FLORENCE SCHOOL OF REGULATION

ROBERT SCHUMAN CENTRE

POLICY BRIEF

How green is 'Green LNG'?

Highlights

- Full decarbonisation of the LNG sector remains a long-term objective. Meanwhile, efforts by industries to introduce short-term carbon footprint reduction are welcome initiatives.
- Green LNG through offsetting is now emerging as an international practice, which remains controversial because of a lack of transparency at the implementation level.
- To account offset emissions, a more rigorous approach to *Life Cycle Assessment* (LCA) of LNG is necessary. In particular, it should take into account the fact that indirect emissions may include gas flaring, which occurs in the oil and gas sectors in general.
- The current offsetting practices focus on carbon dioxide emissions, whereas methane emissions should be considered in LNG offsetting calculations.
- Biomethane LNG could be an interesting product for consumers interested in clean molecules and, even more, in negative emissions models.

Issue 2021/38
July 2021

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Introduction

The year 2021 marks a tipping point in the policy approach to natural gas, a fossil fuel which was earlier deemed the cleanest in terms of its carbon footprint.[1] In the light of the EU climate neutrality targets, natural gas companies will need to find pathways to decarbonise their supply chain. This reality also affects the general approach to liquefied natural gas (LNG), a cryogenic state of natural gas which has for a long time been considered the best alternative to low carbon dioxide emissions in maritime transport and heavy vehicle transport. On the one hand, LNG offers the possibility of gas supply by tankers, which offers greater market flexibility and diversification compared to piped grid-bound gas supply. On the other hand, the LNG supply chain involves greenhouse gas emissions, which need to be considered and tackled. Therefore, despite the presumed advantages of the LNG sector, the new climate neutrality objectives require a reassessment of earlier priorities. As a notable confirmation of this trend, the World Bank has published a report which puts into question the positive effects of LNG on global emissions and further suggests focusing on alternative fuels for maritime transport, such as hydrogen and ammonia.[2] However, the penetration of new fuels in the transport sector remains a lengthy and costly process. In this context, industries are attempting to find short-term solutions to make their LNG supplies 'greener.'

The concept of 'Green LNG' has emerged with the objective of mitigating the carbon footprint of LNG delivery without losing the competitive advantages of cryogenic fuel deliveries. Green LNG refers either to a direct reduction of greenhouse gas emissions in the LNG supply chain or to offsetting the greenhouse gas emissions with alternative projects outside the suppliers' core activity. So far, there is no generalised definition of the term even though suppliers report 'Green LNG' deliveries.[3]

The absence of a uniform approach to the concept of Green LNG provides an open road to make the supply chain compatible with the climate neutrality objectives. Based on this assumption, this policy brief provides a broad overview of the practices leading to Green LNG and explores possible pathways for the recognition of their value *vis-à-vis* the climate neutrality objectives.

1. Green LNG: an evolving concept

Reference to sustainability standards in industry was initiated in 2011. The Green Award Foundation, a voluntary organisation for the certification of sustainability in the shipping industry, allocated a sustainability award to Qatargas, the world's largest LNG supplier.[4]

In July 2019, the first-ever certified green LNG was delivered by Shell Eastern Trading to Tokyo Gas and GS Energy of Korea.[5] In March 2021, the first green LNG was delivered to Europe, more precisely to the Dragon terminal in the UK, by Russia's Gazprom.[6] In May 2021, US LNG supplier Cheniere reported the delivery of a carbon-neutral cargo to the Netherlands. ICIS reports 15 green LNG deliveries worldwide, but notes that not in all cases have buyers or sellers been identified.[7]

In each case, Green LNG suppliers offset their emissions by investing in pro-climate projects outside the gas supply chain. The offsetting consists in purchasing transferrable rights to emit (carbon credits) either from carbon removal projects such as reforestation or from the development of renewable energy projects. The certification process of transferrable rights is based on voluntary decisions by companies and industrial associations. The process remains quite fragmented. The major trading company Vitol has reported the possibility of Green LNG supplies being certified through one of the following schemes: the UN Clean Development Mechanism, Verified Carbon Standard, the Gold Standard, the American Carbon Registry, the China Green House Gas Voluntary Emission Reduction Programme and Climate Action

1 Wood Mackenzie, 'Future of gas in energy transition to be defined in 2021,' 21 January 2021, available at https://www.woodmac.com/press-releases/future-of-gas-in-energy-transition-to-be-defined-in-2021/
2 The World Bank, 'The Role of LNG in the Transition Toward Low- and Zero-Carbon Shipping,' Washington, 2021.
3
4 SeaNews, Green award given to Qatargas LNG carriers - SeaNews, 28 March 2011.
5 Shell, Tokyo Gas And GS Energy to receive world's first Carbon neutral LNG cargoes from Shell | Shell Global, 18 June 2019.
6 Oil Price, Russia's Gazprom Boasts First Carbon-Neutral LNG Delivery In Europe | OilPrice.com, 8 March 2021.
7 A. Froley, 'Tracking the growth of the carbon neutral LNG market,' LNG Edge market intelligence platform, ICIS, May 2020, publicly available version: https://www.linkedin.com/pulse/tracking-growth-carbon-neutral-lng-market-alex-froley/?trackingId=AR3asQCgR-92J%2BrXn3rC%2Buw%3D%3D

Reserve.[8] Reportedly, three Green LNG deliveries have been certified by Verified Carbon Standard, the world's leading voluntary certification of greenhouse gas emissions. Two deliveries have been reported under CBL Emissions offset, another voluntary scheme, and another under the Clean Development Mechanism in accordance with article 6 of the Paris Agreement. The market-based approach to transferring emission rights has been persistently questioned as there is no political consensus on the transparency and effectiveness of the measure.[9] Similarly, a lack of transparency in the implementation of offsetting and the fragmentation of certification remain core concerns for an effective recognition of Green LNG. Hence, the question emerges of the compatibility between the Green LNG concept and current efforts towards climate neutrality.

2. GHG emissions in the LNG supply chain: the life-cycle assessment (LCA) approach

The life cycle assessment (LCA) approach has been conventionally considered when advocating for LNG final use in transport rather than heavier and more carbon-intensive fossil fuels.[10] However, an absence of uniform methods and of harmonised assumptions behind LCA has engendered a quasi-constant need for improvement of the approach.[11] Recently, the scholarly literature on LCA has shifted towards more rigorous analysis, which needs to be considered in the light of the climate neutrality objectives.[12] At the policy level, the recent EU Strategy for Energy System Integration stipulates that *"further measures are needed to ensure that customers' decisions to save, switch or share energy properly reflect the life cycle energy use and footprint of the different energy carriers, including extraction, production and reuse or recycling of raw materials, conversion, transformation, transportation and storage of energy, and the growing share of renewables in electricity supply."*[13] In short, the text alludes to the necessity of taking LCA into consideration, while trade-offs — such as offsetting practices — have to be carefully considered.

To provide a better illustration of the LCA approach applied to LNG, we probably need a basic explanation of the LNG sector itself. The LNG supply chain has increasingly been viewed as beyond the traditional natural gas sector, which provides primary energy for various industrial activities and power generation.

Until recently, LNG was primarily associated with a method of long-distance natural gas shipment by dedicated tankers. This supply chain requires natural gas supply to a liquefaction plant and then transport by LNG tanker to a regasification terminal, where the LNG is either regasified or stored. The natural gas previously transported in liquefied form is injected into the conventional natural gas grid. However, technological progress has allowed on-the-spot regasification of LNG and its direct use in engines as a form of cryogenic fuel. In this context, small-scale liquefaction has gained relevance, and short distance transportation either in water barges or on-land trailers and containers has become economically feasible.[14]

The development of cryogenic fuels has removed the need to link LNG supplies to regasification terminals and foregrounded a proper LNG market apart from the natural gas market.

The main market for cryogenic fuel supplies has been the transport sector, in which heavy hydrocarbons traditionally dominated the primary energy supplies. Unlike, for example, electricity generation, where inter-fuel competition is strong and characterised by a fast penetration of carbon-neutral renewable energy sources, the transport sector is still heavily reliant on carbon-intensive oil products. Therefore, a shift to LNG in transport has been deemed to be the most cost-effective option for carbon dioxide emissions reduction, particularly in hard-to-

8 Vitol, Vitol launches Green LNG offering - Vitol, 1 March 2021.

9 Asian Development Bank, Decoding Article 6 of the Paris Agreement-Version II (adb.org), *Decoding Article 6 of the Paris Agreement*, December 2020, p. 13.

10 Y. Zhiyi and O. Xunmin, 'Life Cycle Analysis on Liquefied Natural Gas and Compressed Natural Gas in Heavy-duty Trucks with Methane Leakage Emphasised,' *Energy Procedia*, 2019, Vol. 158, pp. 3652-3657.

11 G. Heath and M. Mann, 'Background and Reflections on the Life Cycle Assessment Harmonization Project,' *Journal of Industrial Ecology*, April 2012, available at https://onlinelibrary.wiley.com/doi/full/10.1111/j.1530-9290.2012.00478.x

12 J. Ren and S. Toniolo, *Life Cycle Sustainability Assessment for Decision-Making*, Elsevier, 2020.

13 European Commission, Communication To The European Parliament, The Council, The European Economic and Social Committee and the Committee of The Regions, *Powering a climate-neutral economy: An EU Strategy for Energy System Integration*, COM(2020) 299 final, p. 5.

14 International Gas Union, World LNG Report: 2015 Edition (Fornebu: International Gas Union, 2015), available at https://www.igu. org/sites/default/files/node-page-field_file/IGU-World%20 LNG%20Report-2015%20Edition.pdf (accessed 22 May 2021).

abate maritime shipping.[15] Taking into account these market developments, Green LNG methodology has been primarily considered for the transport sector.

The International Group of Liquefied Natural Gas Importers (GIIGNL) suggests summarising the LNG greenhouse gas emissions footprint as a two-stage process:

The Well-to-Tank stage — from gas extraction to liquefaction and then to LNG cargo (Figure 1)

Tank-to-Wheel stage — from shipping LNG to delivery and its final use by transport units such as vessels or heavy trucks. Hence the term 'wheel' is used (Figure 2).

Figure 1.

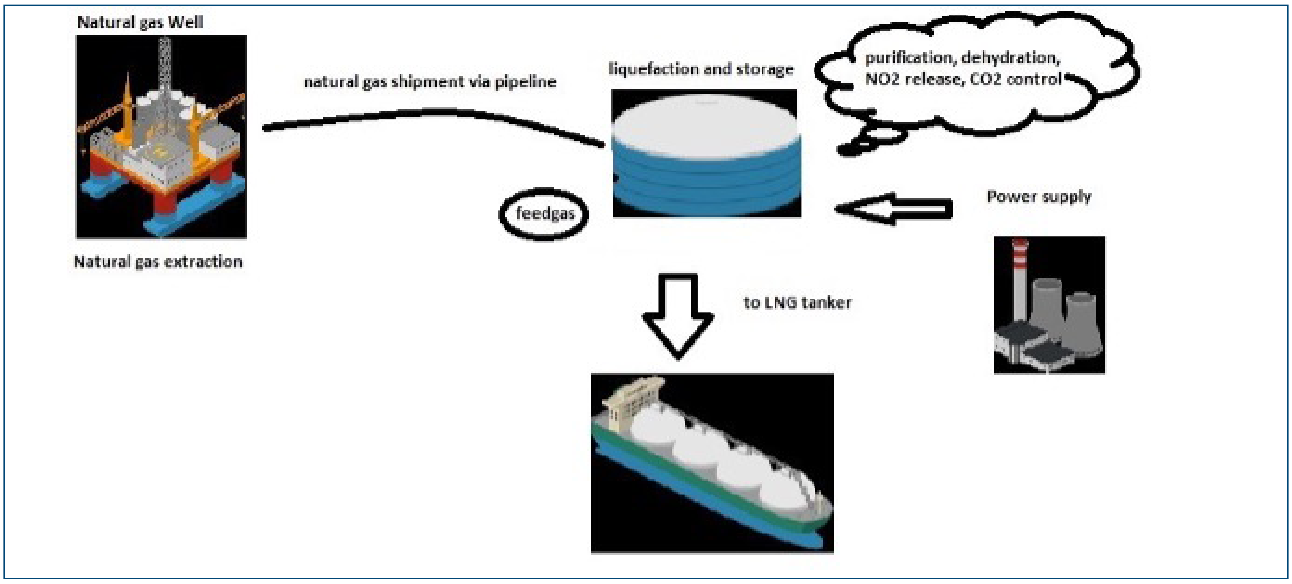

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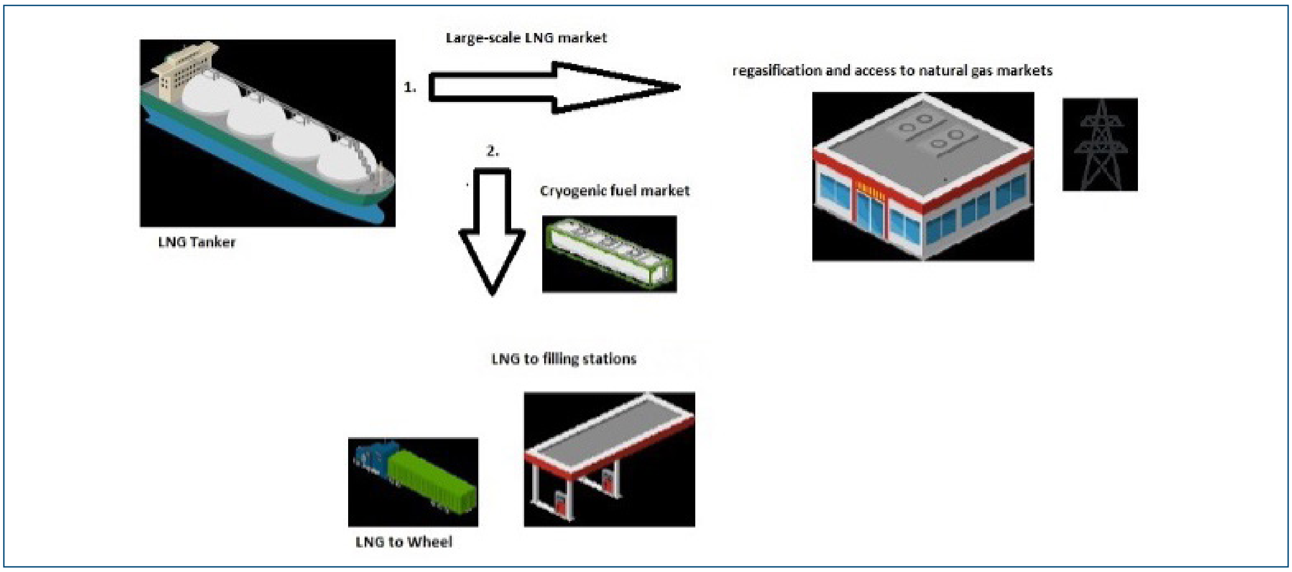
Figure 2.



Source: Authors, using https://icograms.com/designer

15 Madden M. and White, N., *LNG in Transportation*, Rueil Malmaison: CEDIGAZ, 2014.

GIIGNL[16] proposes a method for carbon offsetting and points out that only a small number of suppliers include both stages, while most frequently companies tend to offset the Tank-to-Wheel stage. Methods of estimating exact emission volumes also differ. The UK Government estimates that each kilogram of LNG generates 0.88 kg of carbon dioxide emissions in the Well-to-Tank stage and 2.54 kg in the Tank-to-Wheel stage.[17] As a standard cargo of 175,000 cubic metres generates emissions of 270 thousand tonnes, it takes about 250 thousand trees to offset it.[18] According to GIIGNL estimates, some investments in offsetting can reach USD 0.5 per MMBtu, or a quarter of the current US-based Henry Hub price.

However, because of difficulties in accounting Well-to-Tank emissions, a focus on the Tank-to-Wheel stage may seem more appropriate from the short-term economic viewpoint, although it may not meet long-term sustainability objectives if a large part of Well-to-Tank emissions are ignored in the process. It still remains unclear if the existing subdivision in two stages takes into account all possible indirect emissions from the LNG supply chain. Already prior to the liquefaction process, natural gas is extracted and shipped using compressor stations, which emit greenhouse gases. Then, the liquefaction process includes dehydration and purification, leading to the removal of non-usable gases. During this process, power generation is necessary and therefore emissions from the combustion process can also occur (see Figure 1 above). The scholarly literature identifies at least three stages of emissions in the LNG supply chain[19]:

(1) direct greenhouse gas emissions from the LNG chain, from liquefaction and purification to transport and storage to final use, where LNG also generates carbon dioxide emissions after the combustion process;

(2) indirect emissions such as from power generation during the purification and liquefaction process;

(3) all emissions including the carbon footprint of producing natural gas as a feedstock before the liquefaction and purification process.

Furthermore, existing accounting methods usually take into account carbon dioxide emissions whereas methane leakage is not considered. In fact, both fugitive and vented methane emissions constitute significant issues in natural gas extraction and transport, and partly occur in the LNG supply chain. For example, the International Council on Clean Transportation medium-speed four-stroke LNG carrier emits up to 5.5g of methane for each kWh, and its slow-speed alternative can generate between 0.2 and 2.5 g of methane for each kWh of leakages.[20] According to this analysis, the volumes of fugitive methane emissions from LNG transportation and consumption would risk jeopardising the supposedly positive contribution of LNG fuels in the maritime sector.

Moreover, the rising demand for LNG requires more natural gas as a feedstock and more indirect emissions upstream, which include gas flaring and methane venting independently of the gas processing for liquefaction (Figure 3). Flaring and venting have often been understated in European policy debates,[21] mainly because most global gas flaring occurs upstream beyond the EU by small and medium-size oil producers with no direct access to the EU markets.[22] As a result, there is a risk that industries which produce more flaring and venting are not incentivised by the direct EU regulatory measures.

16 GIIGNL, 'LNG carbon offsetting: fleeting trend or sustainable practice?' *LNG Insight*, 18 June 2020, pp. 6-7.

17 UK Government, Publishing Service, conversion factors for 2019, available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/847122/Conversion-Factors-2019-Full-setfor-advanced-users.xls cited in A. Mchich and C. Britnell, Going Green with Carbon-Neutral LNG - CME Group, 31 March 2021.

18 G. Thomson, What is carbon-neutral LNG? | Wood Mackenzie 18 November 2020.

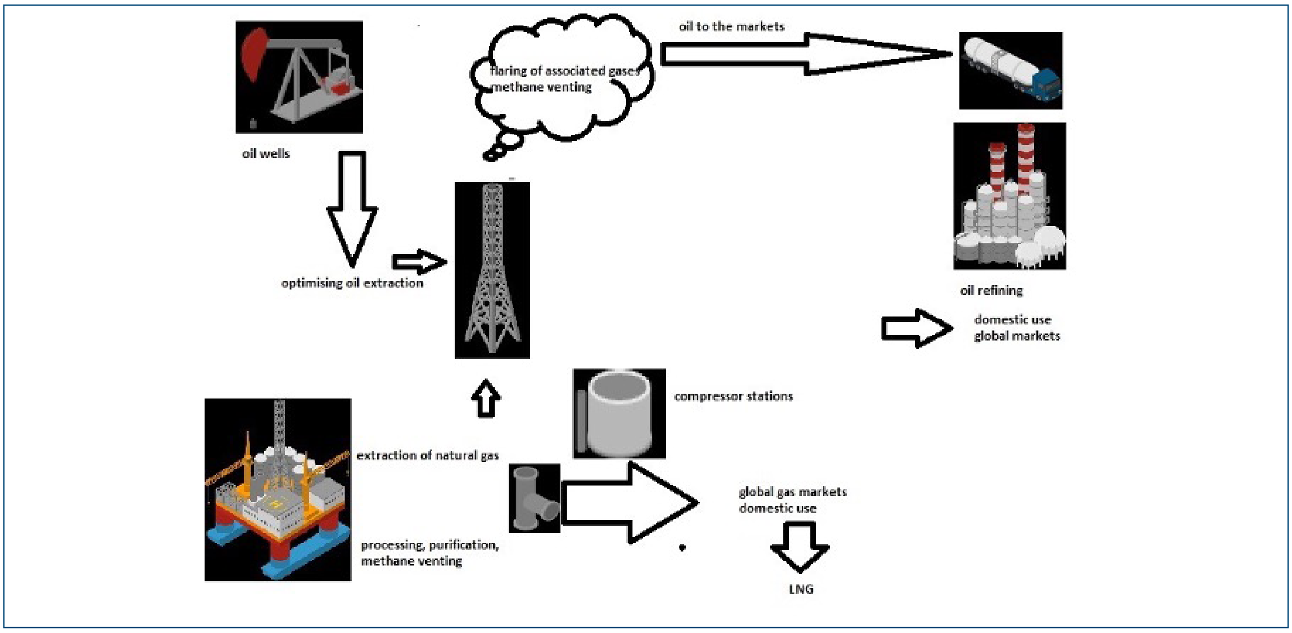
19 S. Miles, 'Carbon neutral natural gas: a solution to LNG competition with renewables, 9 September 2020, available at https://www.bakerinstitute.org/media/files/files/cfd8ad42/miles-gastech-09092020.pdf

20 International Council on Clean Transportation, 'The climate implications of using LNG as a marine fuel,' Working Paper 2020-02, January 2020, pp. 6-7.

21 J-H Charles and M Davis, Twelve things the EU should do about gas flaring, Capterio, 23 November 2020, available at https://capterio.com/insights/twelve-things-the-eu-should-do-about-gas-flaring

22 A. Belyi, EU methane emissions strategy: European ambitions, global challenges [GasTransitions] (naturalgasworld.com), *Gas Transitions-Natural Gas World* magazine, 23 November 2020.

Figure 3.



Source: Authors, using https://icograms.com/designer

3. How to make LNG really 'green'

If LNG is to become greener, the first step would consist in finding criteria applicable to LNG supplies which can be accepted as in line with the EU climate neutrality objectives. Given the multiple co-existing certification schemes in place, the EU might prioritise some schemes over others through various bilateral agreements. If this approach to the recognition of certificates in bilateral agreements is followed, then the question arises of possible recommendations for the EU on setting criteria for LNG offsetting to be recognised inside the Union.

Elaborating a set of preferred EU criteria for LNG offsetting would mostly favour direct emissions reductions rather than indirect offsetting. However, offsetting can be an equally virtuous practice if a conventional LNG supplier offsets emissions by its national peers through joint efforts in upstream flaring and methane emission reduction. For example, large companies such as Exxon Mobil (US) and Novatek (Russia) can deliver proof of gas flaring and venting reduction by smaller peers which do not have direct access to the EU markets. Including flaring and venting in offsetting allows levels of abated emissions to be measured and existing digital and satellite technologies to monitor the actual implementation. Therefore, at least in terms of measured LCA, gas flaring and methane venting reduction could become more tangible alternatives compared to other offsetting schemes such as reforestation.

The system of green LNG certification would need to support alternative LNG promotion, such as liquefied biomethane. In fact, biomethane is generated from biogas, which usually comes from bio-waste from agriculture and the residential sector. In this way, biogas production allows better waste management and even a reduction of methane emissions from agriculture. A model produced by a consortium composed of the Joint Research Centre, EUCAR and Concawe even claims that because of the methane emissions from agriculture saved, the concept of negative emissions gains relevance in the case of biogas production.

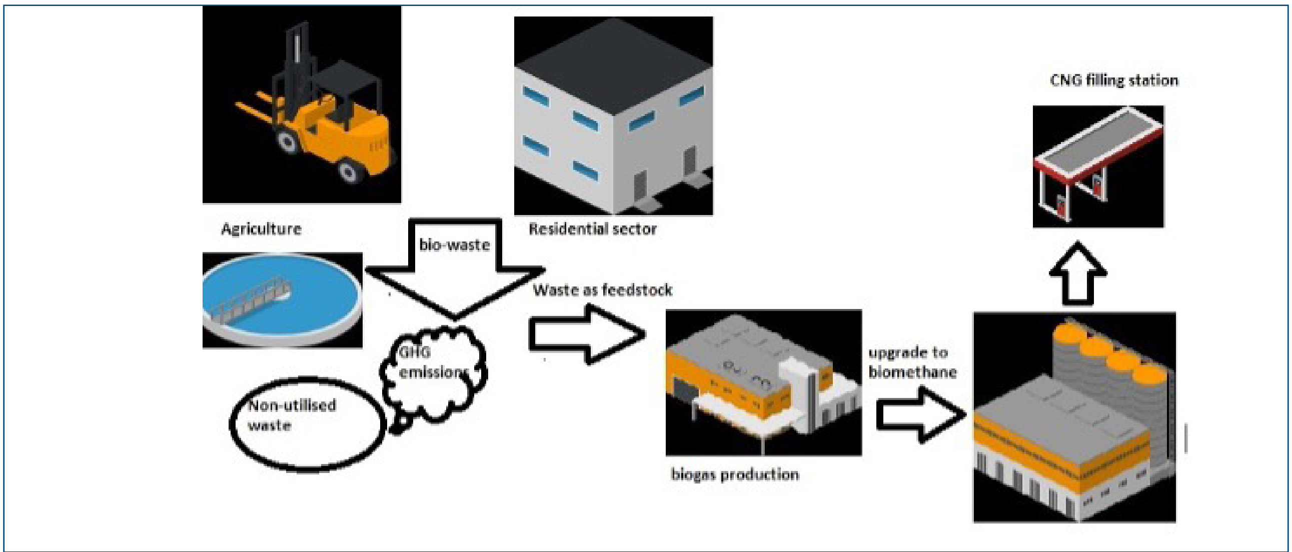
According to the model,[23] a standard fossil CNG vehicle generates 114 g of CO2/km if both stages (Well-to-Tank and Tank-to-Wheel) are considered. However, introducing biomethane allows negative emissions to be estimated for biomethane-driven vehicles, mostly because of the effect on bio-waste reduction. The study assumes that negative emissions from bio-CNG would account for -171 g CO2/km if all the methane emissions reduction from the agricultural bio-waste is accounted in the biomethane supply chain. Although the calculation is based on a probabilistic estimate rather than on direct observation of emissions reduction, the results reveal that if refined biogas in the form of bio-

23 Gmobility EU, [Well-to-Wheel – How to better understand it — gmobility](), 2020.

methane is mixed in compressed natural gas (CNG) vehicles it allows emissions reduction from the overall carbon footprint beyond the natural gas sector (Figure 4).

favoured by the markets, sustainability certificates produced by European bio-LNG producers may serve to offset both European and international conventional LNG supplies.

Figure 4.



Source: Authors, using https://icograms.com/designer

Using biomethane can be applied beyond CNG-driven road transport and can further expand to LNG. A comprehensive feasibility study on liquefied biogas has been produced by the University of Vaasa. This reveals further opportunities for biomethane development triggered by micro-scale liquefaction technologies. The report lists various existing technological options for micro-scale liquefaction, revealing that there are only limited technological options in the field.[24] Above all, companies involved in liquefied biogas development have to have know-how both in biogas purification and in liquefaction. Although there are only a few operational bio-LNG plants in Europe at this stage, the sector has the potential to grow because of the solid experience in biogas purification which already exists in the EU. Assuming a potential growth in competitiveness over time, industry associations estimate that liquefied biomethane can constitute up to 40% of the European small-scale LNG market by 2030.

So far, costs of bio-LNG remain higher than of conventional LNG. Reportedly, bio-LNG suppliers set a price benchmark of USD 23-25 per MMBtu, which is about 4 times more than the price cleared at European gas hubs. As direct use of bio-LNG will not be automatically

4. Conclusions

Among various initiatives supporting decarbonisation, LNG offsetting is now becoming a new market reality. However, because of issues related to transparency and monitoring of Green LNG credentials, one may expect the EU to set new norms for the recognition of certifications of carbon-neutral supplies. In this case, the EU may promote the following requirements for Green LNG:

i. accounting should be based on a rigorous LCA method which accounts both methane and carbon dioxide emissions and considers both the Well-to-Tank and Tank-to-Wheel stages;

ii. suppliers can be less ambitious in offsetting, but then consumers and market participants need to be informed about which part of the emissions has been offset;

iii. offsetting could also prioritise gas flaring and methane venting reduction upstream effectuated by companies with no access to the EU market;

iv. the system of certificates should incentivise European liquefied biomethane production as a potential source of negative methane emissions;

24 University of Vaasa, School of technology and Innovation, Techno-economic analysis of biomethane liquefaction processes, March 2021, pp. 10-20.

v. A uniform certification method for LNG offsetting will have to be promoted, while the EU can use bilateral agreements to ensure a unification of certification and correct monitoring of the offsetting mechanisms.

In short, adaptation to the Green LNG trend will require further international coordination of certification and design of the priority lines for Europe in the field. Meanwhile, offsetting will permit suppliers to remain competitive on the pathway towards carbon neutrality.

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Co-funded by the
Erasmus+ Programme
of the European Union

doi:10.2870/435098
ISBN:978-92-9466-076-3
ISSN:2467-4540
QM-AX-21-038-EN-N