opportunities is catalyzing the development of new markets and instruments[67] that are improving transparency, liquidity, price discovery, and opportunities for risk management.[68]

However, these markets still face challenges. Several NGOs have raised concerns that the development of exchanges and new traded instruments could provide companies with the ability to trade lower quality offsets.[69] In the case of the relatively new 'carbon-neutral' LNG market discussed in this paper, the lack of clear definition of what constitutes carbon neutrality and the absence of accepted standards on how to measure, monitor and verify lifecycle GHG emissions raise concerns about the claims themselves. At a fundamental level, offset buyers need to address concerns that they are engaging in 'greenwashing' while shrinking from their responsibilities to directly reduce emissions within their operations and supply chains.

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[64] Self-attestations by producers or other participants in the transaction will be viewed with skepticism and considered not credible. See for instance, Argus Media, 2021. 'Oil firms struggle with 'carbon offset' messaging', September 13. The article notes that key criticisms include 'the lack of transparency and standardisation on monitoring, reporting and verifying the GHG emissions associated with such cargoes, resulting in companies effectively judging themselves and making assumptions, without any third-party verification'.

[65] See Blanton, E. and Mosis ,S. The Carbon-Neutral LNG Market: Creating a Framework for Real Emissions Reductions, Columbia Center on Global Energy Policy, July 2021

[66] https://pub.lucidpress.com/DigitalFuelsProgram/#ZRIBRIPTp_5G

[67] https://www.climateimpactx.com/

[68] Bloomberg, 9 July 2021, "Carbon offset trading is taking off before any rules are set"

[69] Financial Times, 29 Sept 2020, "Carbon offset market progresses during coronavirus"

Over the past three decades, the creation and continued evolution of carbon offset markets has involved a massive commitment from thousands of scientists, regulators, investors, project operators, among others, confronting a wide range of financial, technical, and political challenges. These efforts need to be accelerated to ensure that investments in carbon offsets result in real, verifiable emission reductions and effectively help meet science-based targets.