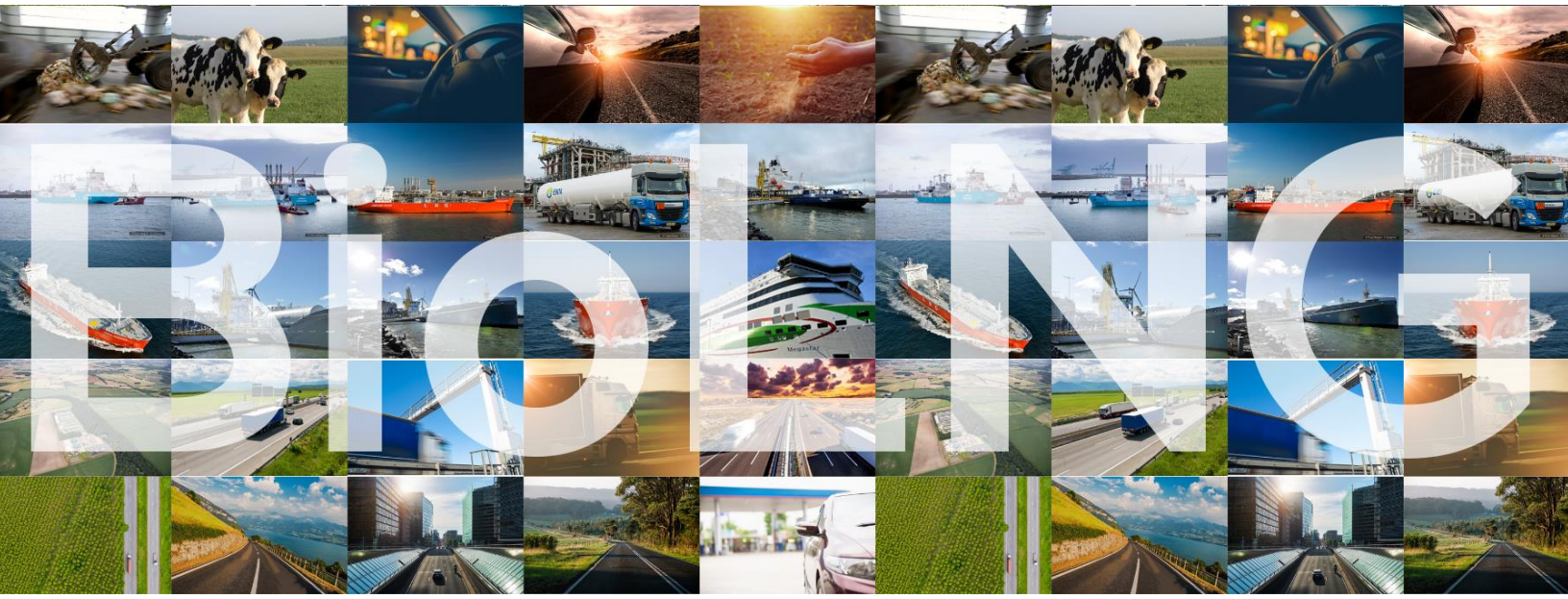
BioLNG in Transport: Making Climate Neutrality a Reality



A joint White Paper about bioLNG production and infrastructure as enabler for climate neutral road and maritime transport

EBA European Biogas Association

gie Gas Infrastructure Europe

NGVA Europe for sustainable mobility

SEA-LNG

The European Biogas Association (EBA) is the voice of renewable gas in Europe since 2009. EBA advocates the recognition of biomethane and other renewable gases as sustainable, on demand and flexible energy sources that provide multiple knock-on socio-economic and environmental benefits. Supported by its members, EBA is committed to work with European institutions, industry, agricultural partners, NGOs and academia to develop policies which can enable the large-scale deployment of renewable gases and organic fertilisers throughout Europe, supported by transparent, well-established sustainability certification bodies to ensure that sustainability remains at the core of the industry. The association counts today on a well-established network of over 100 national organisations, scientific institutes and companies from Europe and beyond.

Gas Infrastructure Europe (GIE) is the European association of gas infrastructure operators. GIE members are active in transmission pipelines, storage facilities and LNG terminals. With 70 industry members from 26 European countries, GIE perfectly embodies the multiple transitional decarbonization pathways of the EU regions. GIE is committed to help achieve EU's ambition to deliver a 90% reduction in transport related GHG emissions and aim to become the first climate neutral region by 2050.

The Natural & bio Gas Vehicle Association (NGVA Europe) is the European association that promotes the use of natural and renewable gas as a transport fuel. Founded in 2008, its 124 members from 27+4 countries include companies and national associations from across the entire gas and vehicle manufacturing chain. NGVA Europe is a platform for the industry involved in producing and distributing vehicles and natural gas, including component manufacturers, gas suppliers and gas distributors. It defends their interests to European decision-makers to create accurate standards, fair regulations and equal market conditions.

SEA-LNG Founded in 2016, with numerous high-profile members including shipping companies, ports, LNG suppliers, bunkering companies, infrastructure providers and OEMs (Original Equipment Manufacturers), classification societies, banks and brokers, SEA-LNG is a multi-sector industry coalition whose members work together to demonstrate the benefits of LNG as a marine fuel throughout the entire value chain.

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Purpose statement

In the perspective of the upcoming Smart Sustainable Mobility Strategy and revision of multiple important European transport laws, four associations – EBA, GIE, NGVA Europe and SEA-LNG – decided to join forces to demonstrate the great potential of bioLNG to decarbonise heavy-duty transport and shipping in a fast and cost effective way.

This joint White Paper provides with key facts and figures on several dimensions covering the bioLNG value chain, from production to infrastructure and usage. It aims at demonstrating the concrete benefits of using bioLNG as a fuel for heavy-duty transport and shipping, which are sectors where greenhouse gases (GHG) emissions are hard to cut. It further illustrates how bioLNG can help the European Union to reach its 2030 climate targets and become climate neutral by 2050.

The paper formulates key policy recommendations for European policy makers to consider when drafting future strategies and legislation to decarbonise transports.

Policy recommendations

- Adopt an approach based on **technology openness** and guarantee a true level playing field between different mobility solutions under a well-to-wheel/well-to-wake thinking.
- Integrate the bio dimension of LNG in the revision of the **CO2 emissions standard regulation for HD vehicles and in GHG reduction targets for shipping** to stimulate a quick take off of the decarbonisation effect.
- Extend the scope of Annex IX of the **Renewable Energy Directive** to integrate more feedstocks such as residues that cannot be used for other purposes or secondary crops.
- Create a **single market** for biomethane and bioLNG by facilitating trading of volumes and certificates across borders free of technical or political barriers.
- Recognise the role of LNG infrastructure as an enabler for integrating higher shares of bioLNG, in particular by supporting the development of refuelling infrastructure for road and maritime transport along with SSLNG, under the revision of the **Alternative Fuels Infrastructure Directive**.
- Acknowledge the benefits of LNG/bioLNG in maritime and road transport to reduce local pollutant emissions.

1. Introduction

The European Union (EU) set itself the ambitious objective of being carbon neutral by 2050, and is in the process of consequently raising its 2030 climate-related goals. Targets increase, as does the urgency for transport to accelerate its decarbonisation.

This is not an easy challenge. Heavy-duty and maritime transport are two sectors where greenhouse gases (GHG) emissions are especially hard-to-abate. At the same time, cutting GHG emissions must come hand-in-hand with affordability and technology availability, in order to guarantee a successful transition towards carbon neutral transportation.

Against this background, Liquefied Natural Gas - LNG - has great potential to drastically cut GHG emissions from heavy-duty transport and shipping, as an enabler to integrate a growing share of bioLNG in the European fuels mix. It is a solution that is available today, ready to decarbonise trucks and shipping fleets at a reasonable cost. From its production to its use as a fuel, LNG, and increasingly bioLNG, is a key solution to kick-start transport's transition towards carbon neutrality without further delay.

It is of paramount importance that the European Commission (EC) acknowledges the benefits of renewable fuels in the upcoming Smart and Sustainable Mobility Strategy, and supports the take-up of LNG and bioLNG as a clean fuel for carbon neutral transport.

2. Production of Bio-Liquified Natural Gas

Availability of sustainable feedstocks for the production of BioLNG

Potential for bioLNG production in Europe

BioLNG is produced by liquefaction of biomethane. Biomethane itself comes from renewable resources only and can be obtained from various pathways and feedstocks:

Anaerobic Digestion

Biogas, a mixture of methane and carbon dioxide, is produced from Anaerobic Digestion (AD) from organic waste, manure, municipal waste and other suitable residues such as sewage sludge treatment. It can be upgraded to Natural Gas quality. Within the last couple of years, the installation of upgrading units has grown.

Synthetic Natural Gas

In addition to Anaerobic Digestion, synthetic Natural Gas (SNG) can be produced via gasification of lignocellulosic biomass and subsequent methanation or via electrolysis and methanation. The production of methane from electrolysis powered by electricity is seriously considered as a possibility to use surplus electricity from intermittent renewable electricity generation, such as wind power and photovoltaics (PV).

Power to Gas

Methane produced via electrolysis and methanation has different names, such as Power-to-Gas (PtG), Synthetic Natural Gas (SNG), e-gas, or windgas etc. BioLNG and synthetic LNG are also being produced via micro or small-scale liquefaction plants[1].

Agriculture and waste are the two largest potential feedstocks for biomethane production and as such forms the bases of bioLNG.

[1] https://sphera.com/reports/life-cycle-ghg-emission-study-on-the-use-of-lng-as-marine-fuel/

The graph below shows the potential of feedstocks as analysed by Navigant[2]:

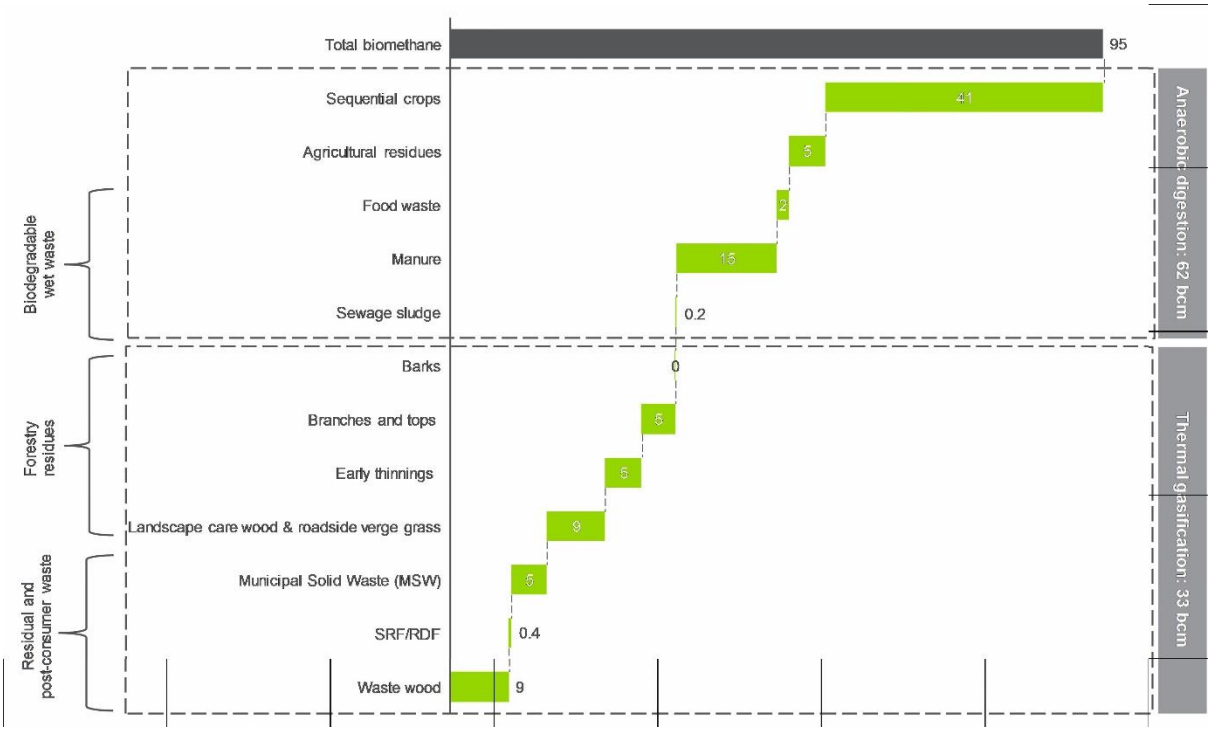


Figure 1: Availability of feedstocks for producing biomethane (bcm)

Figure 1 shows the potential of feedstock expressed in biomethane production in bcm (billion cubic meters). The EBA believes that the wastewater sector (sewage sludge) offers significant potential to capture biogas and utilise this instead of flaring, which is still common practice. Another source of additional sustainable feedstock is industrial waste from, for example, the food and beverage industry, and waste water from industry such as the paper industry.

Whilst the current annual production of biomethane amounts to 3 bcm[3], a minimum of 95 bcm of biomethane can be reached by 2050. Other reports such as Eurogas[4] and Cerre[5], are providing even a larger potential share of biomethane production in Europe.

These volumes are sufficient to cover future demand for bioLNG within the transport sector. Navigant estimates the bioLNG demand for transport to reach 461 TWh by 2030. This approximately represents 45-50% of the total production capacity of biomethane in Europe.

Indeed, according to NGVA Europe, the LNG-fuelled vehicles fleet will require approximately 100 TWh fuel in 2030, with at least 40% being represented by bioLNG. With regard to the maritime sector, analysis by CE Delft[6] concludes that bioLNG is a scalable solution for the shipping industry. Estimated sustainable

[2] https://gasforclimate2050.eu/publications/
[3] https://www.europeanbiogas.eu/eba-annual-report-2019/ + recent statistics
[4] https://eurogas.org/knowledge_centre/a-pathway-to-a-carbon-neutral-2050-the-role-of-gas/
[5] https://cerre.eu/publications/gas-and-electrification-heating-transport-scenarios-2050/
[6] https://sea-lng.org/our-work/availability-and-costs-of-liquefied-bio-and-synthetic-methane-the-maritime-shipping-perspective/

global supplies potentially exceed the future energy demand of the global shipping fleet as shown on the forecasts for 2030 and 2050, in Figure 2, below. Clearly, future policy will play a key role in allocating biomass resources to the hardest to abate sectors such as shipping, heavy-duty goods transportation and aviation.

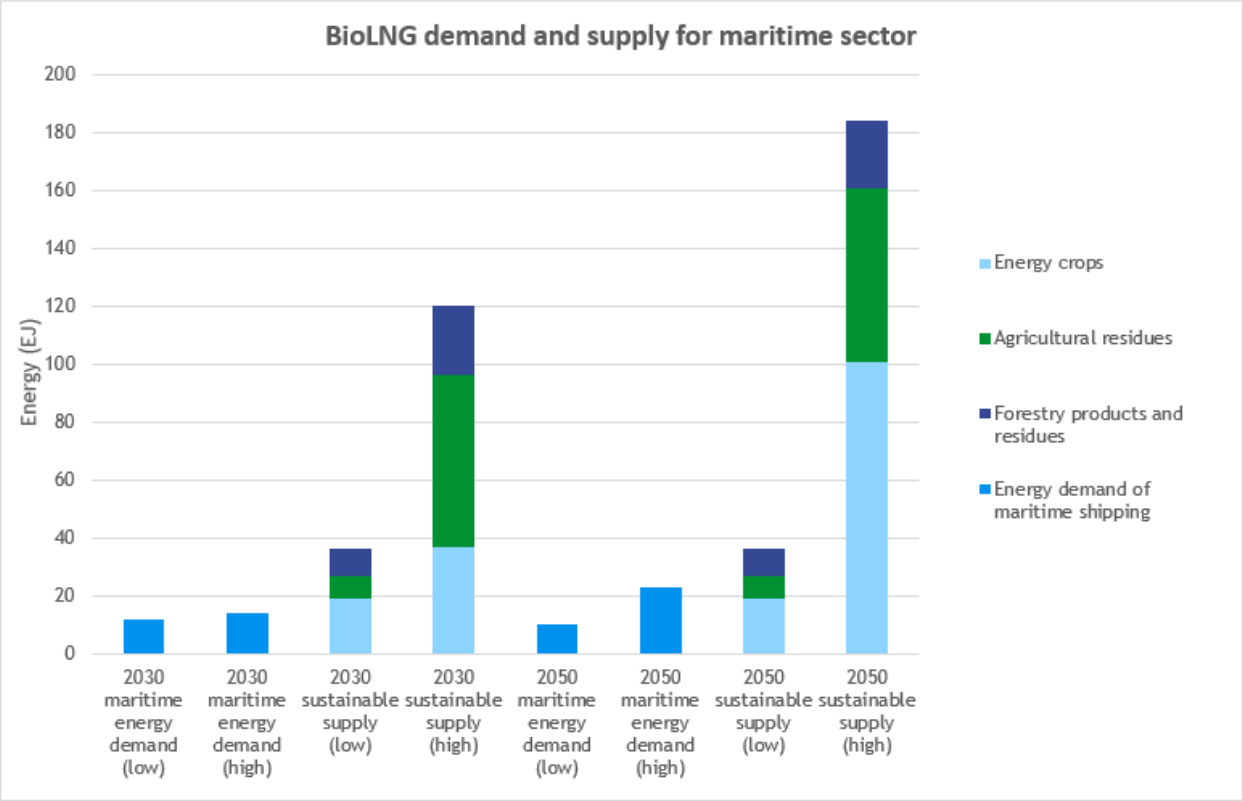


Figure 2: BioLNG demand and supply for maritime sector, 2030 and 2050 scenarios

The benefits of bioLNG used as a fuel

Liquefied biomethane, bioLNG or also called Liquefied Biogas (LBG), is distributed typically by LNG truck to the LNG terminal or LNG fuel stations to be used as fuel for ships, HD Vehicles (HDV) and for other purposes.

Biomethane as fuel enables huge reduction in GHG emissions. In the recent methane strategy of the EU[7] biogas is mentioned as an important tool to prevent methane emissions from the Agriculture and Waste sector. Those emissions, both anthropogenic as well as biogenic, come from feedstocks which currently are not being used to produce renewable energy.

Capturing those methane emissions will thus lead to a twofold benefit:

- Avoiding any emissions that would otherwise occur naturally
- Use this energy to displace fossil fuels, enabling an even a larger CO2 mitigation effect.

[7] https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1833

Another large positive effect the biogas sector provides is the needed increase in soil-carbon, and soil biodiversity in agriculture. The state of soil in Europe, described in a report of the EC Joint Research Centre (JRC)[8] is endangered, amongst other things, by biodiversity decline and organic matter decline. Sustainable cropping which at a later stage is being used for renewable energy can increase soil health significantly and on top of that can avoid nitrogen emissions.

In this way, extra sustainable biomethane is produced whilst it is embedded in agro-ecology.

Production capacity is being scaled up throughout Europe: growth trends and show case examples

The production of bioLNG is ramping up quickly in Europe. Whereas, in previous years, it was a niche green fuel, it is now being recognised as a needed green fuel that can be blended in with LNG and assume an increasing share over the years to come. Figure 3 below shows that the production capacity is quickly developing in the coming years and further significant increase is expected.

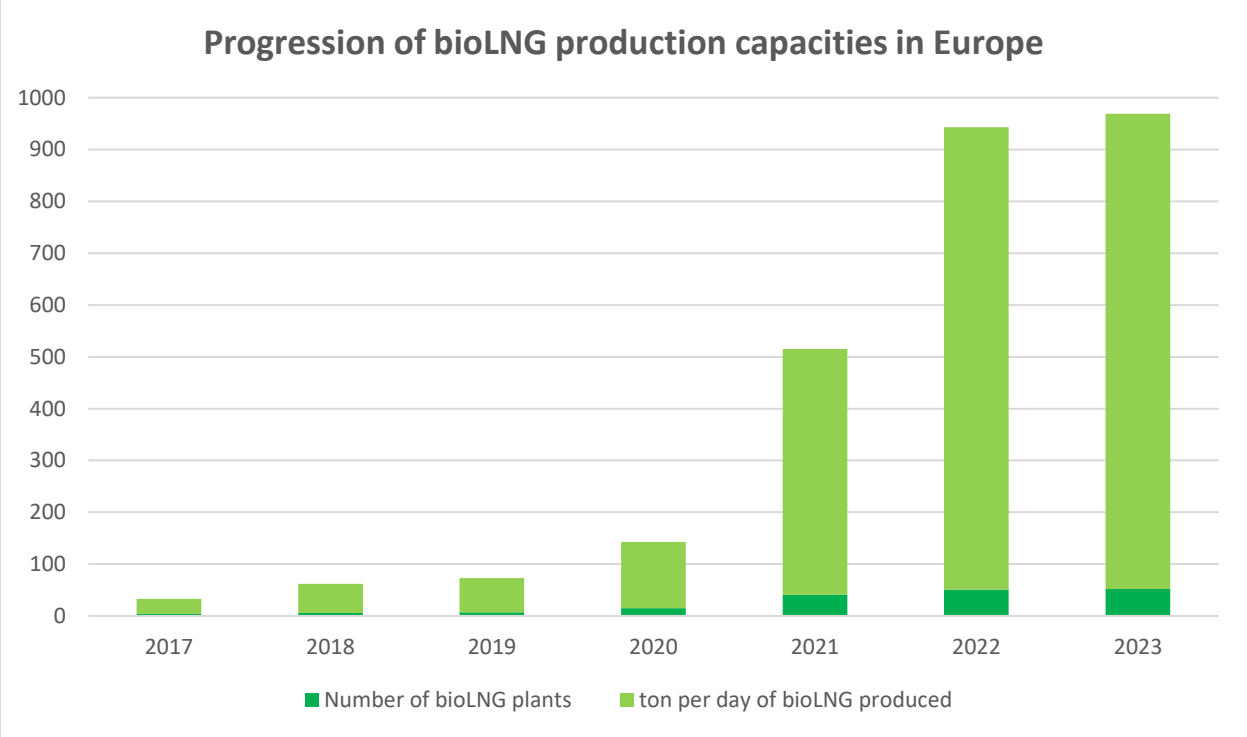


Figure 3: Progression of bioLNG production capacities in Europe

Show case - Biokraft Skogn (current largest production facility)

Biokraft has designed, built and since 2018 operated the world's largest facility for integrated on-site biogas production, biogas upgrading (to biomethane) and liquefaction of biomethane to LBG (or "BioLNG"). It was built adjacent to the paper mill and the LBG unit converts the cleaned biogas from fishery

[8] https://publications.jrc.ec.europa.eu/repository/bitstream/JRC68418/lbna25186enn.pdf

waste and residual paper mill slurry into liquid fuel. Warstila provided the equipment for the project. The first stage of LBG production in terms of energy output is 125 GWh/year, currently in the process of being doubled to 250 GWh/year (2021 – 2022). The LBG is being applied as vehicle fuel in Norway, both in busses and in heavy trucks. In 2019, Biokraft entered into what is currently the largest LBG delivery contract in the maritime sector – supplying cruise operator Hurtigruten with LBG for its fleet of cruise ships. Biokraft processes the bioresidue from the LBG production to a refined bio-fertiliser, currently being supplied to farmers in the region and around the location of the LBG plant.

Show case - Greenville Energy

At the smaller end of the capacity scale is the bioLNG site of Greenville Energy Ltd. in Northern Ireland. This plant is the first farm-based bioLNG plant in the world. Started in January 2018, this plant produces only 3 tons per day (300Nm3/h of raw biogas). Greenville Energy is a farm-based biogas production company using agricultural organic waste. The liquefaction technology was provided by CryoPur. In addition to producing BioLNG, it also enables the production of liquid BioCO_2, which can be sold as industrial gas and, as per the RED II, directly impacts the bioLNG carbon intensity of the project. Greenville also takes the waste from the wastewater treatment unit from LacPatrick dairies (the local dairy farm).

ASSOCIATED POLICY RECOMMENDATIONS:

- Extend the scope of Annex IX of the **Renewable Energy Directive** to integrate more feedstocks such as residues that cannot be used for other purposes or secondary crops.
- Create a **single market** for biomethane and bioLNG by facilitating trading of volumes and certificates across borders free of technical or political barriers.

3. Small Scale LNG & LNG infrastructures

BioLNG is interchangeable with LNG, both as a fuel and when it comes to usage of existing infrastructure, and does not require different expertise.

LNG infrastructure for road transport

Europe's market for bioLNG is expanding, driven by a combination of government support and demand from the private sector. The path for bioLNG in road transport starts to bloom, for example in Norway (Norske Skog Skogn Bio LNG plant[9], Cryo Pur and Sunnhordland Naturgass project in Stord[10]) and in the Netherlands (Nordsol project)[11].

There is a strong existing LNG refuelling network already in place in Europe, supporting the uptake of bioLNG. As the gas fuelling station map available on the Natural & bio Gas Vehicle Association website illustrates, there are already more than 333 public LNG stations in service today in Europe.

Figure 4: 333 European LNG fuelling stations as of 17 November 2020, NGVA Europe/gibgas

[9] https://www.ngvglobal.com/blog/huge-bioLNG-plant-produces-rng-for-norwegian-public-transport-0903
[10] http://www.cryopur.com/en/news/new-cryo-pur-bio-lng-contract-norway/
[11] https://bioLNGeuronet.eu/objectives/

This network is developing fast: since January this year, 50 LNG stations have started to operate.

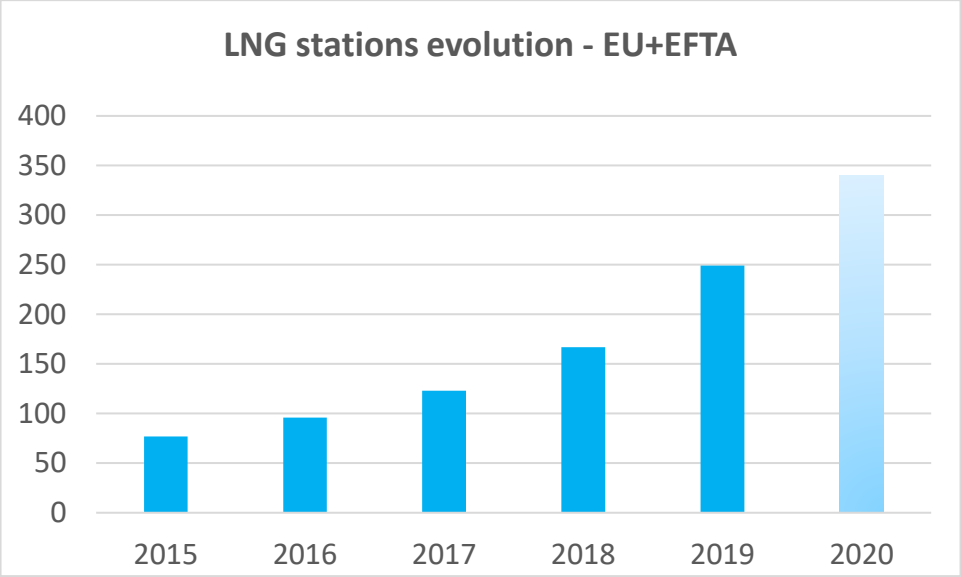


Figure 5: Evolution of LNG stations

With their great range, these stations are sufficient to fuel the entirety of today's LNG vehicle fleet in Europe, although it is not enough to face the rapid demand, especially coming from the Eastern European countries. As such, the development of adequate fuel distribution infrastructure is a crucial factor to guarantee the flexibility that logistics operations require, noting that LNG infrastructure is 100% compatible with bioLNG.

Looking towards the future, the industry roadmap developed by NGVA Europe and the EBA outlines the growth of LNG stations in Europe towards 2030. According to this document, LNG stations will increase to about 2,000 across the EU28, if properly supported by EU legislation.

LNG infrastructure for maritime

For ship bunkering, bioLNG presents a very viable business case. In Europe, as at summer 2020, nine vessels dedicated to LNG bunkering have been registered, with five more expected to be delivered by the end of 2020, while in 2017 there were only two in operation.

The bunkering infrastructure to support LNG as a marine fuel continues to snowball. LNG bunkering facilities are now established in 118 ports and under development in 90. This includes most of the leading oil bunkering locations. Ship-to-ship bunkering is upscaling dramatically. In early 2019 there were just six LNG bunkering vessels in operation; five in Europe and one in North America. As of July 2020, this has grown to 13 with a further 28 on order and/or undergoing commissioning. Geographies such as Brazil, China, Japan, Malaysia, Singapore, South Korea and South Africa are all developing bunkering solutions, the majority due to come into service within the next two years.

LNG bunker vessels are a very flexible form of 'supply infrastructure' considering that ship-to-ship bunkering is available in any port where the relevant permitting is in place.

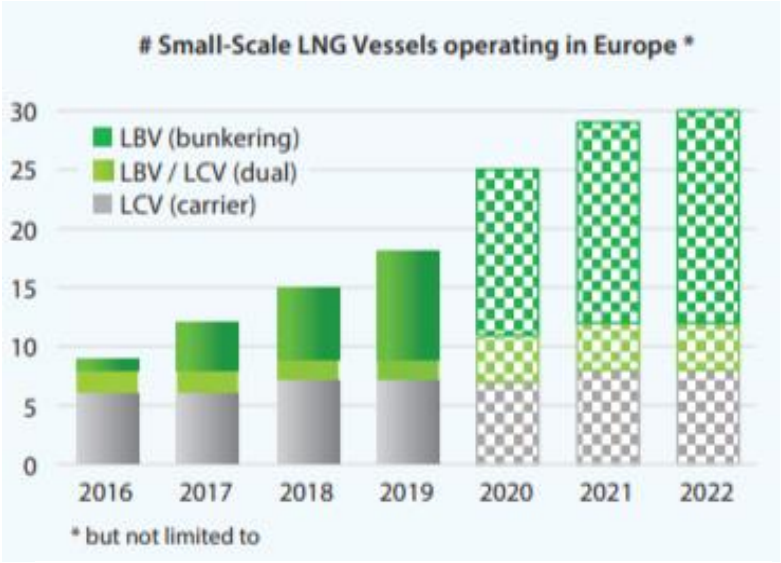


Figure 6: Evolution of SSL vessels fleet operating in Europe

As of 2020, there are 53 European ports where LNG bunkering is available (EU and UK) and 37 European ports where LNG bunkering facilities are under development.

LNG bunkering is available through ship-to-ship, tank-to-ship and truck-to-ship and leverages the existing bulk and SSLNG infrastructure in Europe.

Supplying industrial sites (including filling stations, satellite storages) not connected to the gas grid and truck-to-ship operations are another expanding major usage of small-scale LNG: truck loading quantities increased with an average of 8% year on year, with a consistent increase of 15.6% in 2019 vs 2018:

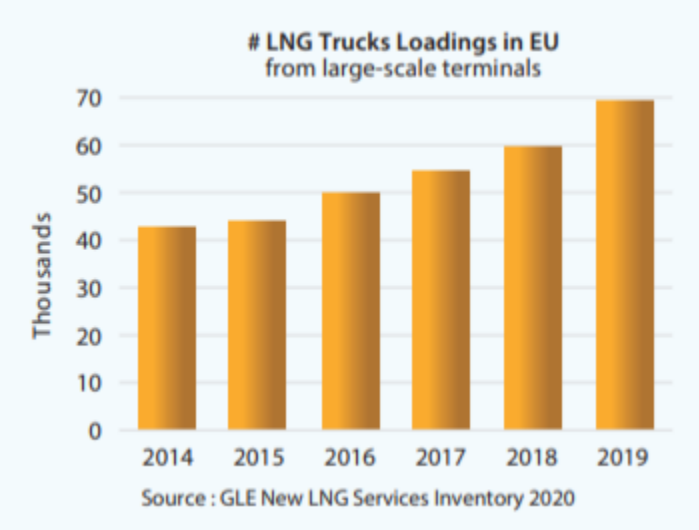


Figure 7: Evolution of LNG trucks loadings from large scale terminals in the EU

For example, in Finland, bioLNG bunkering is available today in the Port of Gothenburg (Swedegas/ FordonsGas[12] with first bio LNG bunkering of Fure Vinga vessel in 2018[13] and bunkering bioLNG tests take place in Raahe, Finland (Gasum) for the M/S Viikki vessel[14]. There are further projects underway in Zeebrugge, Belgium (Titan LNG Bio2bunker[15]).

ASSOCIATED POLICY RECOMMENDATIONS:

- Recognise the role of LNG infrastructure as an enabler for integrating higher shares of bioLNG, in particular by supporting the development of refuelling infrastructure for road and maritime transport along with SSLNG, under the revision of the **Alternative Fuels Infrastructure Directive**.

[12] http://www.ngvjournal.com/s1-news/c7-lng-h2-blends/swedegas-fordonsgas-sign-agreement-to-bring-bio-lng-to-gothenburg/
[13] https://www.portofgothenburg.com/news-room/news/first-ever-bunkering-of-liquefied-biogas-in-sweden-at-the-port-of-gothenburg/
[14] https://www.gasum.com/en/About-gasum/for-the-media/News/2020/ssab-raahes-steel-plant-is-testing-biogas-from-gasum-as-a-maritime-transport-fuel/
[15] https://titan-lng.com/titan-lngs-ambitious-bio-lng-breakthrough-project-receives-eu-funding/

4. BioLNG in the road transport sector

BioLNG vehicles, a broadly available and fast-growing reality on the European roads

(Bio)LNG trucks are a cost effective and sustainable solution that is already available and ready to accelerate the decarbonisation of HD transport. This is an important point for the EU to consider in reaching its 2030 EU climate target and start the process without further delay. This is especially true since these ambitions are very likely to be revised upwards.

HD transport is technically hard to electrify, as it requires highly rated power engines able to cover long distances while carrying a heavy payload. This demands specific and highly efficient powertrains supported by the adequate amount of onboard energy. Yet, to operate a 40-tonne HD truck for over 1,000 km, an electric truck would require a 6.4 tonnes battery with today's best technology, while the same distance can be covered with approximately 280 kg (620 litres) of LNG. LNG trucks can offer comparable performances to diesel engines with a range of dedicated products up to 460 HP, offering at the same time a significant GHG emissions[16] and pollutant emissions (NOx, PM)[17] reduction. It is therefore not surprising to see that LNG trucks are already driving this change on European roads.

The development of LNG trucks remains relatively recent as it started in 2011-2013, thanks to the strong support from the LNG Blue Corridor project. Today, less than 10 years later, there are already about 12,000 LNG-powered trucks in the European fleet, as shown in Figure 8.

The European LNG trucks market is becoming increasingly dynamic, with continuous rising sales and an ever-expanding range of models. By 2030, NGVA Europe expects that 280,000 LNG trucks will be on the roads, representing at least 25% of the market share. This fleet of LNG vehicles will require approximately 100 TWh fuel in 2030, with at least 40% being represented by bioLNG. This growth will need to be supported by the constant development of LNG infrastructure and stations across Europe.

[16] http://ngvemissionsstudy.eu/

[17] http://www.projetequilibre.fr/rapport-officiel-du-projet-equilibre/

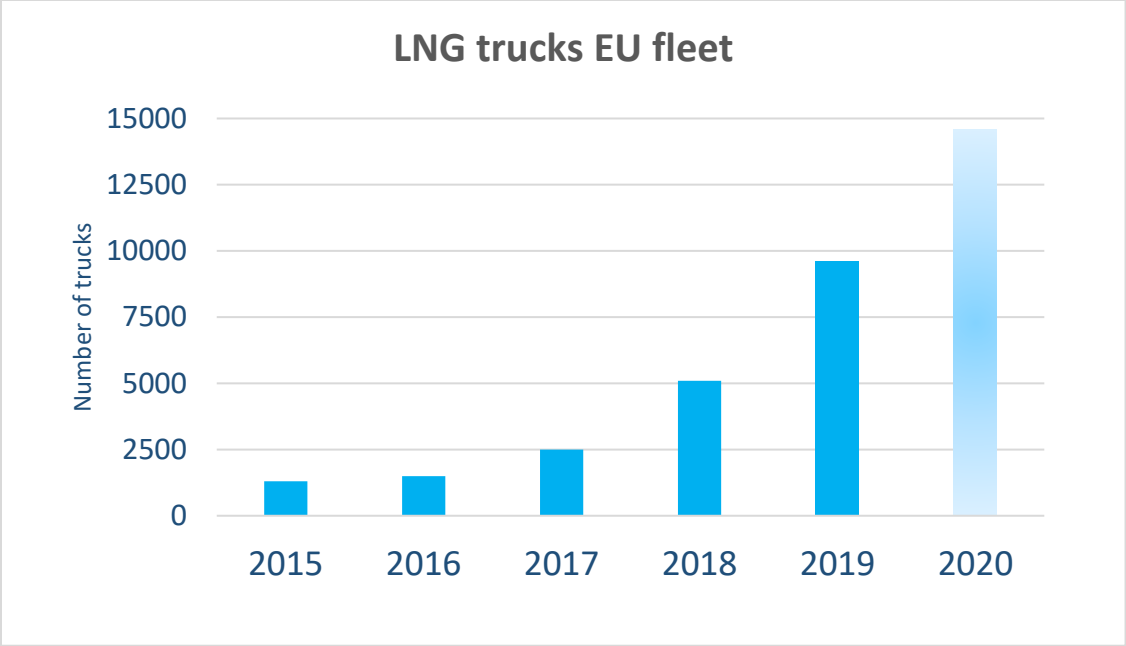


Figure 8: Evolution of LNG vehicles fleet in Europe

Using natural gas to power trucks and HDVs translates in an immediate CO_2 tailpipe emissions reduction of up to 20%[18] compared to diesel. But thanks to bioLNG, net zero emissions becomes an easy task.

BioLNG means heavy-duty transport decarbonisation

The progress of cutting GHG emissions has been very slow in the HD sector, as progress made on the vehicle efficiency side has been overcome by the increase in demand for freight transport. All available solutions will be needed to drastically reduce emissions, and bioLNG is key to that scope.

Using bio and synthetic LNG in HDVs results in a boosting effect when looking to GHG emissions under the well-to-wheel perspective. The graphic in Figure 9 draws a comparison between diesel and fossil LNG, GHG relative emissions. According to the different engine technologies, GHG emissions reduction ranges from -10% and -20% in favour of LNG. The third bar refers to the effect of a blend containing 17% bioLNG. This translates to an average 34% emissions reduction towards diesel.

When it comes to 100% biomethane, and particularly when it is produced from liquid manure, the GHG emissions balance is even negative. This means that at system level (fuel+vehicle), the utilisation of the truck is not increasing the CO2 emissions but, instead, reducing them. This is the simple result of the effect induced by the biomethane process, which is capturing natural emissions of methane that would have been otherwise released into the atmosphere.

[18] http://ngvemissionsstudy.eu

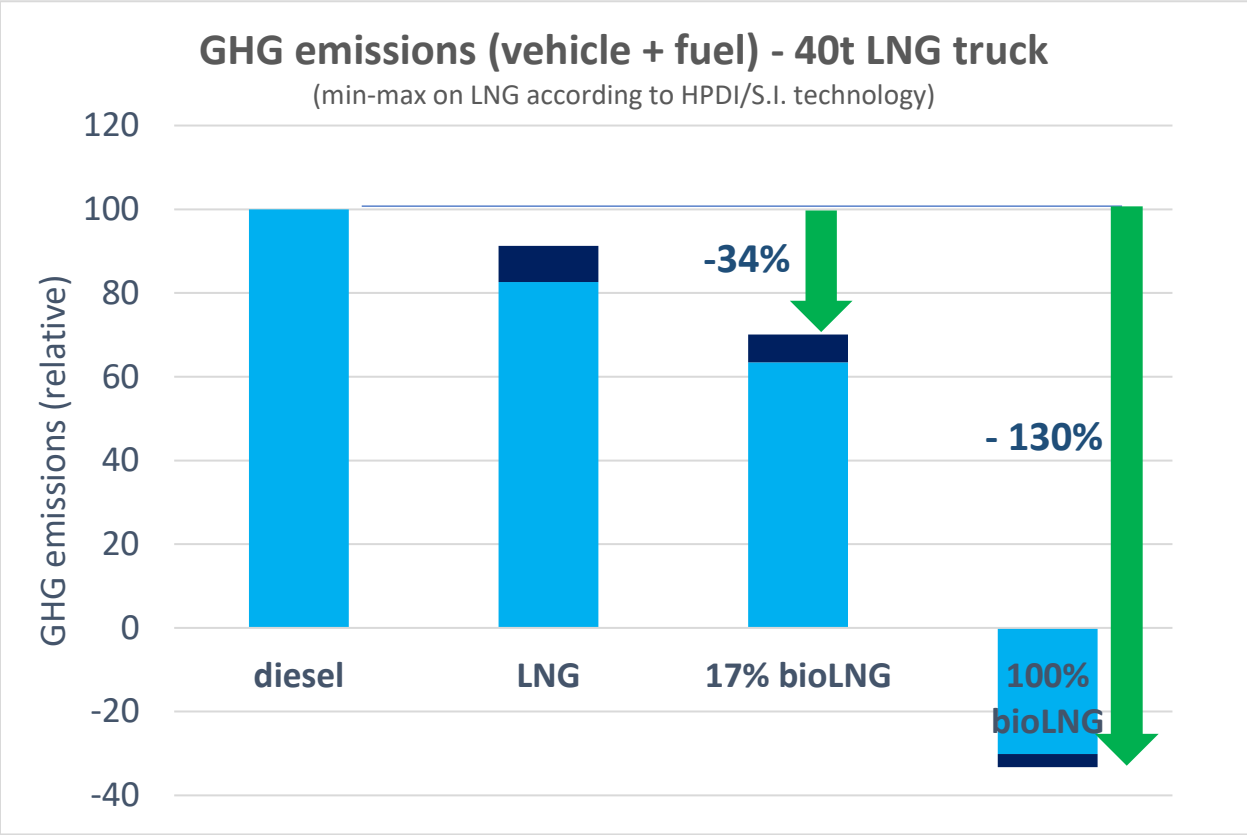


Figure 9: well-to-wheel emissions comparison

BioLNG is a competitive and cost-effective solution

The HD transport is a sector particularly sensitive to the Total Cost of Ownership (TCO). It is very dependent on a fuel's operational cost, due to the high mileage associated with long distance missions. As a consequence, every alternative to conventional fuels is analysed under this perspective. Indeed, the transition to alternative powertrains for the HD sector is quite complex, as it is fundamental to consider the specific priorities of the sector. Fuel costs represent an important part of all operating costs and most of the fleet owners are small and medium enterprises (SMEs). The resulting Total Cost of Ownership, the environmental performance, load capacity, vehicle range, maturity and reliability of the technologies are fundamental parameters.

LNG-powered vehicles are today the only viable and concrete alternative to Diesel-powered vehicles when aiming to lower CO_2 emissions at a similar TCO.

Today the fuel price differential between LNG and diesel is able to compensate the delta CAPEX associated with the higher costs for a LNG truck, mainly due to the current lower production volumes (scale effect) of the dedicated engine and vehicle components (dedicated gas engine, gas tanks, feeding system, etc.). Resulting TCO is slightly in favour of gas and this, associated with the environmental benefit, has supported the market uptake.

Considering the impressive benefit from bioLNG in terms of GHG emissions reduction, a bioLNG transport system is the most promising way to quickly abate emissions from the sector and adequate policies for incentives to further support its development will be needed in the future to partly compensate the higher cost of bioLNG production.

ASSOCIATED POLICY RECOMMENDATIONS:

- Adopt an approach based on **technology openness** and guarantee a true level playing field between different mobility solutions under a well-to-wheel thinking.
- Integrate the bio dimension of LNG in the revision of the **CO2 emissions standard regulation for HD vehicles** to stimulate a quick take off of the decarbonisation effect.
- Acknowledge the benefits of LNG/bioLNG in road transport to reduce local pollutant emissions.

5. BioLNG in the maritime transport sector

Status of the LNG-fuelled fleet and bunkering infrastructure

There are currently 173 LNG-fuelled vessels[19] in operation with approximately 230 on order and a further 150 LNG-ready ships (vessels which have been designed for retrofit to LNG) either in operation or on order. LNG accounts for just over 3% of total marine fuel consumption.

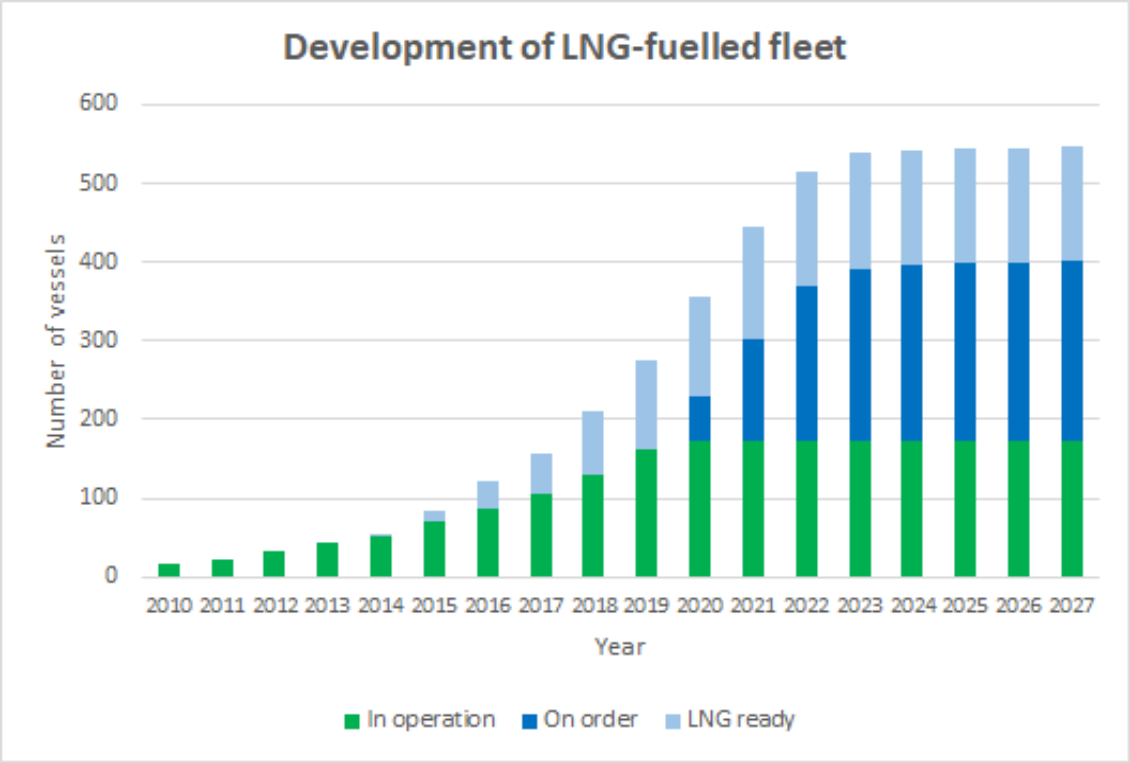


Figure 10: Development of LNG-fuelled fleet

Since the beginning of the decade the number of LNG-fuelled vessels has grown consistently by between 20%-40% per annum, expanding from the short sea shipping sector in North West Europe, where LNG as a marine fuel was pioneered, to international deep-sea shipping.

LNG-fuelled vessels amount to about 13% of the current newbuild order book, rising to 16% if LNG-ready vessels are included. For some segments, such as the ultra-large container vessels which underpin the global trading system, more than 50% of the order book is either LNG-fuelled or LNG-ready.

BioLNG as a drop-in fuel

BioLNG is simply liquefied methane and contains minimal amounts of impurities. It can be used in existing LNG engines with little, or no modification and transported, stored and bunkered in ports utilising existing LNG infrastructure. Consequently, it can be used seamlessly as a drop-in fuel.

[19]This number excludes 378 LNG-fuelled LNG carriers.

BioLNG is available commercially, now. In November 2020, Total completed the world's largest LNG bunkering operation to date in Rotterdam, supplying 17,300 cubic metres of LNG to French shipping group CMA-CGM's ultra-large container vessel, JACQUES SAADE, 13% of which was bioLNG[20]. In Finland, Gasum is bunkering ESL Shipping's dry bulk carrier m/s Viiki with 100% renewable bioLNG to transport iron ore for the Swedish steel company SSAB. Gasum is also supplying a 10% bioLNG blend for two LNG-fuelled tankers chartered by Swedish oil company Preem, while ferry operator Destination Gotland is using a bioLNG blend in two of its high-speed, ropax ferries.

Greenhouse gas emissions reductions and air quality benefits

The use of LNG in the maritime sector can reduce GHG reductions up to 21% compared with current oil-based marine fuels over the entire life cycle from well-to-wake, including methane emissions[21]. This means that when combined with Energy Efficiency Design Index (EEDI) improvements to ship design, ships fuelled by fossil LNG will likely meet the IMO 2030 decarbonisation target for new build vessels and possibly the current European 2030 target.

The use of bioLNG, initially as a drop in fuel, can reduce emissions by up to about 92%[22] compared with fossil LNG in the combustion cycle, with even further reductions possible on a well-to-wake basis depending on the origin of the bioLNG. For example, if bioLNG is produced from domestic and agricultural waste it has the potential for negative emissions.

Methane slip in marine engines is receiving much attention in relation to the GHG benefits of LNG as a marine fuel. Slip is often misleadingly characterised as an irremediable design flaw which is not correct.

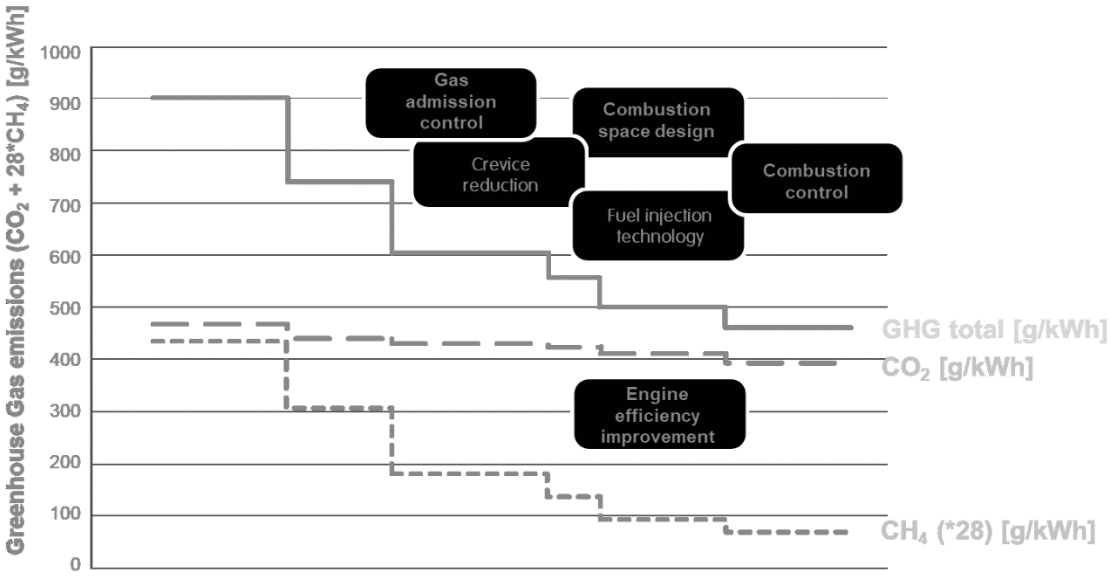


Figure 11: Example of efficiency improvement and methane slip development on medium speed 4-stroke Otto combustion low-pressure gas engines and some of the enabling technologies. (Source: Wärtsilä, MAN ES, Caterpillar & WIN GD)

[20] https://www.bioenergy-news.com/news/biomethane-used-in-major-dutch-lng-bunkering-operation/
[21] https://www.thinkstep.com/content/life-cycle-ghg-emission-study-use-lng-marine-fuel-1
[22] Ibid

Engine manufacturers recognise slip as an issue for certain types of internal combustion engines but not for all of them i.e. high-pressure reciprocating engines and gas turbines[23].

It is important to note that LNG-fuelled engines were originally developed in the 1990s to address local emissions, i.e. NOx and SOx. GHG emissions were not an area of focus at the time. Since then, levels of methane slip, where applicable, have been reduced by a factor of four[24] and engine manufacturers continue to invest in R&D to further reduce the slip in response to both commercial and regulatory pressures. Hence, the LNG-fuelled vessels being built today have much lower levels of methane slip than that which is often cited in academic studies which are based on older engine technologies and outdated data. The 2019 study[25] which SEA-LNG commissioned used the most current data available. The engine manufacturers are on a pathway to continue to reduce methane slip even further[26] by working on more design changes and the implementation of advanced combustion algorithms.

For example, MAN Energy Solutions states it has reduced emissions from four-stroke engines by half in a decade. In addition, it indicates that engine design changes together with new solutions for post-treatment and the transfer of technology from high-performance two-stroke engines to four-stroke engines has the potential to reduce methane slip by a value greater than 90 percent. Fellow marine engine manufacturer Wärtsilä has said methane slip from its dual-fuel engines has been slashed by 75% over the past 25 years and further advances will drastically reduce it gain over the next three years. WinGD has just announced a technology improvement that will reduce methane slip in its 2-stroke low-pressure internal combustion engine by 50%, a significant breakthrough.

Air quality benefits

The air quality benefits resulting from the use of LNG as a marine fuel are well known and accepted. Vessels using fossil fuel LNG emit virtually no SOx while dramatically limiting emissions of NOx. It also virtually eliminates particulate matter, including black carbon or soot, which while not yet regulated, is a growing environmental concern. BioLNG is pure, liquefied methane, consequently, the only local emissions it produces are associated with the combustion of the very small amounts of pilot fuel used in LNG dual-fuel engine technologies.

[23]Ibid 2

[24]https://www.ics-shipping.org/docs/default-source/Submissions/IMO/short-term-measures-to-reduce-ghg-emissions-from-international-shipping.pdf?sfvrsn=0

[25]Ibid 3

[26]https://www.wartsila.com/media/news/06-04-2020-cutting-greenhouse-gas-emissions-from-lng-engines; https://www.wingd.com/getattachment/2ae9feb2-8f08-45af-a97a-8ce11fb0a983/press-release; https://www.tradewindsnews.com/gas/man-energy-solutions-ups-ante-on-methane-slip-battle/2-1-831636 https://shippingwatch.com/regulation/article12346282.ece

Cost effectiveness: Total cost of ownership with LNG and bioLNG

LNG's accelerating adoption as a marine fuel is driven by increasing recognition of its commercial and operational viability. The investment case is robust. It is based upon independent modelling of the economics of LNG-fuelled vessels across a variety of different vessel types and trade routes using publicly available data on CAPEX. The cases show that LNG provides a compelling business case for ship-owners when compared to conventional marine fuels. LNG as a marine fuel currently delivers the best return on investment on a net present value (NPV) basis over a conservative 10-year horizon compared with low sulphur fuel oil, with paybacks varying from less than one year to five years and CAPEX for LNG engines, fuel systems and storage tanks continues to fall[27].

The investment case for bioLNG is identical to fossil LNG in terms of CAPEX. In terms of price, bioLNG blend is currently commercially viable in NW Europe, with a 10% blend of bioLNG with LNG on par with 0.10% marine gasoil (MGO), in Rotterdam.

Analysis in the recent study[28] commissioned by SEA-LNG from CE Delft concludes that bioLNG is likely to be commercially competitive relative to other low- and zero-carbon fuels such as green hydrogen and ammonia. It has the clear commercial advantage over these fuels that existing LNG infrastructure can be used to transport and bunker bioLNG.

ASSOCIATED POLICY RECOMMENDATIONS:

- Adopt an approach based on **technology openness** and guarantee a true level playing field between different mobility solutions under a well-to-wake thinking.
- Integrate the bio dimension of LNG in the revision **in GHG reduction targets for shipping** to stimulate a quick take off of the decarbonisation effect.
- Acknowledge the benefits of LNG/bioLNG in maritime transport to reduce local pollutant emissions.

[27]See series of investment cases 'LNG as a marine fuel - the investment opportunity' published by SEA-LNG https://sea-lng.org/why-lng/commercial/
[28]SEA-LNG study with CE Delft

Gas Infrastructure Europe


The European Biogas Association (EBA) is the voice of renewable gas in Europe since 2009. EBA advocates the recognition of biomethane and other renewable gases as sustainable, on demand and flexible energy sources that provide multiple knock-on socio-economic and environmental benefits. Supported by its members, EBA is committed to work with European institutions, industry, agricultural partners, NGOs and academia to develop policies which can enable the large-scale deployment of renewable gases and organic fertilisers throughout Europe, supported by transparent, well-established sustainability certification bodies to ensure that sustainability remains at the core of the industry. The association counts today on a well-established network of over 100 national organisations, scientific institutes and companies from Europe and beyond.

Gas Infrastructure Europe (GIE) is the European association of gas infrastructure operators. GIE members are active in transmission pipelines, storage facilities and LNG terminals. With 70 industry members from 26 European countries, GIE perfectly embodies the multiple transitional decarbonization pathways of the EU regions. GIE is committed to help achieve EU's ambition to deliver a 90% reduction in transport related GHG emissions and aim to become the first climate neutral region by 2050.

The Natural & bio Gas Vehicle Association (NGVA Europe) is the European association that promotes the use of natural and renewable gas as a transport fuel. Founded in 2008, its 124 members from 27+4 countries include companies and national associations from across the entire gas and vehicle manufacturing chain. NGVA Europe is a platform for the industry involved in producing and distributing vehicles and natural gas, including component manufacturers, gas suppliers and gas distributors. It defends their interests to European decision-makers to create accurate standards, fair regulations and equal market conditions.

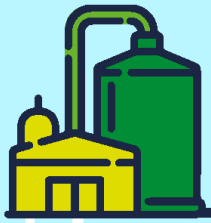
SEA-LNG Founded in 2016, with numerous high-profile members including shipping companies, ports, LNG suppliers, bunkering companies, infrastructure providers and OEMs (Original Equipment Manufacturers), classification societies, banks and brokers, SEA-LNG is a multi-sector industry coalition whose members work together to demonstrate the benefits of LNG as a marine fuel throughout the entire value chain.

BioLNG in transport
MAKING CLIMATE NEUTRALITY A REALITY

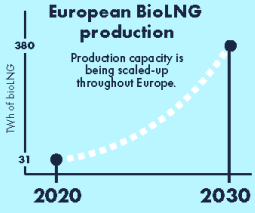
BioLNG can deliver EU Green Deal's goal by helping reduce CO_2 emissions in transport by 90%.

How do we produce BioLNG?

Organic residues are used to generate biomethane liquefied to create BioLNG.
The BioLNG value chain generates negative carbon emissions.



Sustainable feedstock is already available to foster BioLNG growth.



Cost Competitive
(Zero-carbon fuels)

How do we transport and distribute BioLNG across the EU?

100% OF THE EU GAS NETWORK IS FIT FOR BioLNG TODAY

CARBON NEUTRAL READY

IN 2020
53 PORTS (EU27 & UK)
HAVE LNG BUNKERING

37+ PORTS
DEVELOPING LNG BUNKERING

330+ LNG STATIONS
IN 2020

2.000+ LNG STATIONS
IN 2030

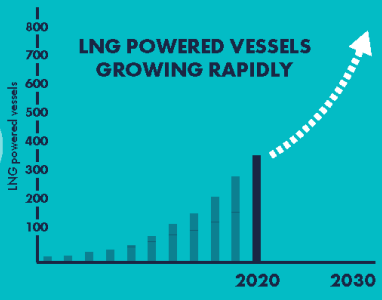
How can BioLNG decarbonise the transport sector?

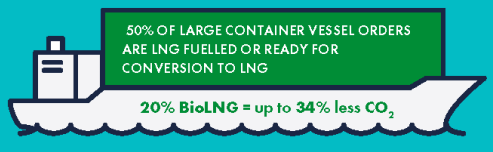
SHIPPING

95% LESS NOx

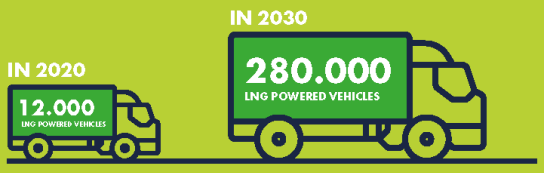
99% LESS SOx

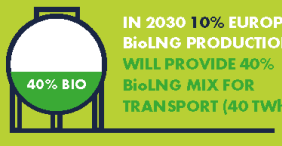
99% LESS PARTICULATE MATTER





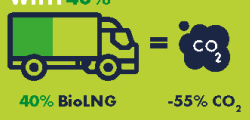
HEAVY-DUTY TRANSPORT

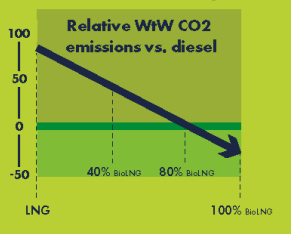




IN 2030 10% EUROPEAN BioLNG PRODUCTION WILL PROVIDE 40% BioLNG MIX FOR TRANSPORT (40 TWh)

80% BioLNG = Carbon Neutrality





BioLNG: AVAILABLE, SCALABLE & COMPETITIVE

EBA European Biogas Association
gie Gas Infrastructure Europe
NGVA Europe
SEA-LNG