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BEST ACE

BIOGAS- ESTABLISHED SUSTAINABLE TECHNOLOGY IN A CIRCULAR ECONOMY

BIOGAS BUSINESS ROADMAP

- For bridging the market gap in Baltic Sea region

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With contribution from the Best Ace Consortium

2. SUMMARY

The Baltic Biogas Business Roadmap provides a comprehensive overview of the biogas market in the Baltic Sea region, including the current status, potential growth, and future opportunities for biogas in Estonia, Finland, Latvia, and Sweden. The Best ACE Project Aims to secure continuous development of biogas production and bridge the market gap from compressed biogas (CBG) to liquefied biogas (LBG). The goal is to create a common understanding among biogas producers, share best practices, and analyze market segments like gas grid, long-haul transport, maritime, and power-to-x (P2X) solutions.

The demand for low-carbon intensive fuels is increasing due to climate change. Europe aims to reduce energy imports and increase renewable gas production. The focus is on biogas and synthetic e-methane production, which can replace natural gas and liquefied natural gas in applications such as heavy-duty vehicles and shipping. Various EU initiatives and regulations are driving the decarbonization of the energy system, promoting renewable gases like biogas and biomethane. The EU aims to tenfold biogas production to 35 billion cubic meters per year by 2030. Biogas production addresses waste handling, fertilizer production, and contributes to the UN Sustainable Development Goals. There is significant potential for increasing biogas production, especially with proper planning for digestate and nutrient recovery.

Estonia: Positive trends in upgrading and new vehicles, but there is a lack of ongoing projects in the industry. Well-developed gas grid with potential for biomethane injection.

Finland: Many biogas plants upgrades to biomethane, several ongoing projects, and a gas grid in the southern part that could be utilized.

Latvia: Four biogas plants upgrading to biomethane, but low numbers of CNG vehicles. Well developed gas grid with dedicated injection points exists.

Sweden: A frontrunner in long-haul transports, many biogas plants, limited use of LBG in ferries, and several ongoing carbon capture and utilization projects.

The market conditions for analyzed markets and countries indicates a great possibility to utilize the existing gas grid in Estonia and Latvia. The use of LBG for heavy-duty vehicles is a growing and promising market segment. The maritime sector also indicates an increasing interest in using LBG for shipping to meet EU emission regulations. The market segment for reforming and E-fuels is still in the exploration phase of biohydrogen and other e-fuels derived from biogas. On the other hand, a ten-fold of biogas production in EU opens up a huge potential for e-methane production from green CO_2.

The transition from light vehicle markets using CBG to new markets using LBG such as long-haul transport and maritime usage can cause a time gap, risking existing investments and halting the development of biogas. The EU countries have varying support schemes that affect market development. Harmonizing these could boost the biogas market. The biogas market in the Baltic Sea region has significant growth potential, especially with increased support, proper infrastructure, and harmonized regulations. Biogas is strategically important and a crucial component of the EU's strategy to reduce greenhouse gas emissions and transition to renewable energy.

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PUBLICATION INFORMATION

Issued by: Best Ace Consortium
Layout and graphics: Moa Jonsson, BioFuel Region

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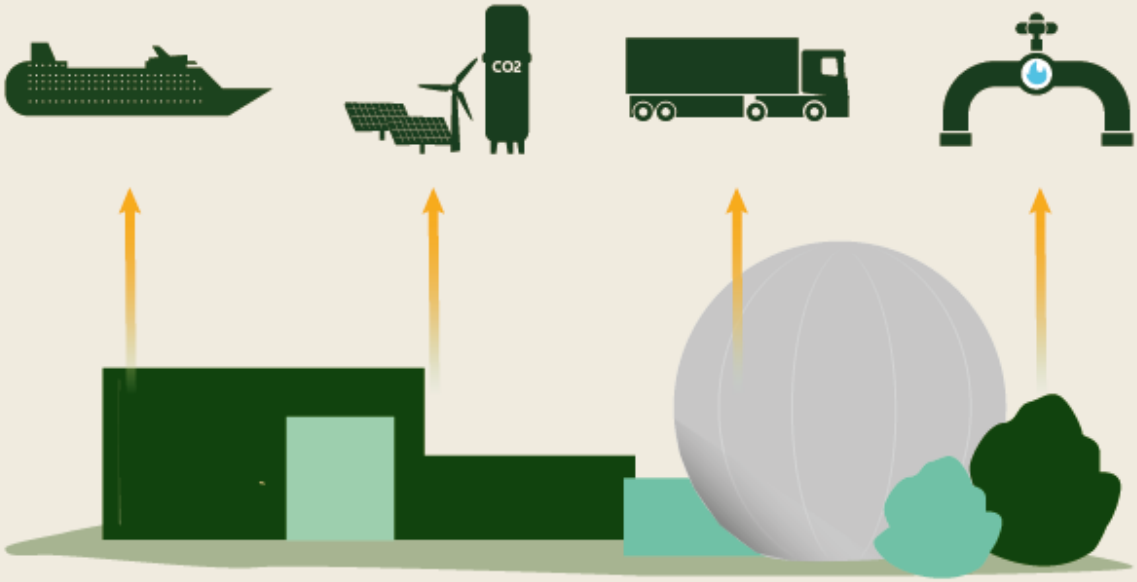

1. INTRODUCTION

The demand for low-carbon fuels is increasing significantly due to climate change. At the same time, Europe's dependence on energy imports should be reduced; this has led to increased demand for renewable gas. Biogas production can be supplemented with power to gas technology, i.e. synthetic e-methane production, which is based on biogenic CO_2 sources and hydrogen obtained from electrolysis. Both biomethane and synthetic e-methane can replace natural gas and liquefied natural gas, especially in applications that are difficult to electrify, such as heavy-duty vehicles and shipping.

Further, the fuel market in the EU is changing. For biogas and bio-CNG the ban of the combustion engine as of 2035, due to the new emission agreement for light vehicles within the fit-for-55 package, has meant that the light vehicle market is rapidly decreasing. On longer term the city bus market is decreasing due to the Clean Vehicle Directive. The commission has pointed out that biogas as liquefied biomethane (LBG), which is primarily a locally produced and available resource, should instead primarily be aimed for long-haul transports, maritime use, replacing natural gas and reformation into e-fuels. Those markets with the use of LBG instead of compressed biomethane (CBG) will demand larger volumes. The challenge is the time gap between the end of the light vehicle market to a full implementation in the new markets. This time gap could be devastating for the billions of euros already invested in biogas production and infrastructure in the Baltic region. Therefore, it is of great importance to identify the conditions and elaborate a transitional business roadmap for biomethane in the Baltic area for the use in long-haul transports, maritime sector, reformation/e-fuels and for feeding into the natural gas grid. The aim of this is to speed up the market process, avoid the time gap for implementation and to secure a continuous development of biogas production. This is the core of the project BEST ACE. The biomethane status was mapped in the beginning of the project in a State-of-play report.[1] The biomethane status in the countries is summarized in Table 1. The Biogas Business Roadmap is launched for the countries Estonia, Finland, Latvia and Sweden with year 2022/2023 as base year.

1 Norberg, I., et al., (2023) State of play report, BEST ACE project.
Source: https://biofuelregion.se/wp-content/uploads/2023/05/Best-Ace-State-of-play-FINAL-VERSION.pdf Visited 2024-09-03

Table 1. Summary of the biomethane status in the markets long-haul traffic, maritime, industry and gas grid in Estonia, Finland, Latvia, and Sweden.

Country	Long-haul transport	Maritime	Reforming and E-fuels	Gas grid
Estonia	Positive trend in upgrading and new vehicles such as city buses. Only a few LNG trucks.	One LNG-ferry in traffic.	No ongoing projects or use of biogas in the industry.	Well-developed gas grid. Possible to inject bio-methane into the gas grid.
Finland	Many biogas plants upgrade biogas to biomethane.	Several LNG-ferries in traffic	Several ongoing projects to utilize CO2. One project to split methane into hydrogen and carbon.	Gas grid only in the southern part. Possible to inject bio-methane into the gas grid.
Latvia	Four biogas plants have upgraded already and 3-4 is planning an upgrade to biomethane in 2024. Still low number of CNG-vehicles.	No LNG-ferries in traffic.	No ongoing projects or use of biogas in the industry.	Well-developed gas grid. Possible to inject biomethane into the gas grid at dedicated points.
Sweden	Frontrunner in EU in long-haul transports. A lot of biogas plants upgrade and/or liquefies biogas.	Limited use of LBG in ferries. Ongoing possibilities to blend in LBG in LNG vessels.	Increasing demand for e-methane. Several ongoing CCU-projects to start production of green e-methane. A trend in replacing natural gas and liquefied petroleum gas with biogas.	Gas grid only exist along the west coast and several local gas grids. Possibility to increase production into the grid for industrial use.

There are different main markets for biogas and biomethane in Estonia, Finland, Latvia and Sweden, see Table 2. The biogas as such can be used for heat and electricity, which is the main usage in Latvia and Finland. In Sweden and Estonia, the main part of the produced biogas is further upgraded to biomethane, as well as around 20% in Finland. There are more available options for the main product biomethane, either compressed or liquefied. CBG can be used as vehicle fuel, injected to the gas grid or used for industry and LBG is effectively transported and suits well for long-haul transports and maritime sector, which is increasing in both Sweden and Finland. Moreover, the capture and usage of carbon dioxide is an upcoming potential that can increase the output of biomethane at existing biogas plants and make use of existing gas infrastructure.

Table 2. Summary of production volumes and usage from the State of Art report 2021 in GWh, extended with filling stations and vehicles statistics for 2023.

GWh	Estonia	Finland	Latvia	Sweden
Biogas production	200	906	687	2265
Flare	0	91	0	204
Heat	31	535	453	417
Electricity	17	125	227	68
Industy	0	0	0	68
Upgrading (CBG)	152	156	7	1471
Liquefaction (LBG)	0	60	0	156
CBG- / LBG - filling stations	28/2	69/15	9/0	257/30
CBG-/ LBG - vehicles	6.600/10	16.000/150	500/0	51 000/1000

The countries have different support schemes for biogas, which might be a factor for market development. The support scheme in Sweden is mainly fiscal incentives and in Finland investment support plus a quota system for biomethane sold to the transport sector since 2021. In Estonia there are feed-in-premium and in Latvia there is a lack of support schemes. The biogas potential is big in all of the countries and the European Union is pointing out biomethane as a key player in RePower EU and Fit for 55. The RePower EU plan aims for rapidly reducing dependence on Russian fossil fuels and making a fast transition to green technologies. The biomethane-hydrogen economy solutions also connect to the FIT for 55 on reducing the CO_2-emissions by 55% to year 2030 and enhance the sector coupling.

2. VISION AND MISSION

The Best ACE project aims to secure a continuous development of biogas production and bridging the market gap from CBG to LBG. The vision is to be an enabler for the Baltic Sea region in contributing to the EU-target of ten-folding biogas production.

The mission of the Best ACE project is to:

- Create a common understanding and share knowledge among biogas producers and market stakeholders.
- Share best practice and proof of concept solutions.
- Analyze biogas market segments: Gas grid, Long-haul transport, Maritime and P2X-solutions to identify the best market possibility for each country.

Photos: Best Ace project. LBG/LNG filling for heavy-duty vehicles in Västerås, Power to gas solutions integrated at biogas plant in Hjörring, Denmark and the Wasaline ferry running on LBG/LNG between Vaasa (FIN) and Umeå (SWE).

The Biogas Business Roadmap is aimed for biogas producers and distributors, but also functions as a suporting document for decision makers on regional and national development pathways.

The markets have not only been analyzed and evaluated in the reference groups, but the project has also made study visits together with the stakeholders as proof of concept for different market solutions. All in all, four study visits have been made with different markets in focus:

1. Sweden, Long-haul transport, and LBG-production.
2. Denmark, and the use of natural gas grid and P2X solutions but also the valorization of green CO_2 from biogas production.
3. Estonia, biogas potential from paper and pulp industry and the use of CBG for city buses, but also fuel cell running on biogas.
4. Finland, different P2X-solutions both for biogas production and larger CCU-projects for waste incineration and production of LBG as well as development of engines for different fuels in the maritime sector.

3. BIOGAS AS A DRIVER FOR SUSTAINABLE GROWTH

Biomethane or biogas is generally quite unique in the way that apart from being an energy carrier for different purposes and the ability to be mixed into existing infrastructure it is also a solution to several social problems such as waste handling and fertilizer production. In 2020 according to the European Environment Agency the food and garden waste contributed 34 percent of all municipal waste, which could be used for biogas production instead of being combusted or put on landfills. Additionally, there is a huge potential in agricultural manure and waste. Waste water cleaning contributes to sludge based biogas production When biogas is used to reduce climate impact and oil dependence additional added values for society arise, which is why it connects either directly or indirectly to the UN sustainable development goals seen in Figure 1.

The bigger the biogas production, the more feedstock is needed. Which also means more digestate, and thus more valuable nutrients will be available from the plant. A higher biogas production generally means a more feasible business case, especially when liquifying the biogas into LBG. Therefore, it is important to plan the recovery of digestate and nutrients in a sufficient way for keeping a sustainable production. The market for bio-fertilizers must be developed so there is a complete valorization of the biogas production. Biogas production is not only an energy source with security of supply compared to import of fossil fuels it is also a fertilizer product diversifying the security of supply in food production. Except nutrients also carbon is recycled back to the fields thus helping soil depletion and achieving climate neutrality. Phosphorus is for example listed as a critical raw material by the EU, which only has one small reserve and mining for phosphorus situated in Finland. EU is highly dependent on imports of phosphorus, about 90 percent. An estimated two thirds come from the three major exporters Morocco, China and the USA. Phosphorus is vital for both plants and humans.

The high potential to increase biogas production and achieving the RePower EU goals means there will be a need for labor and competence. It might be a challenge to find biogas competence since EUs ambition to ten-fold biogas production has not yet found its way into the educational institutions. This is both a challenge and a great opportunity since new working places will be needed when fossil fuels are phased out.

Figure 1. Biogas contributes to all UN sustainability goals, either directly or indirectly. The Best ACE project has essentially worked towards goal number 9 Industry, innovation, and infrastructure.[2]

Biogas production and usage is a competitive and existing technology in several market sectors. As transport fuel for both light- and heavy-duty vehicles but also as a maritime fuel or for heat- and electricity production. It gives cleaner air, less particles and NOx, but it is also less dirty compared to liquid fuels that can drip, thus creating a cleaner working environment. Biogas driven engines also create less noise compared to diesel engines. In other words, biogas contributes to good health and well-being.

As stated above, biogas connects to the UN sustainability goals on all three levels environmental, social and economic. The latter is then directly connected to circular economy solutions. On an even wider perspective biogas connects to energy sector coupling as both an energy carrier and a green CO_2-source, but also as a part of creating a green hydrogen economy.

4. EU FRAMEWORK FOR BIOGAS

Synthetic formation of methane occurs through thermal gasification of biomass. Biogas and biomethane are today the main renewable gases available to help decarbonize the EU's energy system. Biogas or biomethane production needs to be scaled-up to 35 billion cubic meters per year by 2030 to replace natural gas. This is a ten-fold increase in production and its estimated investment need for the period amounts to 37 billion euro. The key actions for achieving the target can be boiled down to:

- The Biomethane Industrial Partnership (BIP), which promotes active engagement between the Commission, EU countries, industry representatives, feedstock producers, academics, and NGOs.
- The revised Renewable Energy Directive (RED) raises the target for 2030 to 42.5% share of renewables in the EU energy consumption, which also covers the transport sector and thus encourages the use of bio- and renewable fuels. [3]
- Recommendation by the Commission to speed up permit-granting procedures for renewable energy projects.

[2] UN (2024) Take Action for the Sustainable Development Goals.
Source: https://www.un.org/sustainabledevelopment/sustainable-development-goals/

[3] European Comissions (2024) Renewable energy targets.
Source: https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-targets_en

- Incentives for upgrading biogas into biomethane and actions for assessment of infrastructure challenges and bottlenecks potentially standing in the way of achieving a cost-efficient deployment of biomethane.[4]

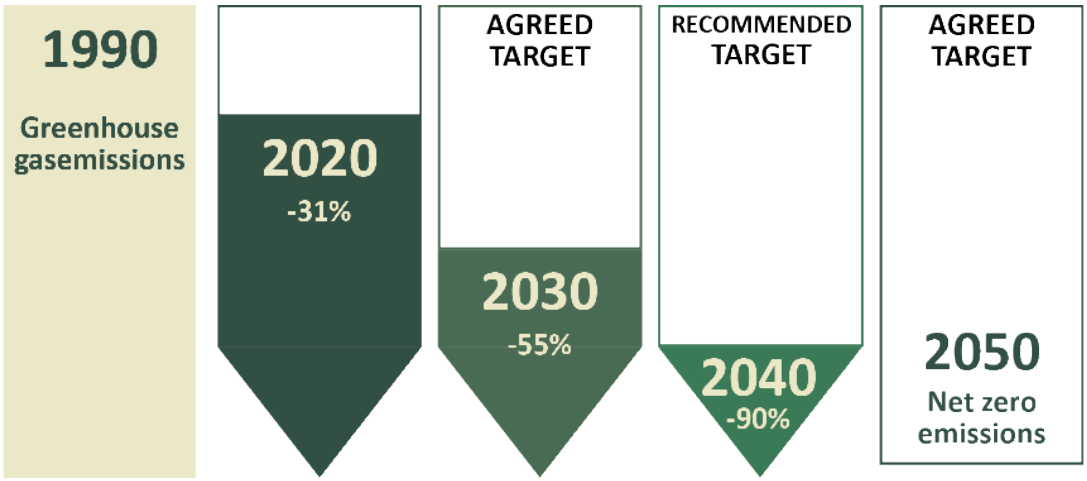

Figure 2. Europe's 2040 climate pathway relies on CCUS technologies to achieve 90% GHG reduction by 2040.[5]

The EU 2040 climate target seen in Figure 2 sets aim for a 90% reduction of greenhouse gas emissions relative to 1990 to ensure that EU reaches climate neutrality by 2050. Climate neutrality is the core of the European Green Deal and a legally binding objective set out in the European Climate Law. The EU 2030 target is set for a 55% reduction of GHG-emissions compared to 1990 and as help the Fit for 55-package has been created as a central part in the Green Deal strategy, which connects to many aspects like Renewable Energy Directive and EU-taxonomy rules. [6]

According to EBA biogas has a lesser role in the 2040-target compared to other energy pathways and its contribution to the energy system integration and flexibility is overlooked. Biogas can make use of all resources by refining organic waste by supporting the development of a circular bioeconomy and promoting the agroecological transition by its recycled nutrients. [7]

A central part of the EU 2040 target and the path to 2050 for neutrality is turning the Green Deal into an industrial de-carbonization deal that builds on existing industrial strengths where CCU/CCS, biogas and biomethane, and the circular economy is mentioned.[8] Hydrogen on the other hand is set out to play a key role in the decarbonization of industry and transport. Hereby comes the link to green CO_2 from biogas plants that can be combined with clean hydrogen for production of sustainable e-fuels. Biomethane will play an important role as transition fuel until hydrogen and electricity infrastructure is in place.

EU Emissions Trading System (ETS) is EU's main tool for reducing greenhouse gas emissions from industry and power generation, now also including the maritime sector. It doesn't directly regulate fuels for long-haul transport but can indirectly influence fuel prices by placing a price on carbon emissions, thus creating competitiveness of alternative fuels.

The system allows flexibility for companies to cut their emissions in the most cost-effective way or continue to pay for their emissions.[9]

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4 European Comissions (2022) Biomethane.
Source: https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/biomethane_en

5 European Comissions (2024) 2040 climate target.
Source: https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2040-climate-target_en

6 European Comissions (2024) 2040 climate target.
Source: https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2040-climate-target_en

7 EBA (2024) Biogas sector necessary to strengthen system resilience.
Source: https://www.europeanbiogas.eu/eba-welcomes-2040-climate-target/

8 European Commission (2024) Commission presents recommendation for 2040 emissions reduction target to set the path to climate neutrality in 2050. Source: https://ec.europa.eu/commission/presscorner/detail/en/ip_24_588

9 European Commission (2024) Maritime transport in EU Emissions Trading System (ETS).
Source: https://climate.ec.europa.eu/eu-action/transport/reducing-emissions-shipping-sector/faq-maritime-transport-eu-emissions-trading-system-ets_en

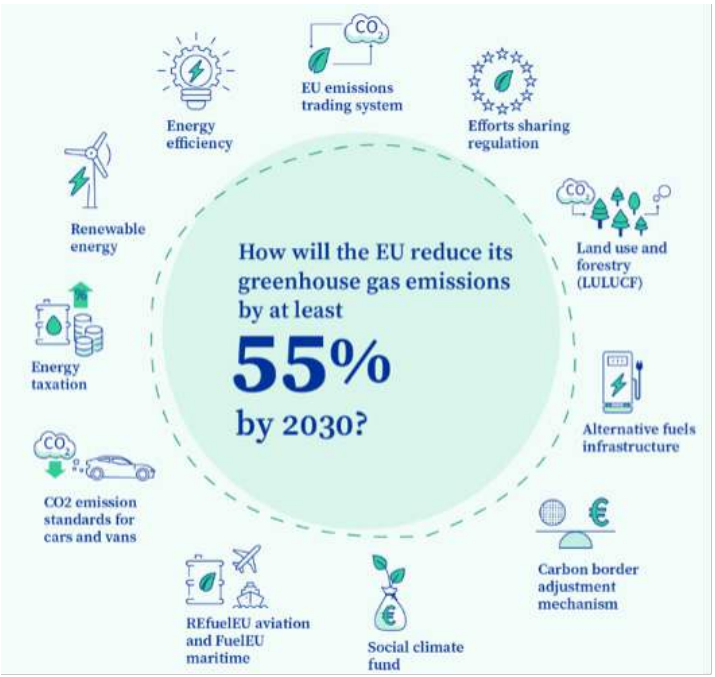

Figure 3. The Fit for 55 package is a set of proposals to update the European Union's climate legislation and is named after the climate target of reducing EU emissions by at least 55% by 2030.[11]

To show Europe's commitment to the net-zero technology transition and help to deliver on the Fit-for-55 illustrated in Figure 3 and REPowerEU objectives the commission has proposed The Net-Zero Industry Act for Accelerating the transition to climate neutrality. Sustainable biogas technology is one of the included technologies.[10]

The EU Energy Taxation Directive provides a framework for the taxation of energy products, including fuels used in road transport. National governments can apply different tax rates to different types of fuels, which might influence the competitiveness of various fuel options. Other regulations that differ between the countries are building permit processes, environmental and safety permits, but also subsidy mechanisms for biogas production and biomethane usage.

4.1 Gas grid

When it comes to putting biomethane in the natural gas grid there is no general EU-legislation or rules, it is pretty much nationally decided for the moment. The gas grid can be used for transferring green certificates, as the physical connection between production plant and user. For example, biomethane from Denmark can be put on the natural gas grid and then liquified in some other country and shipped over to Finland and withdrawn from the LNG-terminal with the green certificate. For industry, biomethane can be used to replace LPG with a green gas, which could enable national initiatives to have a certain % of biomethane in the gas grid system.

As a part of the Fit for 55 package the EU Council and Parliament has reached a political agreement on regulation to establish common internal market rules for renewable and natural gases and hydrogen. The purpose is to facilitate the penetration of hydrogen and biomethane gases into the energy system[12]. There is also the Directive 2009/73/EC on common rules for the internal market in natural gas, which aims for common rules for the transmission, distribution, supply and storage of natural gas. The objectives are to provide market access and to enable fair and non-discriminatory competition and covers natural gas, liquefied natural gas (LNG), biogas and gas from biomass.[13]

4.2 Long-haul transport

The EU has actively been working on initiatives to reduce greenhouse gas emissions from the transport sector, including long-haul transport. There are several directives, policies and initiatives influencing fuel requirements and usage in the transport sector.

The Clean Vehicles Directive promotes clean mobility solutions in public procurement to boost the demand and deployment of low- and zero-emission vehicles. As a clean heavy-duty vehicle counts, any truck or bus

10 European Commission (2023) The Net-Zero Industry Act: Accelerating the transition to climate neutrality. Source: https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act_en

11 European Commission (2023) Fit for 55. Source: https://build-up.ec.europa.eu/en/resources-and-tools/links/fit-55

12 European Council (2023) Gas package: Council and Parliament reach deal on future hydrogen and gas market. Source: https://www.consilium.europa.eu/en/press/press-releases/2023/12/08/gas-package-council-and-parliament-reach-deal-on-future-hydrogen-and-gas-market/

13 EUR-Lex (2009) Internal market in gas. Source: https://eur-lex.europa.eu/EN/legal-content/summary/internal-market-in-gas.html

using one of the following alternative fuels: hydrogen, battery electric (including plug-in hybrids), natural gas (both CNG and LNG, including biomethane), liquid biofuels, synthetic and paraffinic fuels, LPG. There are national targets defined for minimum percentage of clean vehicles per member state and the member states can choose how they distribute the effort across different contracting authorities. For buses half of the target has to be fulfilled by procuring zero-emission buses for urban usage in the second period 2026 to 2030.[14]

The Council and Parliament have however reached a deal to lower CO_2 emissions from trucks, buses and trailers even further. The proposed amendment introduces a 100% zero-emission target for urban buses by 2035, while setting an intermediate target of 90% for this category by 2030. At the same time the Commission will have to evaluate a methodology for full lifecycle CO_2 emissions of new HDVs and the role of a carbon correction factor (CCF) for HDVs. Also, the role of registering HDVs exclusively running on CO_2-neutral fuels will also be assessed in the review.[15]

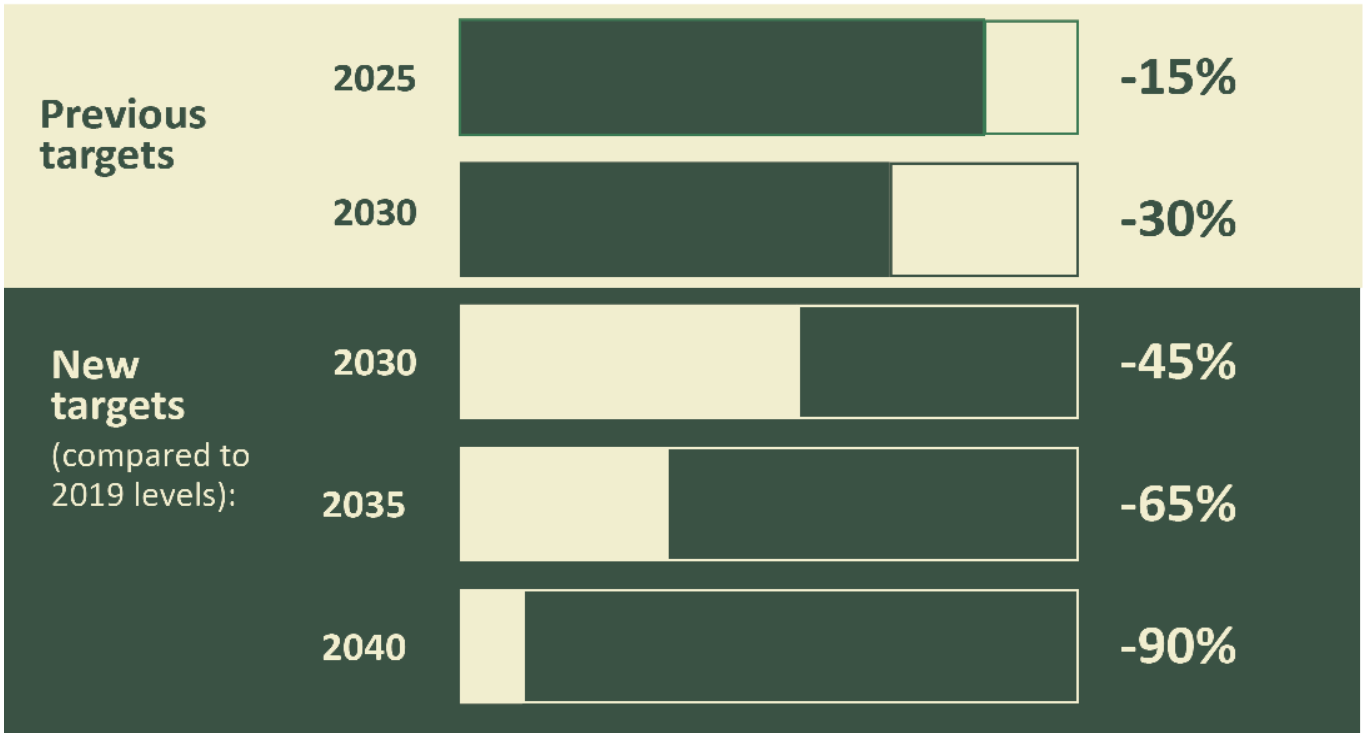

Figure 4. EU:s existing targets on CO_2 emissions from Heavy-duty-vehicles (HDV) and proposed targets for the revision of the regulation.[16]

The existing targets seen in Figure 4 are set in the EU regulation, CO_2 standards for heavy-duty vehicles demands manufacturers to reduce average fleet emissions of new heavy-duty vehicles (HDVs) within regulated vehicle groups by 15%, by 2025 and 30%, by 2030. The proposed revision of the Regulation on CO_2 emission standards for heavy-duty vehicles will set much higher targets 90%, by 2040.[17]

14 European Commission (2019) Clean Vehicles Directive.
Source: https://transport.ec.europa.eu/transport-themes/clean-transport/clean-and-energy-efficient-vehicles/clean-vehicles-directive_en

15 European Council (2024) Heavy-duty vehicles: Council and Parliament reach a deal to lower CO_2 emissions from trucks, buses and trailers.
Source: https://www.consilium.europa.eu/en/press/press-releases/2024/01/18/heavy-duty-vehicles-council-and-parliament-reach-a-deal-to-lower-co2-emissions-from-trucks-buses-and-trailers/

16 European Commission (2023) Reducing CO_2 emissions from heavy-duty vehicles.
Source: https://climate.ec.europa.eu/eu-action/transport/road-transport-reducing-co2-emissions-vehicles/reducing-co2-emissions-heavy-duty-vehicles_en

17 European Commission (2023) Reducing CO_2 emissions from heavy-duty vehicles.
Source: https://climate.ec.europa.eu/eu-action/transport/road-transport-reducing-co2-emissions-vehicles/reducing-co2-emissions-heavy-duty-vehicles_en

The Parliament and Council have also reached an agreement at the end of 2023 on the regulation for the type-approval and market surveillance of motor vehicles (Euro 7) which aims to support the transition towards clean mobility.

The new Euro 7 standards not only set limits on NOx and PM, but also for example on emission limits from brakes and rules about microplastic pollution from tires. The new EURO 7 rules will apply to both cars, vans and heavier vehicles.[18]

There is also the EU directive on Alternative Fuels Infrastructure, which aims to ensure the development of alternative fuels infrastructure, including charging points and refueling stations for hydrogen and methane gas. The new regulation adopted for the directive in 2023 puts the focus on charging points and hydrogen fueling. Liquefied methane fueling stations are set to be at least along main roads, in this case core TEN-T network, to allow vehicles to circulate through Europe.[19]

The TEN-T policy is an instrument for development of the transport infrastructure across the EU including railways, inland waterways, short sea shipping routes and roads linking urban nodes, maritime and inland ports, airports, and terminals, see Figure 5. The core network consists of the most important connection links and the comprehensive network connects all regions of the EU to the core network. The core network is to be completed by 2030 and the comprehensive by 2050. A revision of the TEN-T Regulation is ongoing, where a third layer, the extended core network will be added as an intermediate milestone, to be completed by 2040.[20]

Figure 5. Comprehensive & Core Network: Roads, ports, rail-road terminals and airports.[21]

18 News European Parliament (2023) Euro 7: Deal on new EU rules to reduce road transport emissions.
Source: https://www.europarl.europa.eu/news/en/press-room/20231207IPR15740/euro-7-deal-on-new-eu-rules-to-reduce-road-transport-emissions

19 European Council (2023) Fit for 55: towards more sustainable transport.
Source: https://www.consilium.europa.eu/en/infographics/fit-for-55-afir-alternative-fuels-infrastructure-regulation/

20 European Commission (2024) Trans-European Transport Network (TEN-T)
https://transport.ec.europa.eu/transport-themes/infrastructure-and-investment/trans-european-transport-network-ten-t_en

21 European Commission (2021) Proposal for a regulation of the European Parliament and of the Council on Union guidelines for the development of the trans-European transport network.
Source: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021PC0812

4.3 Maritime

The FuelEU Maritime regulation aims for decarbonization of the shipping industry and will enter into force January 1, 2025. This will increase the use of renewable and low-carbon fuels for international maritime transport in the EU. It will set well-to-wake greenhouse gas (GHG) emission intensity for energy used on ships. "Well-to-wake" refers to the entire process of fuel production, delivery, use onboard ships, and all emissions produced therein.[22] The EU regulation for EU Emissions Trading System (EU ETS) has adopted a revision which will include shipping from 2024. There is a three-year phase in period, going from 40% to 100% of the emissions as seen in Figure 6.[23]

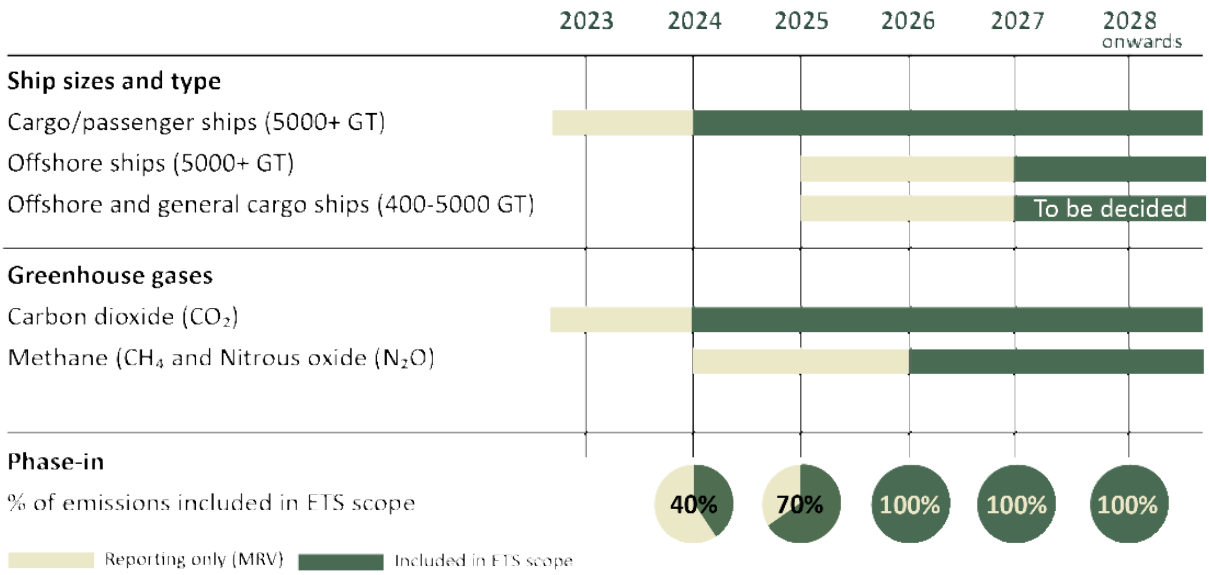

Figure 6. EU ETS introduction timeline for marine sector.[24]

Other measures taken for delivering the European Green Deal and it's Fit for 55' package on Maritime transport is:

- The revised Alternative Fuels Infrastructure (AFIR) with targets for shore-side electricity supply in ports.
- Revising the Energy Taxation Directive (ETD) to align taxation for energy products and remove exemptions, such as those for the intra-EU maritime transport sector.
- Revised Renewable Energy Directive (RED) for accelerating the supply of renewables in the EU to at least 40% by 2030 with a focus on sectors where progress has been slower such as transport. [25]

The International Maritime Organization (IMO) has set a target for reaching net-zero GHG emissions around 2050. To fast track the transition green shipping corridors can help these corridors can help resolve barriers to the uptake of carbon-neutral fuels and technologies.[26]

22 DNV (2024) FuelEU Maritime. Source: https://www.dnv.com/maritime/insights/topics/fuel-eu-maritime/
23 DNV (2024) EU ETS – Emissions Trading System.
Source: https://www.dnv.com/maritime/insights/topics/eu-emissions-trading-system/
24 DNV (2024) EU ETS – Emissions Trading System.
Source: https://www.dnv.com/maritime/insights/topics/eu-emissions-trading-system/
25 European Commission (2024) Reducing emissions from the shipping sector.
Source: https://climate.ec.europa.eu/eu-action/transport/reducing-emissions-shipping-sector_en
26 IMO (2024) IMO's work to cut GHG emissions from ships.
Source: https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx

4.4 Reforming and e-fuels

Biohydrogen or reforming of biogas to obtain green hydrogen is a possibility for biogas producers to diversify the outputs and further increase the flexibility of biogas plants. This is referred to as renewable hydrogen in A hydrogen strategy for a climate-neutral Europe by EU.

In the strategy's third phase, from 2030 onwards and towards 2050, renewable hydrogen technologies should reach maturity and be deployed at large scale to reach hard to decarbonize sectors. It is also recognized that sustainable biogas may have a role in replacing natural gas in hydrogen production facilities with carbon capture and storage to create negative emission.[27] The REDIII however does not recognize a broad definition of possible production pathways for renewable hydrogen, such as steam reforming of biomethane, in favor of green hydrogen produced by electrolysis process using renewable electricity to split water into hydrogen and oxygen.

Green hydrogen produced by electrolysis can be used to produce transport fuels and is covered under the transport targets for renewable fuels of non-biological origin (RFNBO).[28] The rules for production of renewable liquid and gaseous transport fuels of non-biological origin are set out in the first delegated act to the Renewable Energy Directive (RED). It is also stated that these fuels will be important for increasing the share of renewable energy in sectors that are expected to rely on gaseous and liquid fuels in the long term, such as maritime and aviation.[29] A summary of the rules has been compiled by the Hydrogen Cluster Finland.[30]

The FuelEU Maritime regulation does not initially set requirements on the use of renewable fuels of non-biological origin (RFNBOs) but sets their use as an additional incentive: use of such fuels counts as double the energy used. If the total share of RFNBOs in shipping in EU is below 1% in 2031, a separate use requirement will be added from 2034.[31]

The Industrial Carbon Management strategy published in 2024 identifies a set of actions to boost industrial carbon management for all parts of the CO_2 value chain. The strategy aims to establish an EU-wide framework and approach to industrial carbon management. The strategy covers CO_2 from fossil fuel, industrial processes, biogenic emissions and capture directly from the air.[32] Carbon capture and utilization technology (CCU) is regulated in the RED, which also promotes fuels produced from captured CO_2 (RFNBO). [33]

5. MARKET CONDITIONS

5.1 Gas Grid

The gas grid infrastructure has mainly been built for transporting large quantities of cheap natural gas. In Finland, Estonia and Latvia the origin has been Russian, which is now being phased out. In Sweden the origin of the natural gas is from Denmark, however Sweden also imports about 2 TWh of biomethane from Denmark, which is equal to national production in Sweden.[34]

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27 European Commission (2020) A hydrogen strategy for a climate-neutral Europe.
Source: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0301

28 EUR-Lex (2023) Directive, the promotion of energy from renewable sources.
Source: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413

29 EUR-Lex (2023) Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin. Source: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1184

30 H2 Cluster (2023) Rules for producing renewable fuels of non-biological origin – RFNBO.
https://h2cluster.fi/wp-content/uploads/2023/04/Fact-sheet-on-Rules-for-Producing-RFNBOs.pdf

31 DNV (2023) The EU agrees on well-to-wake GHG limits to energy used on board ships from 2025.
Source: https://www.dnv.com/news/the-eu-agrees-on-well-to-wake-ghg-limits-to-energy-used-on-board-ships-from-2025-243501/

32 European Union (2024) Industrial carbon management, Capturing, storing and using CO_2 to reach our climate goals.
Source: https://op.europa.eu/en/publication-detail/-/publication/ae697359-d210-11ee-b9d9-01aa75ed71a1/language-en?WT.mc_id=Searchresult&WT.ria_c=37085&WT.ria_f=3608&WT.ria_ev=search&WT.URL=https%3A%2F%2Fenergy.ec.europa.eu%2F

33 European Commission (2024) Industrial carbon management.
Source: https://energy.ec.europa.eu/topics/oil-gas-and-coal/carbon-capture-storage-and-utilisation_en

34 Energigas Sverige (2023) Statistik om biogas.
Source: https://www.energigas.se/fakta-om-gas/biogas/statistik-om-biogas/

This can be seen as a good example of how a gas grid benefits the biomethane market. Just the amounts of biomethane imported from Denmark are several times higher than the production volumes in all the other three countries. On the contrary Sweden and Finland are the countries with the smallest gas grids, neither of the countries plan to extend them. In Sweden it only covers the western coastal parts and in Finland only the southern part as seen in Figure 7.

Estonia and Latvia have extensive natural gas grids, which could be used for biomethane. The main issues are related to political will and long-term support schemes. In Estonia there is a feed-in tariff but no general political agreement as foundation for creating stability on the biomethane market. In Latvia there is a lack of supporting scheme but also legislative issues for example demands on feed in of biomethane to existing gas grid. The Estonian gas grid is in extension by the Baltic Connector connected to Finland and towards the south through Latvia and Lithuania by the Gas Interconnection Poland–Lithuania (GIPL) to the Polish gas grid as seen in Figure 7.

In all the countries LBG-production is seen as an option to increase production due to several reasons. Feedstock is not always located close to existing gas grid infrastructure, thus LBG provides longer transport distances to customers. Depending on production volumes considered the ownership could either be national or international for large quantities aimed for export market to, for example, central Europe. The need for creating new business models and platforms for developing the biogas market is seen as a vital action in all countries.

Figure 7. Gas grid in the Baltic Sea area integrated by the Baltic connector and the GIPL.[35]

35 Gasgrid (2024) Gas marketintegration. Source: https://gasgrid.fi/en/gas-market/gas-market-integration/

GAS GRID SECTOR

INTERNAL FACTORS – BIOGAS PRODUCERS

STRENGTHS

- All biomethane can be put to use into existing gas grid.
- Low cost of distribution compared to LBG and CBG.
- Origin and Sustainability certificate system could provide and facilitate the uptake of biomethane.

WEAKNESSES

- Expensive to expand the gas grid and to renovate old city systems.
- Few injection points for biomethane.
- Unclear biomethane quality requirements for injection and to be granted permit.
- Hydrogen has technical barriers for mixing into gas grid.

EXTERNAL FACTORS - MARKET RELATED

OPPORTUNITIES

- EU is unifying the usage of gas grid.
- The market is wide and final usage is up to consumers. LBG can be produced close to usage point to a lower cost.
- Facing out natural gas and lowering GHG-impact of gas grid.

THREATS

- The price is bound to natural gas market.
- Different regulations in EU-countries and lack of regulation for mass balancing of biomethane put into gas grid.
- Not an equal market between industry and transport sector due to premiums.
- Risk for terrorism and gas pipes have no redundance.

5.2 Long-Haul Transport

Since passenger cars are not a future market for biomethane market and the clean vehicle directive is pushing for an electrification of city buses there are two categories of heavy-duty vehicles left. The long-haul trucks running on LBG and the CBG-trucks circling on shorter distance like 400 km, for example waste trucks. Here is a market segment that CBG could fill until there is good enough developed electrical trucks running shorter distances. Looking at the EU-level about 90 percent of the buses are diesel and biodiesel driven, meaning there is still a big market segment running on conventional fuels.[36]

In both Finland and Sweden there is a great interest among transport companies to start using LBG, but the change is held back by the lack of infrastructure, basically filling stations. There are more than 1000 trucks running on LBG in Sweden today and the aim for 2030 is 10% of the market equal to 8500 trucks. The share of LBG was 98 %, equal to 226 GWh year 2022. Compared to all other three countries Sweden is way ahead, in Finland there are less than 100 LBG-fueled trucks, a few in Estonia and none in Latvia. To make LBG-trucks an attractive option there must be more filling stations the whole way down to central Europe through Estonia and Latvia along the TEN-T core corridor.

36 Bussamagasinet (2024) Sverige i europeisk gasbusstopp.
Source: https://www.bussmagasinet.se/2024/02/sverige-i-europeisk-gasbusstopp/?utm_campaign=NyhetsbrevNr72023&utm_medium=Email&utm_source=Newsletter&link_id=67daf77f-3ec1-4aaa-a7df-9839757a7e81

A problem with LBG trucks is that they need to be in use more compared to diesel trucks due to the boil off gas, this shouldn't however be a big issue since most transport companies try to keep their vehicles rolling as much as possible. In Sweden and Finland there is a concern about the engines' horsepower since larger cargo tons are allowed and since the market in these two countries is rather small, there might be no bigger interest in developing engines with more than 500 HP.

According to the national reference groups in Sweden and Finland, the main use of biomethane in a longer perspective is as LBG for heavy-duty vehicles and for the maritime sector, which follows the aims of EU. In Estonia the long-term perspective for biomethane is still unclear. Government of Estonia has ordered a study about biomethane potential and possible future markets and outcome will be presented in climate law which will be ready by the end of 2024. In Latvia LBG is questioned as transport fuel and its possibility to compete with electrification and hydrogen or if it already now should be investigated to the possibilities for electricity and hydrogen production with biogas. Due to the limited production volumes in Latvia, there is a thought that biomethane is perhaps best suited for gas grid injection.

Looking on EU-level and the AFIR-directive there is no stated amount of distance between LBG-fueling stations, just that there should be "liquified methane refueling stations at least along main roads to allow vehicles using methane to circulate throughout the EU", by main road it is meant the core TEN-T network. Figure 8 shows the existing LNG/LBG-filling stations.[37]

Figure 8. LNG/LBG-filling stations.

Looking on the map of TEN-T core network leaves large areas in Finland and Sweden with long distances to the Core Network, while two LBG-fueling stations in Latvia would cover its part of the network. There should be at least two LBG-fueling stations in each transport hub to give redundancy and trust for the transport companies. In the hubs, the load can then be changed to regional logistics running on CBG, hydrogen and electricity depending on the most suitable and convenient option. All available renewable fuels will be needed to reach the fit-for-55 targets, and this is not properly defined in a short- and long-term perspective. Additionally, there are new CO_2-regulations to be implemented which will have an impact on the transport market.

In all four countries subsidy schemes are requested to be able to create a market and solve the chicken-egg dilemma between producer and consumer, as well as vehicle purchaser. Sweden has exempted biome-

37 http://www.ngvaeurope.org/stations-map/ Visited 2024-04-18.

thane from carbon tax and excise duty between 2011 and 2023, this measure is discontinued for the time being. Therefore, working subsidy schemes need to be identified and implemented in the long term to be competitive with fossil fuels. The Biomethane Industrial Partnership (BIP) has gathered and analyzed the effectiveness of different biomethane incentives in EU.[38] According to the international reference group of the Best ACE project new business models are needed and that procurement must actively demand biogas and renewable fuels.

An aspect to consider when procuring fuel is that biogas has a certain degree of supply security since it can be produced locally/regionally or nationally. The challenge in these times of uncertainty when the EU needs all kinds of renewable fuels, is to set long-term goals to make long-term business feasible. To create a common understanding, hearings can be held with stakeholders to find out their thoughts for the future. To speed up the implementation of biomethane production and infrastructure the permit processes must speed up.

LONG-HAUL TRANSPORT SECTOR

INTERNAL FACTORS – BIOGAS PRODUCERS

STRENGTHS

- Established technology for infrastructure and vehicles.
- Possible to store larger amounts and transport longer distances compared to CBG.
- The range for LBG-vehicles is comparable to conventional diesel vehicles.
- Possibility to predict market volumes for at least 6-7 years ahead that trucks are used.

WEAKNESSES

- LBG is more expensive to produce and requires larger gas amounts compared to CBG or input to gas grid.
- Lack of filling stations along main routes and as redundancy in regions.
- Filling system needs to be built for two different types and nozzles.
- Lack of national guidance regarding permits for building LBG-filling stations. Evaluation varies between municipalities.

EXTERNAL FACTORS - MARKET RELATED

OPPORTUNITIES

- LBG is a price competitive and reliable green fuel for HDV and is not competing with other renewable fuels for greening transport sector.
- Increases the national resilience for transport system in crisis situations.
- A possibility to disconnect from LNG market prices.

THREATS

- LBG-vehicles are more expensive, compared to conventional vehicles and support for LBG-vehicles is restricted by member states.
- The timeframe of EU-directives is too tight for infrastructure and vehicle fleet investments.
- Access and permits for available sites can be restricted.
- Future access to LBG-vehicles after 2035 is uncertain due to regulatory framework for CO2-emissions.

According to EBA there will be 109 more LBG production plants by 2025 producing a total of about 15 TWh.[39]

38 Biomethane Industrial Partnership (2024) Biomethane Incentives and their effectiveness.
Source: https://bip-europe.eu/wp-content/uploads/2024/04/BIP-TF1_Biomethane-incentives-and-their-effectiveness-Final.pdf

39 EBA (2023) Statistical Report 2023.
Source: https://www.europeanbiogas.eu/wp-content/uploads/2023/12/EBA-Statistical-Report-2023-Launch-webinar.pdf

5.3 Maritime sector

According to the reference groups the EU ETS and EU Fuel Maritime (EUFM) will affect the demand for green fuels, initially little demand but grow over the years. The inclusion of ETS in maritime sector will lead to the need of buying CO_2-credits for about 90 €/ton today. The ETS will increase its demand year by year, meaning that by year 2050 LBG will be very valuable. LBG can on well to tank even give a minus emission depending on substrate used for the biogas production.

Industry will increase the demands for sustainable transport including shipping both passenger and cargo. Bunkering of LBG or LNG is today mostly done from trucks in a few ports. Ports are not part of the AFIR, but they are part of the TEN-T network. The green shipping corridors in Figure 9 are aimed for improved use of alternative fuels in shipping by e.g. speeding up on permission and bunkering of ships.[40]

Figure 9. Green shipping corridors can fast-track the adoption of carbon-neutral fuels.

Despite LNG driven ships being the clear dominant choice of fuel for new orders today, few seem to see the link of using LBG to achieve ETS and EUFM requirements. A reason for the big interest in LNG-driven ships is due to the affordable LNG-price in comparison with low sulfur maritime fuel. The reason for not recognizing the potential with LBG might have to do with that the production volumes are rather small. Therefor it is important to show shipping companies how LBG as a drop-in fuel to LNG drive ships will gradually contribute to lowering CO_2-emissions. Therefor it would be important that biogas producers, LBG-suppliers and the maritime sector better understand each other's operations and needs. Another important aspect of using LBG, but also LNG for ships is the reduction of SOx, PM and NOx.

Regional biogas actors might be too small to create the entire value chain from substrate to filling ships with LBG. Also, the production volumes are too small for taking the step of fulfilling the CBG-market to also start producing LBG. Regional or national biogas networks can e.g. stress the importance of liquefaction to enable producers to participate in an upcoming market for biogas.

40 DNV (2024) Key considerations for establishing a green shipping corridor.
Source: https://www.dnv.com/expert-story/maritime-impact/key-considerations-for-establishing-a-green-shipping-corridor/

The lack of a gas grid in most of Finland and Sweden means that new business models have to be developed, which is not always understood within EU and when stipulating new legislation. A new plant would demand an agreement with a ship to secure the investment. There is a huge interest in LNG-ships but the search for LBG-fuel is mostly local, not on a global scale.

Technological development is progressing rapidly, and the possibility of more small-scale liquefaction is a key factor for many biogas plants to reach the LBG-market. The willingness to pay for LBG is at the moment greatest among long haul transport companies. The maritime sector is seen more as a risk mitigating possibility. A great possibility for both ships and LBG producers is the benefits of the drop-in effect. Production of e-methane on the other hand could increase the amounts rapidly.

There needs to be long-term forecasts and market conditions promoting biogas actors to increase biogas production for enabling LBG-production to an economically reasonable price. LBG is already today a very price-competitive fuel in terms of price compared to other green fuels, indicating that demand will only increase in the coming years.

MARITIME SECTOR

INTERNAL FACTORS – BIOGAS PRODUCERS

STRENGTHS

- Established technology for infrastructure and engines.
- Can be used as a blend in fuel for LNG-ships.
- Possibility to predict market volumes for decades ahead and make long-term agreements between producers, distributors, and users on regional, national or international level.

WEAKNESSES

- LBG is more expensive to produce compared to CBG or input to gas grid.
- Bunkering possibilities for LBG are limited.
- Low production volumes of LBG and thus not interesting for shipping companies.
- The use of LBG in the Baltic market is heavily dependent on passenger cruise ships, which limits the market.

EXTERNAL FACTORS - MARKET RELATED

OPPORTUNITIES

- LBG is a price competitive and reliable green fuel for ships and is not competing with other renewable fuels for greening maritime sector.
- Increases the national resilience for maritime transports in crisis situations.
- A possibility to disconnect from LNG market prices.
- Maritime sector is part of ETS and the fuel maritime regulation. Emissions demands due to ETS will increase market value for LBG.

THREATS

- The timeframe of EU-directives is too tight for infrastructure and shipping fleet investments due to long lifetime.
- Non-functioning market due to volumes are sold to other markets with long-term agreements.
- The best priced market option could lead to a singularity that excludes LBG as shipping fuel.
- End users are not prepared to pay extra cost for LBG.

A marketplace for biomethane and LBG is missing, and the conditions are set by natural gas trading companies. There is also a need for shipping companies to become more concrete in their actions for demanding LBG.

According to a study initiated by the SEA-LNG about alternative marine fuels the analysis reveals:

- A multi-fuel future is inevitable and transition fuels like LNG and methanol will be needed.
- Most methanol today is fossil-fuel-derived with high emissions, therefore the scalability of green methanol is a key challenge.
- Batteries and shore power can support decarbonization, but deep-sea shipping electrification remains unrealistic.
- Future fuels like hydrogen and ammonia hold promise but face hurdles around infrastructure, storage, bunkering and skills.
- Operational and technical optimizations will be crucial alongside alternative fuels.
- The transition will only happen once infrastructure is built, safety issues resolved, regulatory uncertainty reduced, and fuel availability worries lessened.[41]

A study made by the Swedish Maritime Competence Center reveals that the major obstacle today for use of LBG is that the price is affected by price international market prices, lack of suitable logistical solutions. The conclusion is that potential for biogas is large and untapped, but that new solutions for distribution and logistics are needed. There is an interest from maritime actors in Sweden as they see biogas as a strategic solution. It is also highlighted that there is a need for a marketplace to simplify for sellers and buyers of LBG.

5.4 Reforming and E-fuels

In the upgrading process to CBG, the CO_2 is already captured and released, so it's a fairly simple process to instead cool it down to liquified form or to combine the CO_2-gas with hydrogen from renewable electricity to produce e-methane. When the methanation (combining CO_2 and hydrogen) is done in a separate reactor it is called ex-situ, which is done outside of Sonderborg in Denmark. There is also a Danish case in Hjorring where they will do it in situ. This means the hydrogen will be mixed in to the biogas reactor to raise the methane content of the raw biogas thus lowering the investment costs and the upgrading costs for producing CBG, plus then of course increasing the methane output. Making use of the CO_2 in the raw biogas by adding either in-situ or external methanization unit could reduce the upgrading cost at the same time as increasing the production and creating a carbon sink from the green CO_2.

The production of e-methane or other e-fuels requires that the biogas plants must have larger facilities to handle hydrogen production and be located where there is available infrastructure (green electricity) for the electrolyze. The difficult part is not getting the green CO_2 to the e-fuel market, the main challenge is the need of cheap electricity for production of hydrogen.

There is a lack of CO_2 infrastructure, and it becomes easily expensive if needed to transport especially for bigger plants. There might be some competition between different e-fuels, but it has more to do with what is suitable where, e.g. e-methane suits very well for biogas plants with existing infrastructure and market channels. The producer directs production to whoever pays the best. In the Danish case (Hjørring), the gas is exported to Germany due to the quota system. Methanol on the other hand might suit better for new and big plants that aim for more international markets since methanol is easier to store and transport. Both production and market price for e-methane and e-methanol are comparable. Other products that could be of interest is for example formic acid since it demands less hydrogen to make use of the available CO_2 and still get a sellable product.

The ETS will for sure affect but at what time frame is unclear. Other incentives are the carbon intensive score (CIS) that is used in Germany. The CIS promotes carbon capture from the biogas plants which then leads to an increased market price for biomethane. The definition is unclear for the difference between what is bio-electrofuel and electrofuel, respectively.

41 GNV Magazine (2024) Study uncovers complexity of maritime path to net-zero emissions.
Source: https://www.gnvmagazine.com/en/study-uncovers-complexity-of-maritime-path-to-net-zero-emissions/

Possible markets are the transport sector in Germany and marine solutions or regionally through existing market channels.

It is difficult to say what the future market will look like because the industry is changing so quickly with technological development and EU directives. The SWOT-analysis is based on using biogas for reformation and e-fuels production.

REFORMING AND E-FUELS

INTERNAL FACTORS – BIOGAS PRODUCERS

STRENGTHS

- Green CO2-available for methanation to increase methane output from existing biogas plants.
- High-value e-fuel with existing infrastructure and users such as long-haul or maritime sector.
- The green CO2 can be used for diversifying product output e.g. liquefied green CO2, methanol or formic acid.

WEAKNESSES

- High investment and high operational cost compared to traditional biomethane production.
- Requires green hydrogen which requires large amounts of electricity (RFNBO accepted).
- Complex system integration to both electricity market for green hydrogen production and to offset of methane for selling.

EXTERNAL FACTORS - MARKET RELATED

OPPORTUNITIES

- Existing infrastructure for methane can be used to reach market.
- Market ready technology with plants in operation.
- Circular green CO2-atoms with low carbon footprint.

THREATS

- Limited quantities make it a smaller player on the market.
- High demand for green electricity or green hydrogen increases prices.
- Unclear regulatory framework and green certificate trading system is hard to predict.

Synergies between biogas and electricity production are anticipated as more renewable energy sources, such as wind farms are being built. E-fuel production faces significant challenges due to complex processes, substantial investment requirements, and high operational costs. Experts also highlight the need for increased government support, infrastructure development, and industry knowledge to promote e-fuel production. Methanation of CO_2 with hydrogen increases methane production and prevents CO_2 emissions from already existing biogas plants with infrastructure for handling methane. In long-term e-fuel production is determined by the costs of obtaining hydrogen, which is expected to decrease and thus increase the attractiveness. There is a big potential in the pulp and paper industry for green CO_2 source. This could be a possibility for large scale e-fuel projects. Developing a system of incentives for this complex environment requires much effort and perceptiveness by policymakers.

6. BUSINESS OPPORTUNITIES

6.1 Estonia

Gas grid

During the gas grid meeting the main topics of discussion were injection points for biomethane and hydrogen injection possibilities into the gas grid. Main setbacks for biomethane grid injection were legislation about oxygen level at the injection point, which in May 2023 was 0,02mol% and lack of international certificate system that would bring more players into Estonian market. In August 2023 oxygen level was raised to 0,5mol% which would allow biomethane injection into transmission grid, but so far there are still no injection points. Once TSO operated points are set on the grid, local producers will have more possibilities to trade with Central European or Scandinavian off-takers. Hydrogen injection into the grid was considered unlikely both from TSO and University side experts since the grid will not be able to handle hydrogen characteristics and it would need a large-scale renewing of existing pipeline.

Long-haul transport

During the long-haul meeting biomethane possible uptake in the market was compared to hydrogen and electric solutions. Another topic was CNG truck comparison to LNG truck. As a conclusion LNG use was most preferred for long haul and CNG was expected to be best possible option for regional transport. Disadvantages of hydrogen and electric trucks are higher price and shorter mileage per tank/recharge. Main bottleneck for LNG implementation in long-haul is lack of filling stations towards Central Europe. For CNG there is 27 public filling stations in Estonia, but market prefers to use diesel/HVO trucks because of cheaper price, longer mileage per tank and more proven technology. What also caused setbacks in the gas-powered truck market was high price of CNG during 2022 market crisis. Solutions for higher market implementation would be subsidies for purchase, preference for LNG/CNG vehicles compared to HVO, tax exemptions and more developed infrastructure.

Maritime

Estonia has a long shoreline and plenty of islands which means high fuel demand in maritime transportation, fishing, and other applications. Currently National fleet of Estonia has ordered 1 biomethane powered survey vessel and public procurement for hydrogen/electric ferry is ongoing. Tallink, who is one of the main operators between Tallinn-Helsinki passenger shipping, has 1 LNG ship in their fleet. As a conclusion, most preferred user for potential local biomethane would be ferry lines between islands and between island and mainland. There is no LBG production in Estonia yet and no concrete framework for maritime traffic green transition.

Reforming and e-fuels

At the moment there is no e-fuel production in Estonia, yet interest toward the topic is presented by various gas companies. Main problems, which were pointed out during our e-fuel meeting were high production cost, high energy need and lack of legislation that would make this kind of project feasible. On the positive note, it was pointed out that e-fuels can create a pathway to hydrogen production as there is no demand now for hydrogen, but without production there is hard to implement hydrogen powered transportation. Therefore, adaption of e-methane production for example in Estonia can occur in the next few years.

6.2 Finland

Gas grid

- A gas grid from Finland to central Europe, would open an attractive market. Alternatively, some kind of certificate system for transferring the gas to central Europe.
- Local biogas grid with centralized LBG-production and other usage
- LBG-production at plants of bigger size with some kind of LBG-marketing system

Long-haul transport

- Co-operation with transport companies to create new business models.
- Co-operation between plants and substrate producers to increase production volumes and produce LBG. For example, biowaste could be mixed with manure and still be a good fertilizer but sludge will have to be treated separately. Biowaste based production is predicted to increase by 200 GWh due to demand for separate source sorting.
- Permit processes have to speed up. There are several permits from different authorities needed and when for example making use of manure to LBG it means there is an industry going to be located next to the farming.
- The used manure after biogas production has to be put back to the fields in an efficient way.
- Make use of public tendering for cooperation between public and private companies. It is not the same case as when city buses and CBG market was established for solving the chicken-egg dilemma.

Maritime

- Make use of EU-mechanisms to reach environmental targets, LBG is a technically available option both from consumer and producer point of view.
- Create local/regional agreements for drop-in of LBG to fuel ships.
- Co-operation between plants and substrate producers to increase production volumes and LBG.

Reforming and e-fuels

- Turn ETS or the carbon intensive score to a mechanism that increases the biomethane price.
- Make use of large green CO_2 sources like from paper and pulp industry.
- Turn biogas plants into biorefineries to turn side streams into valuable products.

6.3 Latvia

Gas Grid

- The most eligible option is to inject the biomethane in gas grid and to use in long-haul transport, or to use it for heating, and in industry where it is technically complicated to use other energy sources.
- The Latvian Parliament is in the process of amending the Energy Law to incorporate provisions regarding the use of green components in fuels, such as biodiesel, and the development of gas infrastructure. These amendments aim to address the interconnection between the grid and suppliers, ensuring that suppliers are responsible for pipeline construction and grid connection expenses while retaining ownership rights over the infrastructure they build.
- Producers are increasingly utilizing compressed natural gas (CNG) for their own needs, such as supplying workers' vehicles and transportation trucks. CBG could be used for this market instead of natural gas.
- The expansion of biogas production in Latvia aligns with regulatory developments, resulting in an increase in production over the past year. This includes the initiation of biomethane exports to Estonia and liquefied natural gas (LNG) exports to Germany. Plans are underway to install three additional biogas plants in Latvia in 2024.

Long-haul transport

- Support for purchasing a long-haul transport would be the most important, as well as infrastructure projects.
- The Latvian government has taken proactive steps to promote biogas and biomethane within the country. This proposed program includes financial assistance for equipment purchases and infrastructure construction, with an estimated funding of approximately 21 million Euros, slated for delivery in Autumn 2024.

Maritime

- Latvia is a maritime country with approximately 500 km of coastline, ten ports, and intensive ship traffic along its coast. To ensure safe navigation and the protection of the marine environment and coastline, it is essential to effectively implement and apply the conventions adopted within the framework of the International Maritime Organization (IMO). One of Latvia's responsibilities as an IMO member state is to participate in the work of the IMO Assembly, committees, and subcommittees.

Reforming and e-fuels

- At the moment there is no e-fuel production in Latvia, nevertheless national and regional planning documents as well as "Strategy of Latvia for the Achievement of Climate Neutrality by 2050" describes possible solutions which might be applied to ensure low carbon development and these solutions also refers to use of a such tools as the hull design (which improves energy efficiency), different economies of scale resulting from capacity and drive solutions, optimum speed, determination of weather conditions and planning, alternative energy sources, and RES. E-fuel, hydrogen, biofuel in pure form or mixed with fossil fuel are used from RES, thus reducing both GHG emissions and environmental load.

6.4 Sweden

Gas grid

- As only a small part of the country has access to the gas grid it is vital that more industries connect. Here, a realization of the huge biogas potential in south of Sweden would be possible.
- Local biogas production could be a resilient back-up to local district heating.
- Liquefied products have the potential to transport gas to operations outside the gas networks.
- Threshold effects of connecting into the gas network.
- If there is industry within reach of existing infrastructure, it is reasonable to use the gas network, otherwise liquid is more cost-effective to transport.

Conclusions: Existing subsidies and funds for biogas production are sufficient. There is no need to develop any grid access support schemes.

Long-haul transport

- It is important that biogas takes place in the debate for heavy vehicles, for politicians regionally and nationally the focus is on electric vehicles and hydrogen which are of a more future nature.
- The tax exemption is absolutely crucial for increasing the share of biogas for the riders. Even the vehicle manufacturers need to get out and talk about the LBG trucks for the decision makers to understand the market and its needs. For instance, HVO has tax exemption in Sweden, but not biogas, leading up to unjust market conditions for renewable fuels.
- There are not as many filling stations needed for heavy transport as for the passenger car market.
- A challenge with biogas filling stations, especially in northern Sweden inland, where the forest industry is active is an example.

Conclusions: LBG could be a very competitive fuel for long-haul transport if there is a subsidy for transport companies upon purchase, as they are 10-15% more expensive than regular diesel versions. They should have the same support scheme as electric trucks. To maximize the long-distance market, where LBG is the best option, it aims for 8.000 heavy trucks out of the 80.000 trucks that drives in Sweden on daily bases. In average each heavy truck uses approximately 610MWh of LBG per year. Recommissioning of the tax exemption as soon as possible is an absolute must for LBG.

Maritime

- In northern Sweden, it is often felt that regional actors are too small to be able to create the entire chain, more coordination and support from national and international actors is required. This is required to be able to expand biogas production to the potential that has been identified (30 TWh).
- Turnkey facilities and business models need to be developed. A marketplace is missing where buyers and suppliers can meet. The result should be a better long-term forecast and provide conditions for increased production.
- Our geographical situation without a gas network for almost the entire part of the country means that we must develop alternative solutions, something that is not always understood within the EU and legislative politicians.
- Technology development is progressing rapidly, and the possibility of more small-scale liquefaction is the key to exploiting the country's potential.
- Important to show shipping companies how LBG involvement in LNG ships will gradually contribute to sustainable solutions to the EU-ETS and EUFM.

- LBG is still very competitive in terms of price compared to other green fuels, indicating that demand will only increase in the coming years. A normal LNG cargo ship operating in the Baltic and North seas uses 500GWh of LNG per year.

Conclusion: It is important that the national shipping industry becomes more concrete in its needs for LBG. Regional biogas networks can stress the importance of liquefaction to enable producers to participate in the international biogas market.

Reformation and e-fuels

- Fuelcells is an option to balance the grid and to improve the return on investment (RoI) for electricity producers. Giving them the possibility to store at low prices and sell at high prices.
- The heavy transport sector will use the methane fuels mainly including industry. The ETS system will contribute to this.
- Sweden is expected to double its electricity use in the future, while Denmark is expected to fivefold its electricity use, which is a consequence of, among other things, hydrogen production.
- Business developers within ETS2 are business operators who make fuel available for consumption for combustion within selected sectors according to ETS2. It remains to be seen who buys these emissions rights.
- Import of e-fuels to Europe: there should be potential in the Middle East. The EU is expected to put a lot of focus on the hydrogen being produced via renewable electricity. The question is how to ensure it.

Conclusions: The rules of the game in the EU are the basis for how the market can develop, like ETS and ETS2. Technically, there are good opportunities for development if funds are available for development. Although the market conditions change all the time, it is therefore difficult to know which horse to bet on. When developing biogas plants- keep in mind that space is needed around the plants to be able to develop other products (eg. wind power for electricity production), in addition to the power grid connectivity problems (powerlines, potential), which greatly affects the possibilities of e-methane production. National support systems should mainly be addressing production and upgrading, not the market side. Although, the introduction of new fuels often needs some sort of user subsidy as the cost is relatively high for early adapters. There must be a balance between the support side (subsidies) and the legislation (ETS cost) side to make the shift appetizing.

7. THE BALTIC BIOGAS MARKET – CONCLUSIONS

The four analyzed countries are in different stages of biogas production and utilization. There are also different conditions and incentives in the countries which affects the production and markets.

Estonia has foreseen an increase in production planned to 2030. There are 7 projects under planning for 500 GWh, which will increase total production to 700 GWh in total. Main source for biomethane production is and will be agricultural sector and biodegradable waste. The target for 2035 is to produce 1 TWh. The main consumption is believed to be heavy transport, maritime and heating. Consumption related issues will become clearer once climate law is implemented in 2025 and ETS2 is implemented in 2027-2028.

In Finland the biogas sector estimates that domestic biogas and biomethane production will reach 3 TWh by 2030 and by 2035 the production is expected to reach 5 TWh and by 2040, 7 TWh. The initial growth in production is based on the utilization of agricultural byproducts, but later it will rely especially on the production of e-methane. The main consumption is believed to be within heavy transport and maritime sectors. Industrial usage will also increase since EU legislation imposes significant emission reduction targets in the future.

In Latvia no specific goals are set for the certain amount of the biogas production. Due to obstacles in the regulatory field in the past years Latvian biogas market was slowly developing, nevertheless in 2023 and 2024 there are positive shifts towards rapid development with the harmonization of the regulation and the expansion of the production power in the country. With the overall growth of the biogas producers and support from the Latvian government the biogas industry in Latvia and biogas market is having a great perspective.

Sweden has no national goal for biogas production although 15 TWh has been set as a target for 2030 by the Swedish gas association (2018) and 10 TWh by the government´s biogas market investigation report (2019). Currently (2024) there are more than 150 biogas production facilities under construction that has received public funding by the Swedish environmental Agency with a combined production of 1,2 TWh. Almost all of the new production sites have LBG production aimed for the Swedish long-haul market or for export to the European grid.

The countries' market forecasts are summarized in Table 3.

To reach the forecasted market prognoses different measures needs to be taken. There are many action triggers for increasing production and enabling the transition of the BSR Biogas market.

Table 3. The market forecast for each sector and country with a symbolic indication of believed growth.

Country	Gas grid	Long-haul transport	Maritime	Reformation & e-fuels
Estonia	An essential tool for centralised LBG-production, gas export, certificate trading.	Positive trend has started and forecasted to be a major market part as LBG-fuel.	Forecasted to be a major market part. Will start from passenger ships and then for cargo ships.	An optimistic potential but hard to predict the future market share.
Finland	The Gas grid in southern Finland could bring the European gas market closer to Finland and be an attractive market.	Most medium and larger sized biogas plants will upgrade the biogas to LBG for heavy duty vehicle usage.	There are several LNG-ferries in traffic on three passenger routes to Sweden and Estonia, where LBG can be used as drop in fuel.	Several ongoing projects, and it is seen as a big potential due to good wind power conditions along the west coast and the green CO2 from biogas plants.
Latvia	Well-developed gas grid. Possible to inject biomethane into the gas grid.	Multiple biogas plants are upgrading and will continue to upgrade to biomethane. Number of CNG-vehicles fuelled with CBG is expected to increase.	No LNG-ferries in traffic.	If other big RES project will launch (wind, solar) it could create good conditions for innovative new projects in synergy with other RES projects.
Sweden	Gas grid only along the west coast and several local gas grids. Possible to inject biomethane into the gas grid.	Frontrunner in EU in long-haul transports. A lot of biogas plants upgrade and/or liquefies biogas.	Limited use of LBG in ferries.	Increasing demand for LBG. Several ongoing projects to replace natural gas and liquefied petroleum gas with biogas. Also, CO2-liquefation during upgrading.

Biomethane Gas Grid Injection: Common rules are needed for injecting biomethane into the gas grid to make the best use of the existing infrastructure, allowing centralized LBG production through mass balancing. Grid injection enables industries for an easy switch to biomethane instead of fossil gas.

European Market Potential: There is a vast market in Europe for biomethane in the gas grid or as LBG for the maritime sector. The main challenge is finding the most suitable market at the right end price for consumers. There is however a need for incentives for each stage in the market development and an EU internal market for biomethane.

LBG Market Growth and CBG Utilization: Challenges exist regarding the long-term growth of the LBG market for long-haul transport and maritime use. There is a need for a life-cycle approach on the CO_2-emissions for biomethane to further promote the usage and development of uptake in heavy-duty vehicles, for example by a Carbon Correction Factor (CCF). Meanwhile, the existing CBG market should be used for regional vehicles like waste and delivery trucks, and for example manure transport trucks.

Adaptation to Local Conditions: Biogas production needs to adapt to local and regional conditions in the Baltic Sea Region and nationally.

New Business Models: Developing new business models is essential for risk mitigation and increasing biogas production. The biogas sector needs these models to compete with other renewable fuels for subsidies and achieve market stability.

Baltic Trading System: A transparent trading system for all renewable fuels needs to be developed in the Baltic region. The use of EU's Union Database (UDB) needs to be further developed and integrated for the biomethane trading.

Transition to Biorefineries: Biogas plants need to transition to biorefineries, utilizing CO_2, fuel cells for electricity production, and nutrient recovery to diversify product outputs. Additional benefits such as environmental, social, and agricultural benefits need to be considered and incorporated into business cases and incentives schemes.

Increasing Production Volumes: Power-to-gas solutions should be considered to speed up production volumes.

Value of Biogas and Green CO_2: Trading systems for certificates and green CO_2 need to be established to create value. Sustainable solutions for digestate usage and other byproducts are necessary to turn biogas plants into biorefineries and create new revenue streams. A ten-fold of biogas production in EU also opens up for huge potential in e-fuels production from green CO_2.

Incentives: National support schemes for subsidies can be complex and time-consuming for project developers. EU-level subsidy schemes, such as joint auctioning, help avoid competition between Member States and facilitate cross-border trade. In emerging markets production support can kick-start investments by providing stable revenues to project developers and investors. Flexibility mechanisms in subsidy schemes can allow producers to choose between receiving subsidies or producing unsubsidized biomethane to be sold across the EU. In developed biomethane markets, demand-side actions such as greenhouse gas intensity reduction targets or renewable energy (RES) targets can complement or replace national production subsidies. Gradually, national incentives could be harmonized, including joint auctions and pan-EU incentives.

The biogas business roadmap summarizes the foreseen markets from a production point of view, see Figure 11.

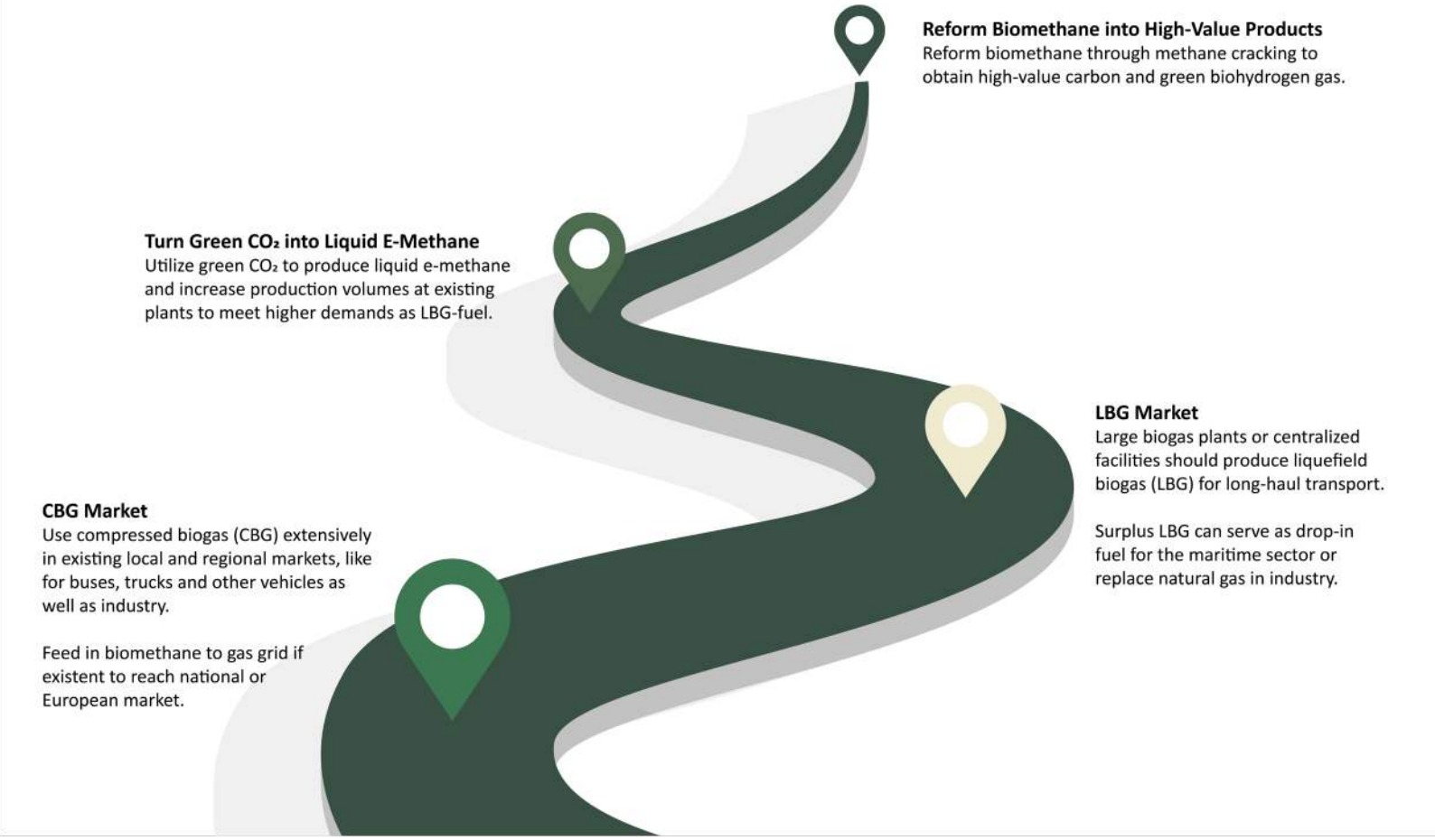

Figure 11. The Baltic biogas business roadmap from a production point of view.

BEST ACE PROJECT HELPS DEVELOP NATURAL GAS GRID INFRASTRUCTURE AND USE BIOMETHANE EFFICIENTLY IN LONG-HAUL TRANSPORT AND MARITIME INDUSTRY.

The current proposal from the EU-commission to measure emissions at the tailpipe, and not from the full production cycle, means that compressed biogas (CNG) will soon be phased out for light vehicles and replaced by electricity and hydrogen. There is also the directive on emission free city transports where public transports are shifting into electric buses. The commission has pointed out that biogas as liquified biomethane, which is a locally available resource, should be aimed for long-haul transports, maritime use and reformed into hydrogen. The current problem is that the light vehicle market will be ending in the upcoming years and the new proposed markets will not be action ready for many years. This time gap could be devastating for the millions of euros already invested in biogas production and infrastructure in the Baltic region. Therefore, it is of great importance to identify the conditions and elaborate a business roadmap for biomethane in the Baltic area for the use in long-haul transports, maritime use, reformation to hydrogen and for the natural gas grids. The aim of this is to speed up the market process, avoid the time gap for implementation and to secure a continuous development of biogas production.

ABOUT THE PROJECT

Duration	2022/10 — 2024/09
Total budget	344 253 €
EU funding	275 402 €

The project BEST ACE helps develop natural gas grid infrastructure and use biomethane efficiently in long-haul transport and maritime industry.

PARTNERSHIP

Energy Agency southern Sweden	Sweden
BioFuel Region AB	
Ab Stormossen Oy	Finland
Estonian Biogas Association	Estonia
Zemgale Planning Region	
Ekodoma Ltd.	Latvia