Interreg Baltic Sea Region

Co-funded by the European Union

ENERGY TRANSITION
BEST ACE

https://interreg-baltic.eu/project/best-ace/

State of play report

Lead Author

Ida Norberg, *BioFuel Region*

Co-authors

Tommy Lindström, *Energy Agency Southern Sweden*
Tauno Trink, *Estonian Biogas Association*
Johan Saarela, AB *Stormossen Oy*
Anda Jekabsone, *Ekodoma*

Table of content

Publication information

Issued by: Best Ace Consortium
Layout and graphics: Simon Oja, *BioFuel Region*

This report is funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Interreg Baltic Sea Region. Neither the European Union nor the granting authority can be held responsible for them.

Introduction and aim

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. The commission has pointed out that biogas as liquified 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 demands for larger volumes. The challenge is the time gap between the end of the light vehicle market to a full implementation on the new markets. 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 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. This is the core of the project BEST ACE. This report describes the state of play in a market perspective for the countries Estonia, Finland, Latvia and Sweden as of 2022/2023. In a previous project, *Baltic Biogas Circle*, an overview of the biogas situation in the whole Baltic Sea Region was preformed.[1]

The countries included in the Interreg Baltic Sea Region-programme.

[1] https://biofuelregion.se/wp-content/uploads/2021/09/Biogas-in-the-Baltic-Sea-Region-Current-state-of-affairs-2021-1.pdf Visited Jan. 11, 2023

The biogas process

The biogas process contributes directly or indirectly to all the 17 UN sustainable development goals.[2] There are many benefits for the society except from the biogas/biomethane product itself. The locally produced digestate can be used as fertilizer to replace fossil based mineral fertilizer and increase the degree of self-sufficiency. Biogas or biomethane is a source for energy as heat, electricity or vehicle fuel and contributes to security of supply. Biogas is an important part of the development of the biobased circular economy in the business sector as well.

Biogas can be produced using different processes. The most common way is through anaerobic digestion. However, it is also possible to obtain biomethane through synthesis.

Anaerobic digestion

The substrates, or raw materials, used for producing biogas is commonly manure, municipal household waste, sewage sludge or other waste streams from agriculture and industry. The substrates are fed into a digester at temperatures between 37°C to 55°C in anaerobic environment and left for 15 to 30 days. Then, biogas constituting of around 55 to 65% methane (CH_4) and 40% carbon dioxide (CO_2) is formed together with small amounts of sulphur and nitrogen compounds. This is called raw biogas. The main usage for raw biogas is for producing heat and electricity. The biogas process is described in Figure 1.

To obtain biomethane, which constitutes of >97% CH_4, the raw biogas needs to be upgraded. To remove the CO_2 from the CH_4, different types of upgrading techniques can be used. Upgraded biomethane or compressed biomethane (CBG) meets the standards to be injected into the natural gas grid or used as vehicle fuel in CNG-vehicles.

To obtain liquefied biomethane (LBG), the biogas plant needs to invest in a liquefaction unit. The biomethane is cooled to -162°C and the volume is decreased around 600 times. Liquefied methane is transported using cryo tanks under a certain overpressure manufactured according to the EU-directive on transportable pressure equipment (TPED).[3]

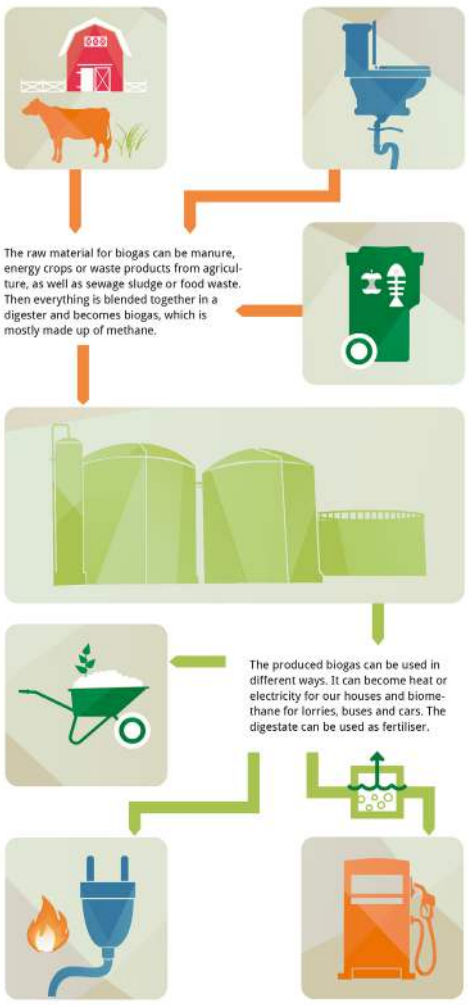

Figure 1. The biogas process.

Synthetic biomethane

Synthetic formation of methane occurs through thermal gasification of biomass. The biomass used is often agricultural or forest residues which are degraded at high temperatures in presence of a gasification medium. The process can be optimized depending on the wanted end-product and for biomethane, the gasification medium used is often oxygen or steam that forms the synthesis gas constituting of mainly carbon monoxide (CO) and hydrogen (H_2). Then, biomethane (>97% purity) can be obtained through a following methanisation step.[4]

[2] https://liu.diva-portal.org/smash/get/diva2:1161103/FULLTEXT01.pdf Visited March 3, 2023.

[3] https://www.energigas.se/fakta-om-gas/naturgas/sakra-transporter-av-flytande-metan/ Visited Jan. 17, 2023.

[4] https://www.energigas.se/fakta-om-gas/forgasning-av-biomassa/ Visited April 6, 2023.

Reformation

Reformation is the transformation of methane to hydrogen. The methane (most commonly natural gas) is blended with hot steam at a temperature between 700°C and 1100°C and a catalyst. This is called steam reformation and except from hydrogen, carbon dioxide is also formed. The drawback with this method is that it causes large carbon dioxide emissions because natural gas is used.[5]

Methane cracking

Methane cracking or methane pyrolysis means when methane (biomethane or natural gas) is heated to more than 1000°C and is bubbled through a catalyst of melted metal. The methane is then split into two hydrogen molecules and one carbon atom. The carbon atom can then be stored in solid form without being released into the atmosphere. The advantage with this method is the transformation of hydrogen without release of carbon dioxide. The method is relatively new and needs to be further developed into industrial scale. Hydrogen is sometimes categorized into certain colours depending on the production process and methane pyrolysis is called turquoise hydrogen. If this process uses renewable electricity and biomethane, it has the potential to become carbon dioxide negative.[6]

CO_2-liquefaction

The process is similar to liquefaction of biomethane, but the main difference is the temperature, which for carbon dioxide is -78.5°C (boiling point)[7] as compared to between -162°C for biomethane.[8] The liquefaction of carbon dioxide from the upgrading of biomethane has the benefit of being very pure carbon dioxide. Depending on the applications of carbon dioxide, the purity is of varying importance, and for food applications in for example sparkling beverages the purity has to be very high. Other common applications are in greenhouses and as refrigerant in air cooling systems. Another usage of carbon dioxide is in the power-to-X field. By reacting with hydrogen produced by renewable energy and electrolysis, methane and water is formed.

Power-to-X

Power-to-X (P2X or PtX) means the use of electrical power to produce a synthetic carbon-neutral fuel such as hydrogen, methane, liquid fuels or chemicals. If the purpose is gas, the term power-to-gas (P2G) is often used. If the product is a liquid fuel such as methanol, it is called an e-fuel (e-methanol).[9]

Fuel cell

In Estonia, the biogas plant at Siimani farm owned by Biometaan OÜ, has installed a 60 kW fuel cell system to produce electricity and heat. The efficiency for electricity and heat production is around 60% and 20%, respectively. This is a small-scale system that uses the raw biogas without upgrading directly into the fuel cell.[10] The benefit with this system is around 20% higher electricity output as compared to a gas engine.

---

[5] https://www.uniper.energy/sv/sverige/om-uniper-i-sverige/vatgas-i-sverige Visited Feb. 14, 2023.

[6] https://www.volvogroup.com/se/innovation/electromobility/hydrogen-fuel-cells.html#5 Visited Feb. 15, 2023.

[7] https://www.diva-portal.org/smash/get/diva2:1672202/FULLTEXT01.pdf Visited Feb. 14, 2023.

[8] https://www.energigas.se/fakta-om-gas/naturgas/sakra-transporter-av-flytande-metan/

[9] https://ramboll.com/net-zero-explorers/explainers/power-to-x-explained Visited Feb 14 2023.

[10] https://convion.fi/convion-to-deliver-a-biogas-fuel-cell-cogeneration-system-to-biometaan-ou/ Visited Feb. 14, 2023.

Market situation for biomethane

The European biomethane demand is growing. In 2018, the total biomethane demand was estimated to 23 TWh by IEA. In 2040, the estimated demand based on the support policies is expected to be 140 TWh. In another scenario for 2040, based on achieving the energy-related sustainability goals, estimates the demand to be as high as 419 TWh. The overall biomethane potential in Europe has been estimated by IEA to be 1 350 TWh.[11]

The market trend for LBG plants in Europe is rapidly increasing. In 2018, there were only 5 LBG plants which has increased to 23 plants in 2021, with a production capacity of 1.2 TWh and is believed to reach around 77 plants with 10.6 TWh production capacity by 2024.[12] LBG can be used in the long-haul vehicles sector, the maritime sector and in the industry sector.

The trend in the industry sector is a higher interest towards biomethane as a replacement for natural gas in different processes. In the chemical industry, methane is an important compound in the production of fertilizer and methanol. In the steel industry, biomethane can replace natural gas in the process where neither electricity nor hydrogen can be used. In the food industry, one application is to replace small onsite natural gas-based CHP plants.[13]

Another upcoming trend is to recover the CO_2 during the upgrading of biogas to biomethane. CO_2 is used as a feedstock in many industries, and by using biogenic CO_2, the companies lower their carbon footprint.

National gas grids

Denmark has a substantial infrastructure and grid for natural gas that is interconnected with the European gas grid system. Denmark has the majority of their gas coming from biomethane where Sweden imports half of their gas needs from Denmark. Sweden has a connection to the Danish gas grid, but it only covers the west coast of Sweden where the main users are industries. The Baltic countries, Estonia, Latvia, and Lithuania have been working towards establishing a joint natural gas market and infrastructure since the early 2000s. The goal of this project is to increase energy security, diversify energy sources, and decrease dependence on a single supplier.

The first step in achieving this goal was the establishment of the Baltic Gas Interconnection, a pipeline connecting Estonia and Latvia, which became operational in 2020. This interconnection allows for the transfer of natural gas between the two countries and enables Latvia to access gas supplies from the global LNG market.

In addition to the Baltic Gas Interconnection, the countries are also working towards connecting their national gas grids to the European Union's gas infrastructure. Lithuania has already successfully integrated its gas grid with the EU's network through the construction of a floating LNG terminal in Klaipeda, which allows the country to receive gas from global markets.

Overall, the establishment of a joint natural gas market and infrastructure in the Baltic countries is a significant step towards achieving greater energy security and independence, as well as reducing the region's carbon footprint by diversifying energy sources.

---

[11] https://www.europeanbiogas.eu/wp-content/uploads/2021/12/Gas-for-Climate-Market-State-and-Trends-report-2021.pdf p.12. Visited March 21, 2023.

[12] https://www.europeanbiogas.eu/wp-content/uploads/2021/12/Gas-for-Climate-Market-State-and-Trends-report-2021.pdf p.15. Visited March 21, 2023.

[13] https://www.europeanbiogas.eu/wp-content/uploads/2021/12/Gas-for-Climate-Market-State-and-Trends-report-2021.pdf p.13. Visited March 21, 2023.

Long-haul vehicles

The European market trend is an increase in both CNG/CBG and LNG/LBG vehicles and filling stations. In 2021, there were 4 043 CNG and 438 LNG filling stations in Europe as compared to 2015 when it was 2 957 CNG and 63 LNG filling stations.[14] The infrastructure of CNG and LNG filling-stations is available at the NGVA homepage.[15]

In 2022, there were ten different types of models for CNG long-haul vehicles and seven LNG long-haul vehicles. Annually, there is a compilation of the gas-powered vehicles available on the Swedish market done by BioDriv Öst.[16]



Manufacturer	Iveco	Iveco	Iveco
Model	Daily	Eurocargo	S-Way
Range	350+1500 km (CNG+Petrol)	400 km (CNG)	600 km (CNG) 1600 km (LNG)
Effect	136 hp (350 Nm)	204 hp (750 Nm)	340-460 hp (1500-2000 Nm)
Max load	2700 kg	9-16 Tons	18-32 Tons
No of passengers	2	1-2	1-2

Photo:Gustav Lindh.

Photo:Dan Boman.

Manufacturer	Scania	Scania	Scania
Model	G-Series	L-Series	P-Series
Range	800 km (CNG) 1600 km (LNG)	800 km (CNG) 1600 km (LNG)	800 km (CNG) 1600 km (LNG)
Effect	280-460 hp (1350-2300 Nm)	280-410 hp (1350-2000 Nm)	280-340 hp (1350-1600 Nm)
Max load	16-74 Tons	16-32 Tons	16-32 Tons
No of passengers	1-2	1-2	1-2

[14] https://www.europeanbiogas.eu/wp-content/uploads/2021/12/Gas-for-Climate-Market-State-and-Trends-report-2021.pdf Visited March 1, 2023.

[15] https://www.ngva.eu/stations-map/ visited March 1, 2023.

[16] http://www.biogasost.se/Portals/0/Publikationer/Trycksaker/Gasfordon_2022.pdf

Manufacturer	Scania	Volvo	Volvo
Model	R-Series	Fe CNG	Fm LNG
Range	800 km (CNG) 1600 km (LNG)	400 km (CNG)	1000 km (LNG)
Effect	280-460 hp (1350-2300 Nm)	320 hp (1350 Nm)	420-500 hp (2100-2500 Nm)
Max load	16-74 Tons	18-32 Tons	18-74 Tons
No of passengers	1-2	2	1-2

Manufacturer	Volvo
Model	Fh LNG
Range	1000 km (LNG)
Effect	420-500 hp (2100-2500 Nm)
Max load	18-74 Tons
No of passengers	1-2

Biomethane and carbon dioxide in the industry sector

Industries that today are using natural gas or liquified petroleum gas (gasol) can easily convert to biomethane. The type of gaseous fuel that is used today at the industries is often depending on the distance to the gas grid. Industries close to the gas grid primarily use that gas source. Industries located off-grid most often choose between (bio)liquefied petroleum gas or LNG/LBG. Example of industries with high potential to use biomethane are process, pulp and paper, steel, chemical and food industry.[17]

The incitement of using biomethane differs between industrial branches, the chemical and metallurgical industry might be interested in the carbon source from biomethane while others are interested in the hydrogen from biomethane and yet others in the whole biomethane molecule.

[17] https://www.energigas.se/fakta-om-gas/sa-har-anvands-gas-i-sverige/industri/ Visited 14 Feb. 2023.

Maritime sector

The maritime industry is a significant contributor to greenhouse gas (GHG) emissions, accounting for around 3% of global emissions. The European Union (EU) has set ambitious targets to reduce GHG emissions, including a 75% reduction by 2050. To achieve these targets, alternative fuels must be adopted in the maritime sector. One promising alternative fuel option is biogas, which can significantly reduce GHG emissions. Another alternative fuel option is liquefied natural gas (LNG), which has a favourable hydrogen-to-carbon ratio and can reduce GHG emissions compared to traditional fossil fuels. The adoption of biogas and LNG in the maritime industry can play a crucial role in reducing GHG emissions and achieving the EU's targets.

In 2021, around 500 TWh bunker fuel was consumed within the shipping sector whereof approximately 25 TWh of this (5%) was LNG. The amount of LNG fuelled vessels has grown steadily since the first vessels were introduced and many scenarios indicate that its likely to raise to around 15 % in the coming years. There is though several other “green fuels” who wants a share of the maritime market like green ammonia, green hydrogen, and biodiesel. Some Baltic ferry operators are using LNG powered vessels with a small mix of biomethane (10%), such as the national ferry between mainland Sweden and the island of Gotland. Some coastal cargo shipping companies has also started using a small quantity of biomethane in their LNG cargo ships.

However, implementing these alternative fuels in the maritime industry also poses challenges, such as the availability and accessibility of biogas and the need for significant infrastructure investments for LNG. Nonetheless, the benefits of using biogas and LNG as alternative fuels in the maritime industry outweigh the challenges. The EU has recognized the importance of alternative fuels in the maritime industry and has launched initiatives to promote their adoption. The European Green Deal, for instance, aims to increase the use of sustainable alternative fuels in European shipping and ports. The EU has also included LNG and biogas as potential alternative fuels in its decarbonization strategy for the maritime sector.

EU-DIRECTIVES

The biogas process is affected by different directives and laws, which was well explained by the European Biogas Association at a webinar about the statistical report for 2022.[18] Figure 2 shows the connection of the different directives to the different steps in the biogas process. The first part of the process involves the feedstock, which is linked to the Renewable Energy Directive (RED III – Annex IX and VI) for the substrates intermediate crops, plant by-products and animal by-products. Sewage sludge is also linked to RED II. The biowaste from households and industrial & commercial organic waste is linked to the Water Framework Directive (WFD) and the Urban Waste Water Treatment Directive (UWWTD). The biogas output either as biofuel for transports, heat, electricity or injected to the gas grid is connected to the Fit for 55-package. The digestate output on the other hand is linked to the Integrated Nutrient Management Action Plan (INMAP) and the soil health law. The carbon dioxide is connected to the Carbon Removal Certification Framework (CRCF). This section describes the FIT for 55 Package and the RePowerEU with a biogas perspective.

[18] https://www.europeanbiogas.eu/wp-content/uploads/2022/12/EBA-Statistical-Report-2022_-Short-version.pdf Visited March 21, 2023.

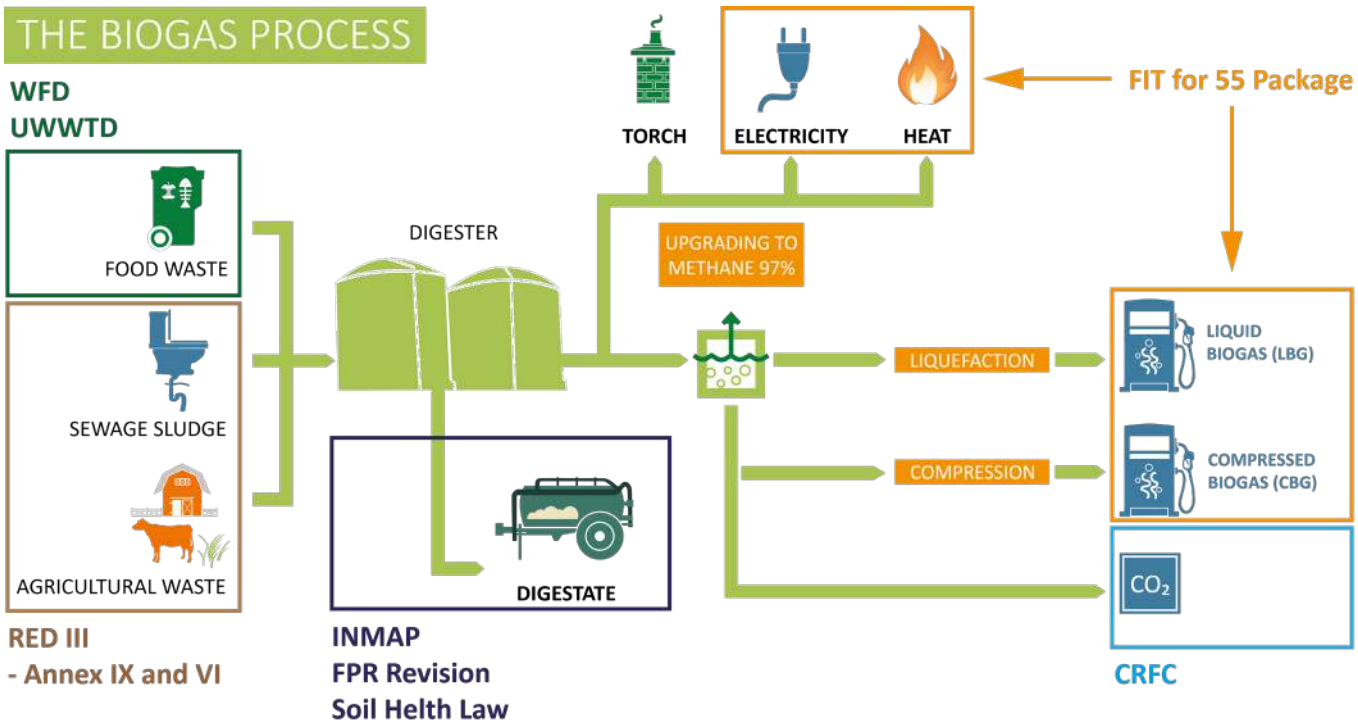

Figure 2. The connections between different EU-directives and the biogas process.

FIT for 55 Package (FF55)

The FF55 package is one part of the European Green Deal legislation. The FF55 is the EU target to decrease the net CO_2-emissions by at least 55% to 2030, compared to 1990, at the latest. The aim with the package is to adapt the EU regulations to the target for 2030.[19] Energigas Sverige explains the Fit for 55 package and how it affects the biogas sector.[20] In FF55, there are both new legislations and revisions of present legislations. The directives connected to biogas are mainly the EU ETD (Energy Tax Directive), EU ETS (Emission Trading System), RED III (Renewable Energy Directive), EU 2019/631 setting CO_2 emission performance standards for new passenger cars and for new light commercial vehicles, Fuel EU Maritime and DAFI (Directive of Alternative Fuels Infrastructure).

REPowerEU

The REPower EU is a strategy on how EU should handle the energy crisis in connection to the Russian invasion of Ukraine. One crucial instrument in replacing Russian natural gas is an increased production of biogas. Today the EU member states produce 3 billion cubic meters (bcm) of biomethane and the aim is to scale-up to 35 bcm (approximately 350TWh). This requires the mobilisation of sustainable biomass feedstock, mostly waste and residues, plus building about 5 000 new biomethane plants. The potential is divided in 16 bcm from manure, 10 bcm agricultural residues, 2 bcm food waste, 3 bcm industrial wastewater and 4 bcm silage produced as sequential/double crops.[21] From a technical

[19] https://www.consilium.europa.eu/sv/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/ Visited March 21, 2023.

[20] https://www.swedegas.se/-/media/Files/GMR/GMR-2021_2022/7-Energigas.ashx?la=sv-SE Visited March 23, 2023.

[21] https://www.europeanbiogas.eu/commission-announces-groundbreaking-biomethane-target-repowereu-to-cut-dependence-on-russian-gas/ Visited March 21, 2023.

perspective this is assessed as feasible during the next eight years. Although the substrate and the possible plants are not close to a natural gas grid, especially in the Nordic countries except Denmark. Here, other markets need to be developed.[22]

The REPower EU has proposed the creation of the Biomethane Industrial Partnership (BIP) to support the goal of 35 bcm to 2030 and further on the goals to 2050. This was launched in 2022.[23]

Different support systems

In a report from 2020 by the REGATRACE project, the different support systems in Europe are explained and then described on a country level for Estonia, Finland, Latvia and Sweden.[24] The support schemes are:

- Feed-in Tariff (FiT). This is a technology specific support scheme that gives compensation per unit of renewable energy. A public authority approves the tariff for a certain period of time. It can be access to the gas grid and long-term contract with producer.
- Feed-in premium. A bonus to be paid above the pre-specified market price. It is a pre-set fixed or floating price and is technology specific per unit of renewable energy.
- Quota/green certificates system. An obligatory share of renewable energy needs to be replaced in the fossil energy. This enables a secured production of renewable energy.
- Fiscal incentives. These are tax exemptions or reductions and are usually not the main support scheme. The renewable energy market is compensated to be competitive as compared to the fossil counterpart.
- Investment support. A fixed amount of money received before, during or shortly after the building of the plant.

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.

[22] https://gasforclimate2050.eu/news-item/new-study-on-biomethane-production-potentials-in-the-eu/ Visited March 21, 2023

[23] https://www.europeanbiogas.eu/about-us/partnerships/biomethane-industrial-partnership/ Visited March 27, 2023.

[24] https://www.regatrace.eu/wp-content/uploads/2020/02/REGATRACE-D6.1.pdf Visited March 27, 2023.

State-of-play on a country level

This section describes the status of biogas in Estonia, Finland, Latvia and Sweden. The production and potential of biomethane, the market situation including consumption of biogas as well as the status for long-haul vehicles,maritime sector, the ongoing projects for usage of biomethane in the industrial sector and into the gas grid.

Estonia

In Estonia, the first biogas plant was built in the 1980s when two pig farms invested in a biogas production facility. In 2008 the first agricultural plants started and in 2021 there were 17 biogas plants in Estonia. Historically, the focus has been on CHP production, but has switched to biomethane production since more plants starting to upgrade to biomethane. Cities have introduced biomethane as a transport fuel including the bus fleet.

The information and sources in this section are based on the following references.[25]

Biogas status today

The total biogas production in 2021 was 200 GWh. Of that, 152 GWh was upgraded to biomethane and 17 GWh electricity was produced with 35% efficiency. No LBG was produced.

The distribution depending on type of substrate was 55.6 GWh from sewage sludge, 61.1 GWh from animal manure, 25.0 GWh from food industry residues, 5.9 GWh from biowaste and 4.8 GWh from other biomass sources.

In Estonia, the main part of biogas is further upgraded to biomethane and the remaining 10% is converted into electricity, see Figure 3.

Potential

The total potential of raw materials in Estonia is sufficient to produce about 1–1.3 TWh of biomethane per year. The optimal for the production of such volumes is about 20–30 biomethane production plants scattered all over Estonia. In the long term biomethane production can be doubled up to 2-2.5 TWh, if the herbaceous biomass from arable land is cultivated according to the sustainability criteria.

Market situation

The year 2020 was of significant importance in the Estonian biomethane market. Two biogas plants started to upgrade to biomethane: Tartu Biogaas OÜ Ilmatsalu and Vinni Biogaas OÜ. From Ilmatsalu, a 6 km long gas pipeline was built to reach the buses in Tartu.

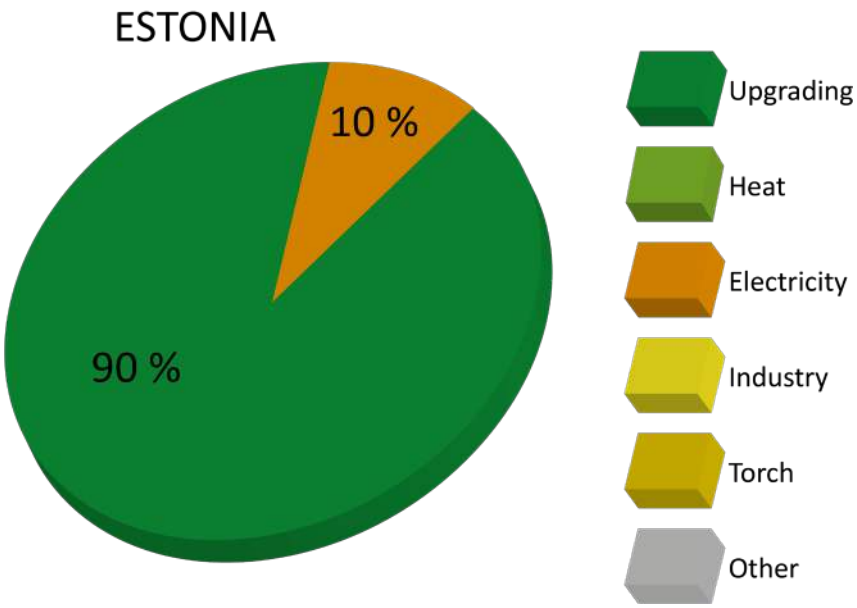

Figure 3. The distribution of consumed biomethane in each sector in Estonia.

[25] Elering, 2020. Estonian Gas Transmission Network Development Plan 2020-2029; Elering, 2021. Estonian Gas Transmission Network Development Plan 2021-2030; and Estonian Biogas Association, 2022. Estonian Biomethane Roadmap 2030 (2050). Visited Dec. 1, 2022.

In Vinni, on the other hand, the biomethane was injected into the natural gas grid, which is located close to the plant. Eesti Biogaas OÜ completed the biomethane up-grading facility in the Oisu Biogas OÜ in the second half of 2021. Bioforce Aravete OÜ installed the membrane up-grading unit to Aravete biogas plant in 2022. There is no natural gas pipeline in Oisu and Aravete, which means that the CBG is transported from Oisu to the consumers in Tartu and from Aravete to Tallinn TLT public CNG buses. The addition of two new biomethane plants increased the amount of biomethane produced by approximately 50%, compared to the amount of biomethane produced in 2019, which was 63.1 GWh.

In 2020, Elering who provides the gas transmission service, issued 97.4 GWh gas origin certificates to biomethane producers, of which 54.2 GWh for biomethane produced from sewage sludge and 43.2 GWh from biomethane produced from animal manure, biomass, biowaste and food industry residues.

Consumption of biomethane in transport has also increased. An important contribution has been made by the commissioning of TLT (public transport company owned by the City of Tallinn) first 100 gas buses in Tallinn, increasing consumption by about 50 GWh (5 million Nm^3), and another 100 gas buses to be added this year. In addition to Tallinn gas buses, buses from Tartu city and county, Saaremaa, Pärnu city and county, Võru city and county are also consumers of biomethane. Many taxi companies and other regular transport operators have started to use CNG/CBG in their vehicles.

The ever-expanding network of methane filling stations has certainly contributed to the introduction of the CNG vehicles. Ten years ago, there were two CNG filling stations, today there are 26 and some are under development. The circle of operators of CNG filling stations has also increased, in addition to the filling stations of AS Eesti Gaas, AS Alexela and Jetgas OÜ, the circle of operators of Bioforce Infra OÜ, AS Krooning, Thori Tanklad OÜ and AS Olerex has been added.

Long-haul traffic

In Estonia there are in total 1000 CNG trucks and buses, and only a few LNG trucks. There are 1 LNG filling station and 26 CNG filling stations. In 5 municipalities including the bigger cities Tallinn, Tartu and Pärnu, the bus fleets are using CNG/CBG of where most of the produced biomethane is used.

The ambition is that the role of biomethane must increase significantly until 2030 where the goal is to produce 1 TWh of biomethane per year. The target for CNG/CBG vehicles is 15 000 cars and 1 500 heavy goods vehicles and buses and finally, 50 CNG/CBG filling stations. There are several incitements for the ambitions. The REpowerEU plan provides the unique development window for biomethane sector development. Existing and upcoming support measures to biogas/biomethane production, filling stations building, bus fleets to prefer methane buses. Moreover, a biowaste recycling regulation and a certification system for biogas digestate certification exists.

There are also some challenges for biomethane as a vehicle fuel such as regulations, certifications, and lack of knowledge. Public authorities change constantly in ministries, meaning that new persons often have a lack of knowledge about gaseous fuels. For sectors, including biogas associations, it causes additional pressure to educate public authorities on biogas related environmental, agricultural, economic, transport, taxing, state budget issues in almost all ministries. Regarding regulations, the biowaste recycling regulation, which is the local governments responsibility, have not been implemented properly in most municipalities. The certification system for biogas digestate has few experiences and for producers this is very complicated and time consuming (6-12 months).

Another challenge is the uncertain supply of methane fuels (CNG, CBG, LNG, bio-LNG) at the filling stations. There is a regional disbalance since half of the filling stations are in or around the capital Tallinn, while the western part including islands have only 1 LNG based CNG filling station in Saaremaa. Finally, the permitting process of building a biogas plant in urban areas (demand to complete spatial plan) and demand sometimes to complete Environmental Impact Assessment hinders sectoral development.

Maritime sector

At the moment there is one LNG ferry vessel (named Megastar) that operates between Tallinn and Helsinki.[26] In the end of 2021, the same Estonian company will get another one (named MySTAR).

Regarding filling stations, there are no special maritime LNG filling stations, and the ferries are filled with inland bunkering trucks.

Biogas in the industry sector

There are no ongoing projects regarding hydrogen production or other utilization of biogas in the industry sector in Estonia. However, there is an ongoing technological innovation with biogas based solid oxide fuel cell units aiming to support small scale biogas production and consumption. From 100 kW primary energy, 60 kW electricity and 25 kW heat are produced, which means 60% efficiency of electricity production and 25% efficiency of thermal energy.

Gas grid

In Estonia biomethane is distributed both through gas grid and with gas containers either to the injection point at the natural gas grid or directly to the CNG filling station.

Natural gas is a major fuel for multiple end-uses and is increasingly discussed as a potential pathway to reduced oil dependence for transportation as CNG. It is known that fuelling stations are connectors between demand and supply. In Estonia, 21 cities have a natural gas grid. These include approximately 750 000 inhabitants, meaning that there will be a potential market for CNG/CBG demand. Based on “Analysis of the biomethane resources deployment of Estonia” there are totally 437 fuelling stations in Estonia and 158 of them are closer than 200 m to natural gas grids. Mostly only B (0,1-5 bar), C (5-16 bar) and D category (over 16 bar) gas grids are technically important for establishing CNG stations. In Estonia it is possible to inject biomethane to the B and C category grid and there are working solutions already but there is no biomethane injection to D category grid (it is possible, but expensive). D category gas grid is state company owned and this company is called Elering AS.

B and C category gas grids are owned by private gas companies but a majority of this belongs to a company called Gaasivõrk AS.

In the long-term development of gas network is committed to achieve EU climate policy targets, which means that natural gas will have to be gradually replaced by renewable gases in the gas grid. The gas grid’s future role is to transport more biomethane and start adding also hydrogen.

A large-scale use of new technologies has been seen as a key factor in a bi-directional energy flow between gas and electricity systems and therefore can help integrate variable renewable energy into power systems. In the future the new technology prices are more likely to come down and the environmental limits play a more important role in construction of new infrastructures.

[26] https://www.marinelink.com/news/delivered-megastar421119 Visited March 28, 2023.

Challenges

Today we are in a situation where there are still many unknowns about the technology, usability of different green gases in the gas network and end-user devices, as well as possible solutions for the green gas transition. Investments planned today must be adaptable to the future green gases like biomethane and green hydrogen. The investments in the gas network are made for decades, which is why at the moment, only unavoidable investments have been made to maintain the necessary level of security of supply, until it has been found out how to switch the gas system to green fuels.

Finland

The first biogas plant in Finland was built in the 1930's in Helsinki. The development of biomethane plants in Finland has increased from 2 in 2011 to 17 in 2019. The building of more filling stations for both compressed and liquefied biomethane is an increasing trend.

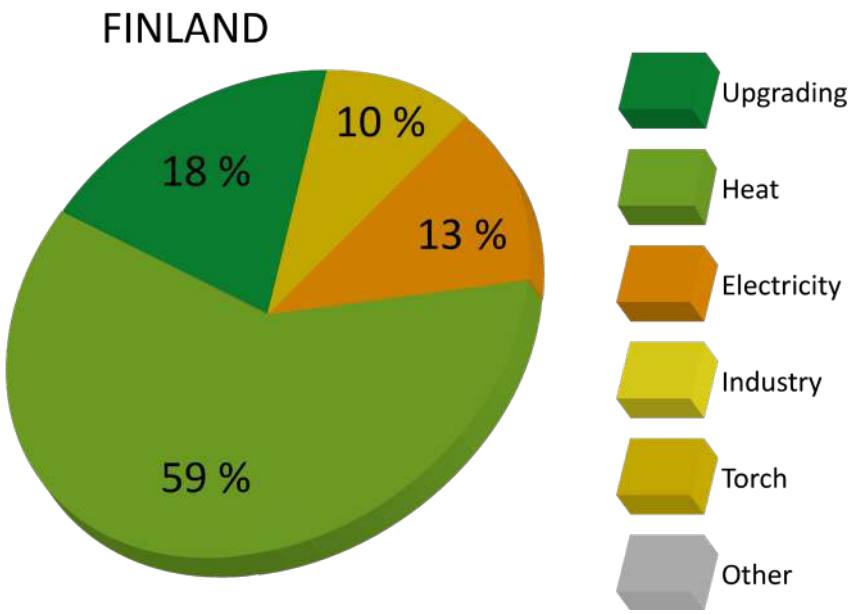

Figure 4. Consumption of biogas in Finland 2021 divided in each sector.

Biogas status today

In 2021, the total biogas production was 906 GWh, of where 156 GWh was biomethane and 750 GWh was biogas.[27] Biogas production has been growing steadily throughout the 2010s, but between 2018 and 2020 there was a dip in development. This is partly due to reduced volumes of landfill gases, partly due to statistical changes. Biomethane production started to grow in 2018, and the growth has continued since then. Finally, in 2021, the growth of biogas flare burning was also brought to a halt.[28] In Finland, around 60 GWh of liquified biomethane (LBG) is produced at the biogas plant in Turku, all of it used in the transport sector.[29] The consumption of LBG is higher, which means that it is imported from for example Sweden and Denmark.

A map with all biogas plants has been developed by the Finnish Biogas Association.[30]

The consumption of biogas is mainly as heat and electricity and 18% is used as biomethane.[31]

[27] https://biokierto.fi/tilastot/ Visited March 23, 2023.

[28] https://biokierto.fi/tilastot/ Visited Dec. 1, 2022.

[29] https://www.gasum.com/kaasusta/biokaasu/biokaasulaitokset/turun-biokaasulaitos/ Visited Jan 23, 2023.

[30] https://www.google.com/maps/d/viewer?mid=1ZHpWSB6Av2QQlZSGySCriDCW7piuXnBM&ll=61.73300753615044%2C27.07230345511769&z=7 Visited Jan 23, 2023.

[31] https://biokierto.fi/tilastot/ Visited March 21, 2023.

Potential

According to various sources, the production potential of Finnish biogas using digestion technology is 10-25 TWh/year.[32] The Finnish government has set a 2030 biogas production target of 4 TWh in connection with the budget and climate negotiations in autumn 2021. This aims to reduce carbon dioxide emissions in the transport, agricultural and waste sectors, improve security of supply and increase national energy and nutrient self-sufficiency.

Finnish Biocycle and Biogas Association considers a biogas production level of 4 TWh realistic and achievable. The association estimates that in 2030, 2 TWh of biogas would be produced from agricultural and food industry waste and side streams, 1 TWh from municipal waste and landfill gases, and 1 TWh with new technology (e.g. synthetic methane). More than 70 percent of the production would be upgraded to biomethane, which could be used in vehicles, ships, industry and transported in the gas network. An estimated 2.5 TWh would be used in road traffic, especially in heavy vehicles.[33]

In another study done by BSRC on the Nordic countries, the energy potential in Finland is 5.6 TWh/year. This is a lower potential, and it shows the difficulty in estimating the biogas potential.[34]

Market situation

The opportunities and challenges for biogas and biomethane was discussed at a workshop in 2020 organized by the Finnish Biocycle and Biogas Association. Historically the biogas has been seen as waste management, but it was agreed that the biogas sector should more shift towards energy production and the production of recycled nutrients. The opportunities are carbon neutrality targets, interests in advancing national self-sufficiency of both energy and nutrients, and emission reduction targets for transport and agriculture. The challenging factors are the low profitability, and the end-product markets from both energy and recycled nutrient products are still under development. Moreover, the fossil fuels are still cheap and easily available. Policy instruments suggested that subsidies and demand for end-products can be increased with for example blending mandate.[35]

Today, the biogas production is very dependent on financial support. The most important subsidies are three different investment support schemes for biogas plants, which depend on the size of the plant and the use of the biogas. There is investment support for large industrial plants, for farms´ own energy production and for agricultural companies.[36]

In addition, there has been a feed-in tariff for electricity production in large industrial plants and a fuel tax exemption for biomethane as vehicle fuel. However, both of these have been changed and there is now a tax on biomethane.[37]

---

[32] https://biokierto.fi/wp-content/uploads/2020/06/Biokaasu2030_raportti_17062020.pdf Visited Dec. 6, 2022.

[33] https://biokierto.fi/biokaasu/biokaasu2030/ Visited Dec. 6, 2022.

[34] https://nordicbiogasconference.com/wp-content/uploads/2022/10/P1_5_Axel-Lindfors_The-current-Nordic-biogas-and-biofertilizer-potential.pdf Visited Dec. 6, 2022.

[35] https://biokierto.fi/wp-content/uploads/2020/06/Biokaasu2030_raportti_17062020.pdf Visited Dec. 6, 2022.

[36] https://task37.ieabioenergy.com/wp-content/uploads/sites/32/2022/02/IEA_T37_CountryReport Summary_2021.pdf Visited Dec. 6, 2022.

[37] https://www.vero.fi/yritykset-ja-yhteisot/verot-ja-maksut/valmisteverotus/Maakaasu_biokaasu_polttotur-ve_kivihiili_mantyoljy_valmistevero/ and https://tem.fi/documents/1410877/2132212/Jakeluvelvoitteen_laajentaminen_loppuraportti_julkaisu.pdf/73b8c4d-c07d-b6ca-d4a7-8af1f2a00b37/Jakeluvelvoitteen_laajentaminen_loppuraportti_julkaisu.pdf?t=1599738665281 https://tem.fi/documents/1410877/2132212/Jakeluvelvoitteen_laajentaminen_loppuraportti_julkaisu.pdf/73b8c4d-c07d-b6ca-d4a7-8af1f2a00b37/Jakeluvelvoitteen_laajentaminen_loppuraportti_julkaisu.pdf?t=1599738665281 Visited March 23, 2023.

Long-haul traffic

In Finland, there are 77 CNG filling stations and 14 LNG filling stations, which are updated in a map.[38] In the end of 2022 there were totally 15 610 CNG powered passenger cars.[39] In the heavy-duty vehicles segment, 469 were CNG-trucks[40] and 55 were powered by LNG.[41] The share of biomethane used in the transport sector was about 53% in 2020, about 56% in 2021 and possibly already over 90% in 2022.[42]

Finland has a national program regarding the distribution network for sustainable transports related to the DAFI-directive. The 2020 goal of 5000 gas-powered cars and 20 000 electric powered cars was both achieved ahead of schedule. The goal for 2030 presented in the energy and climate strategy is at least 50 000 gas-powered cars and 250 000 electric-powered cars. These goals have been updated in the roadmap for fossil-free transport, to about 130 000 gas-powered cars and vans and 700 000 electric cars in traffic, of which at least half are fully electric cars.[43] However, the goal will probably not be fulfilled since there was only 15 600 registered cars at the end of 2022 and the registrations of new vehicles is low.[44] Another goal for 2030 is that all methane used in the transport sector should be biomethane or methane from another renewable source.

Maritime sector

In Finland, there are several LNG ferries in use. The route between Åbo – Stockholm has at least 2 ferries, the route between Vasa and Umeå has one ferry and the route between Helsinki and Tallin has several LNG-ferries. Additionally, the coast guard have one ferry running on LNG.[45] There is no CBG ferries in use today.

The potential by 2030 in the maritime sector is around 1.8 TWh of biomethane use.[46]

[38] https://www.google.com/maps/d/viewer?mid=1pbnHU_8pwXMh1LWkglmwAyepBYs&ll=63.505843099943405%2C24.458878800000008&z=6 Visited Feb. 14, 2023.

[39] https://liikennefakta.fi/fi/ymparisto/henkiloautot/liikennekaytossa-olevat-henkiloautot-kayttovoimittain Visited March 1, 2023.

[40] https://liikennefakta.fi/fi/ymparisto/paketti-ja-kuorma-autot/paketti-ja-kuorma-autojen-kayttovoimat Visited March 1, 2023.

[41] https://trafi2.stat.fi/PXWeb/pxweb/fi/TraFi/TraFi__Liikennekaytossa_olevat_ajoneuvot/040_kanta_tau_104.px/table/tableViewLayout2/ Visited March 1, 2023.

[42] https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164799/LVM_2023_4.pdf?sequence=1&isAllowed=y Visited March 30, 2023.

[43] https://liikennefakta.fi/fi/ymparisto/henkiloautot/liikennekaytossa-olevat-henkiloautot-kayttovoimittain Visited March 1, 2023.

[44] https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164799/LVM_2023_4.pdf?sequence=1&isAllowed=y Visited March 30, 2023.

[45] https://raja.fi/documents/44957406/76502803/Rajavartiolaitoksen-vastuullisuusraportti-vuodesta-2021.pdf/dfb41420-0450-5838-cf25-bfa10523e50c/Rajavartiolaitoksen-vastuullisuusraportti-vuodesta-2021.pdf?t=1663667975232 p.14. Visited March 1, 2023.

[46] https://biokierto.fi/biokaasu/kaytto/ Visited March 1, 2023.

Biogas in the industry sector

Today, there are several on-going projects in this field, but most of them are in the phase of applying for permits and funding. Some of the projects are P2X in Harjavalta, Vantaa energia, Westenergy in Vasa, H-FlexE in Vasa, Hycamite in Kokkola, P2G in Kristinestad, and Ren-Gas that has several project locations with pre-studies on going around Finland with the aim of producing 2.5 TWh synthetical methane.

Nordic Ren-Gas Oy is a project development company established in 2021. It invests in P2X gas production and distribution sites in Finland aiming to create value across the value chain from P2X technology providers to gas and heat end users.[47]

P2X Solutions' Harjavalta plant is the first industrial-scale green hydrogen production plant that is progressing to the construction stage and will be opened in 2024. The plant will also include synthetic fuels (e-methane, e-methanol and e-ammonia). The electrolysis capacity will be 20 MW to start with, but the goal is 1 GW electrolysis capacity by 2031. The main product will be hydrogen produced from water and renewable electricity, but the plant will also include methane production from hydrogen and captured CO_2. The plant has received approximately EUR 26 million grant for new energy technology from the Ministry of Employment and the Economy. In addition, the project has been funded by the Climate Fund.[48]

Hycamite is a company in Kokkola that is using the technology of methane cracking to produce hydrogen and solid carbon.[49]

Gas grid

In Finland, there is a natural gas grid in the southern part of Finland. Five biogas plants (around 10% of the biomethane) are connected to the gas grid, which means that the off-grid infrastructure is very important.[50]

Domestic biomethane production has preferential access as compared to domestic natural gas production and import. When injecting biogas to the transmission system, a biomethane producer must pay the connection fee and the transfer fees. The grid operator is responsible for the rest of the investments.[51]

[47] https://ren-gas.com/en/ Visited Feb. 6, 2023.

[48] https://p2x.fi/en/project/ Visited Feb. 6, 2023.

[49] https://hycamite.com/ Visited Feb. 14, 2023.

[50] Decorte, Mieke (EBA); Tessens, Sam (Biogas-E); et al. 2020. D6.1 | Mapping the state of play of renewable gases in Europe. Download at: https://www.regatrace.eu/wp-content/uploads/2020/02/REGATRACE-D6.1.pdf p. 29. Visited Jan. 16, 2023.

[51] Decorte, Mieke (EBA); Tessens, Sam (Biogas-E); et al. 2020. D6.1 | Mapping the state of play of renewable gases in Europe. Download at: https://www.regatrace.eu/wp-content/uploads/2020/02/REGATRACE-D6.1.pdf p. 30. Visited Jan. 16, 2023.

Latvia

In 2007 there were only three biogas plants in Latvia. Since support system based on a feed-in tariff was released in 2007, the number of biogas plants increased rapidly to 60 plants in 2016. However, the number of plants has decreased since then because of the support system was terminated.

Biogas status today

In 2021 the total biogas consumption of cogeneration stations was 687 GWh. All biogas included in national statistics is used in CHP to produce electricity and heat, see Figure 5. There is rising interest in upgrading to biomethane, and some stations have upgraded, but no official information is available.

In 2021, 47 biogas stations with an installed electric capacity of 55,9 MW were operating under mandatory procurement (OI) system.[52] The amount produced was 213 GWh of electricity. On 1st of January 2022, only 40 biogas plants with an electric capacity of 44,6 MW were operating under mandatory procurement.[53] Information about biogas plants that exit the OI system become uncounted and no official data is available anymore.

OI support is provided to biogas plants with a capacity of up to 4 MW for 10 years.[54] New permits were stopped in 2012 and the last station was built in 2015. Consequently, the number of biogas plants eligible for State aid in the electricity sector is steadily decreasing.

In 2021 there were 2 cogeneration plants that used biogas, that are not part of OI system. In total electricity capacity of all biogas cogeneration plants was 57.1 MW, but heat capacity 63.0 MW.[55] Stations in total used 87 GWh of biogas, produced 292 GWh of electricity and 255 GWh of heat.[56]

By December 2022, the Ministry of Economy submitted in the Cabinet of Ministers amendments to the Energy Law, regulations for the proof of origin certification for the biomethane. After the last election in 2022, the new government and a new Ministry of Climate and energy have just started their work.

There is also foreseen an investment support for biomethane production (or biogas purification), including the purchase of compressors for introducing biomethane into natural gas distribution or transmission networks and transportation, from the EU fund program of the next period. Currently, the amount of funding planned for such investment support is 21 750 000 Euros.

[52] One biogas plant (AS "Cēsu alus") does not produce electricity, but all produced biogas is incinerated in a gas boiler and the generated heat is used in its production.

[53] https://www.bvkb.gov.lv/lv/elektroenergijas-obligata-iepirkuma-mehanisma-uzraudziba-un-kontrole Visited Dec. 1, 2022.

[54] https://likumi.lv/ta/id/189260-noteikumi-par-elektroenergijas-razosanu-un-cenu-noteiksanu-razojot-elektroenergiju-kogeneracija Visited Dec. 1, 2022.

[55] Koģenerācijas staciju sadalījums pēc patērētā kurināmā veida, https://stat.gov.lv/lv/statistikas-temas/noz/energetika/tabulas/enb130-kogeneracijas-staciju-sadalijums-pec-patereta?themeCode=EN Visited Dec. 1, 2022.

[56] Koģenerācijas stacijās patērētais kurināmais, saražotā siltumenerģija un elektroenerģija, https://stat.gov.lv/lv/statistikas-temas/noz/energetika/tabulas/enb140-kogeneracijas-stacijas-pateretais-kurinamais?themeCode=EN Visited Dec. 1, 2022.

Potential

Based on the studies available, the average volume of biogas produced between 2015 and 2017 represented 80% of the total potential of the available raw materials. Data show that there is a high potential to increase the amount of biogas produced from sewage sludge and organic waste in the future.[57] This would mean that current plants biogas production potential is 825 GWh.

Latvian Biogas Association recommends aiming for 680 GWh biomethane production capacity by 2030, based on current and future production capacities according to a roadmap for biomethane production in Latvia developed by LBA for policy makers within a Regatrace project.

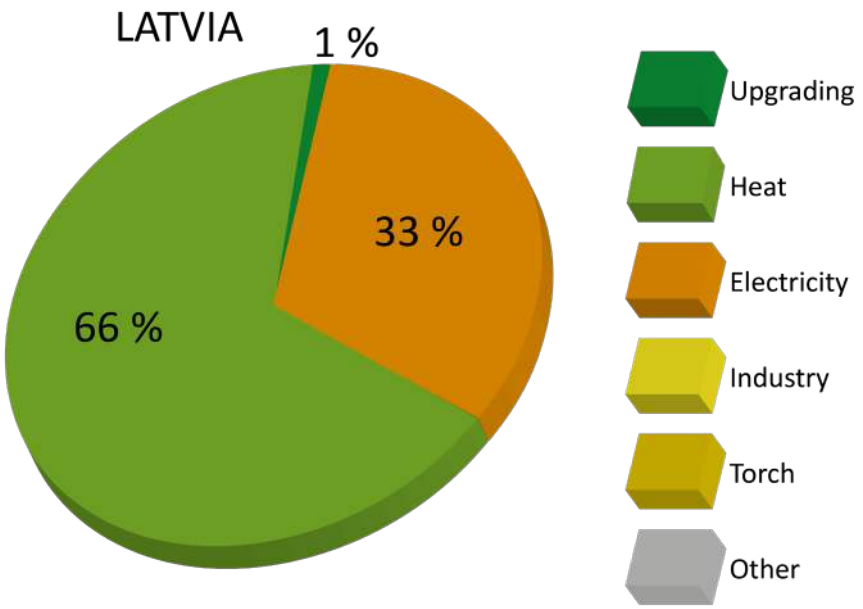

Figure 5. The consumption of biogas in Latvia in year 2021 divided sector wise.

Long-haul traffic

As of October 2022 there were 211 trucks and 18 buses powered by natural gas. There were also 23 trucks powered by natural gas and liquified petroleum gas, 19 trucks powered by petrol and natural gas and 9 trucks powered by diesel and natural gas.[58]

In 2021 there were 10 public CNG filling stations in Latvia.[59]

In the transport sector, Latvia is planning to increase the share of renewable energy sources to at least 7% in 2030, ensuring both the use of advanced biofuels and biogas and promoting the use of electricity in transport. Potential stated in the Latvian National Energy and Climate Plan for 2030 is 433 GWh biomethane consumed by the transport sector.

Today, there are no support mechanisms, but it is currently investigated and amendments to laws are being prepared. It is foreseen that substantial support mechanisms, and proof of origins certification will be functional by end of 2023. It is also planned to reduce fuel tax for natural gas in transport by 2025 and increase again after 2026 to motivate use of biomethane in transport.

The main challenge in Latvia is the lack of fuelling stations and transport units that can use biomethane and create a stable demand. There is also a lack of policy instruments and a clear vision. Legislations are implementing slowly and stagnantly, historically a lot of legislation amendments have been made, that destabilized the biogas industry, and reduced trust in future developments. System for certifying proof or origin and sustainability should be established, and injection in natural gas grid should be made possible.

[57] https://tapportals.mk.gov.lv/attachments/legal_acts/document_versions/bec7a7e9-df59-4e89-8442-7674076dd059/download Visited Dec. 1, 2022.

[58] https://www.csdd.lv/transportlidzekli/transportlidzeklu-ikmenesa-dati Visited Dec. 1, 2022.

[59] https://lg.lv/uznemumam/cng Visited Dec. 1, 2022.

Biogas in the industry sector

There are no ongoing projects regarding reformation or other utilization of biogas in the industry sector in Latvia.

Gas grid

Today, the gas is distributed using a grid and by selling gas containers directly.

JSC "Conexus Baltic Grid" is the only natural gas transmission system operator in Latvia and enables certified traders to use the Latvian natural gas transmission system for marketing, not only in the territory of Latvia, but also in the immediate regions.[60]

The transmission pipelines are composed of regional gas pipelines intended for Latvian supply, and international gas pipelines, which ensure gas transit to neighbouring countries, and their branches. The total length of the transmission pipelines together with the transmission pipeline branches is 1190 km.[61]

Biomethane produced may be entered into natural gas transmission or distribution networks for which the biomethane producer is entitled to request and receive a proof of origin. According to the draft law submitted, it is planned to entrust the issuance of certificates of origin to the single operator of the natural gas transmission and storage system AS "Conexus Baltic Grid". Biomethane must meet certain quality criteria, and these criteria should also be harmonised with EU standards, taking into account the conditions for interoperability of interconnected natural gas networks. Biomethane quality parameters to be entered into the natural gas transmission or distribution system are currently specified in Cabinet Regulation No. 650 of 4 October 2016, Requirements for entering and transporting biomethane and gaseous transformed into a natural gas transmission and distribution system.[62]

For the time being, none of the Latvian biogas plants has been added to the natural gas distribution or transmission network.

There is ongoing incentive/idea to develop 4 injection points on the natural gas grid, where biomethane could be injected into natural gas grid (transported with a truck from biogas station to the injection point), but the project is in early stages yet. The biogas stations are not very close to gas grid, as they are constructed in the countryside, but the gas grid mainly connects populated places. Historically the gas transmission system operator has not been very keen to connect biomethane producers to the natural gas grid either.

Sweden

The development of biogas production in Sweden has increased from around 1.3 TWh in 2005 to around 2 TWh in 2016 and after that it has stayed about the same, although there are many new plants that has been given grants by the government. Sweden is one of the countries in Europe that consumes more biogas than produced; around 50% is imported from mainly Denmark.

[60] https://www.conexus.lv/latvias-gas-transmission-system Visited Dec 6, 2022.

[61] https://www.conexus.lv/latvias-gas-transmission-system Visited Dec 6, 2022.

[62] https://tapportals.mk.gov.lv/attachments/legal_acts/document_versions/bec7a7e9-df59-4e89-8442-7674076dd059/download Visited Dec 6, 2022.

Biogas status today

In 2021, the total biogas production was 2 265 GWh in Sweden. Of that, 1 508 GWh was further upgraded to biomethane. There are a total of 71 upgrading plants, and the most common type of upgrading is water scrubber, but in new plants it becomes more common to use PSA or membrane.[63]

There is an increasing trend in the production of liquified biomethane. In 2021 there are three liquefaction plants that together produced 95 GWh LBG, which is an increase with 22% as compared to 2020.[64]

The total use of biogas in Sweden has almost doubled as compared to the amount of biogas produced. In 2021, around 4 756 GWh was used. 95% of the imported biomethane in 2021 was from Denmark to the gas grid in the southwest of Sweden.[65] The distribution of the use of biogas by sector is shown in Figure 6.[66]

The interest in biogas has increased, where more and more industries substitute natural gas by biogas as well as the use of LBG in long-haul vehicles. During 2021 there was a raised tax on fossil fuels in the combined heat and power sector as well as usage for heating in some industries, which has favoured biogas. Since January 2022, the biomethane bought from a gas grid is no longer part of the EU trade system for certificate of emissions and that will probably increase the demand from those types of industries. The potential for use of biomethane as a raw material in the chemical industry is large as well as in the maritime sector, but today there is a lack of incitements.[67]

In the industry sector, around 81 TWh of fuel was used in 2019 and 2020. Of that, around 33% was fossil fuels meaning that 27 TWh needs to be substituted with sustainable alternatives to achieve a fossil free industry. Regarding the natural gas which directly can be replaced by biomethane, the used amount was 3 TWh and the amount of LNG used was approximately 1 TWh as an average of 2019 and 2020.[68]

Potential

There are several studies based on the biogas potential with both high and low assumptions. A study from Biogas Solutions Research Center has compared the potentials from many studies and tried to make a realistic potential for Sweden, Finland as well as the other Nordic countries.[69] The substrates included in the study were food waste, manure, sludge, food industry waste, landscaping waste, straw, agricultural residues and low ILUC crops. The excluded substrates were marine biomass and forest industry waste. The energy

[63] EnergiGas Sverige. Biogasstatistik 2021. https://www.energigas.se/media/cgtkvm3p/biogasstatistikrapport_2021_webb.pdf Visited 14 Feb. 2023.

[64] EnergiGas Sverige. Biogasstatistik 2021. https://www.energigas.se/media/cgtkvm3p/biogasstatistikrapport_2021_webb.pdf Visited 14 Feb. 2023.

[65] EnergiGas Sverige. Biogasstatistik 2021. https://www.energigas.se/media/cgtkvm3p/biogasstatistikrapport_2021_webb.pdf Visited 14 Feb. 2023.

[66] https://www.energigas.se/fakta-om-gas/biogas/statistik-om-biogas/ Visited 14 Feb. 2023.

[67] https://www.energigas.se/om-oss/nyheter-och-press/nyheter/anvandningen-av-biogas-slar-rekord/ Visited 14 Feb. 2023.

[68] Jivén, K., et. al., (2022) Can LNG be replaced with Liquid Bio-Methane (LBM) in shipping?

Publ. No FDOS 28:2022. Available at https://f3centre.se/en/renewable-transportation-fuels-andsystems/

[69] https://nordicbiogasconference.com/wp-content/uploads/2022/10/P1_5_Axel-Lindfors_The-current-Nordic-biogas-and-biofertilizer-potential.pdf Visited Dec. 14, 2022.

potential in Sweden is almost 13 TWh/year. It is manure that has the greatest potential followed by straw and crops (low ILUC). Moreover, the calculated carbon dioxide production potential for Sweden, when upgrading to biomethane is 1400 kton/year.

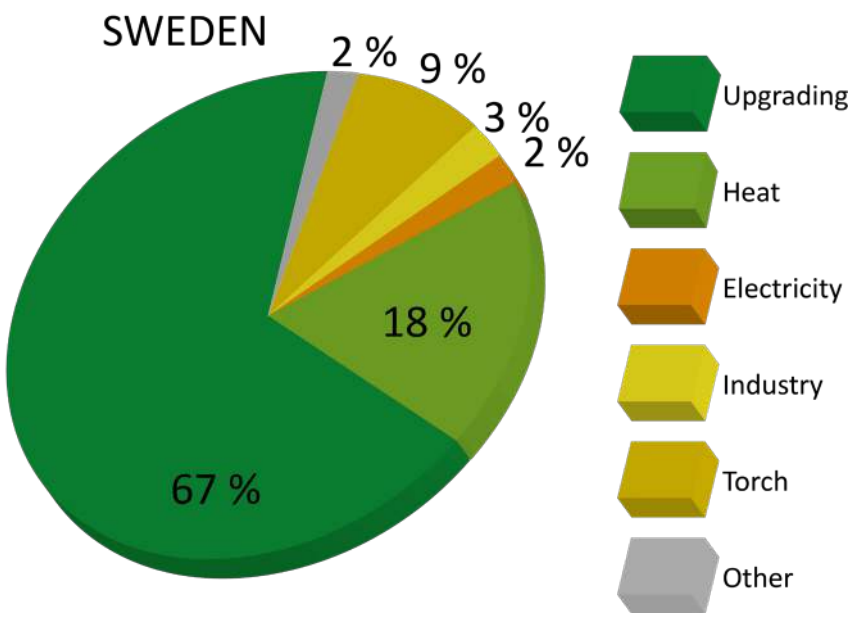

Figure 6. The usage of the produced biogas and biomethane in Sweden in 2021.

Market situation

The main drivers for decarbonisation in Sweden the past 30 years has been the incentives of high CO_2 and energy tax on fossil fuels and tax exemption for renewables. In sectors with high taxes, for example the transportation sector where the upgraded compressed biomethane has been used to a large extent. But for sectors with lower taxes like in the industry, the tax advantage is lower and hence, there has been a minor use of biomethane instead of natural gas in that sector. The tax exemption is focusing on the consumption side. It is more common to have support schemes on the production side, which is the case in for example Denmark. This has led to that biomethane imported from Denmark to Sweden can be double subsidized, which has been a problem for increasing the biogas production in Sweden.[70] However, during the last 2-3 years, the subsidized imported biomethane has been rather competitive with natural gas and the biomethane demand in the industry has been increasing.[71] The tax exemption for biogas and biomethane has been prolonged to 2030, but was revoked by the EU Tribunal as a result of an appeal by the German company Landwärme who claimed that there should have been an added investigation upon the Swedish tax exemption by the commission as they had raised claims. The result was that as of March 5th the tax exemption in Sweden has been revoked, but at the same time, the commission published the new updated version of GBER which allows Sweden to add the tax exemption for biogas here instead. This would be a good long-term solution for biogas if the government of Sweden chooses to do so.[72]

In Sweden, there is a Local climate investment programme, which gives up to 45% for all types of GHG reduction measures, including support to biomethane plants and filling stations (Klimatklivet 2015-2023). There has also been an innovation cluster (2018-2021, around 20 million Euros) called DriveLBG, which supported LBG investments, including biomethane liquefaction plants, filling infrastructures and long-haul heavy-duty vehicles.

[70] Decorte, Mieke (EBA); Tessens, Sam (Biogas-E); et al. 2020. D6.1 | Mapping the state of play of renewable gases in Europe. p. 9. Download at: https://www.regatrace.eu/wp-content/uploads/2020/02/REGATRACE-D6.1.pdf Visited Dec. 1, 2022.

[71] Decorte, Mieke (EBA); Tessens, Sam (Biogas-E); et al. 2020. D6.1 | Mapping the state of play of renewable gases in Europe. Download at: https://www.regatrace.eu/wp-content/uploads/2020/02/REGATRACE-D6.1.pdf p. 49. Visited Dec. 1, 2022.

[72] https://www.energigas.se/om-oss/nyheter-och-press/nyheter/nya-mojligheter-nar-eu-kommissionen-godkanner-andringar-i-gber-for-att-underlatta-den-grona-och-digitala-omstallningen/ Visited March 23, 2023.

In Sweden, a Biogas Market Study was done in 2020, which has been presented but not yet implemented by the parliament. The national production goal set by the market study is 10 TWh of biomethane by 2030 and different production supports for biogas from manure, upgrading and liquefaction.[73]

Long-haul traffic

Since 2018, the number of LNG/LBG vehicles have grown each year. At the end of 2021, there were 375 registered LNG trucks, which is an increase with 176 vehicles or 88% in one year.[74] In 2022, close to 600 trucks were on the road or have been ordered. It is estimated that up to 8000 trucks could be using bio-LNG of the approximately 80 000 trucks that are on the roads in Sweden on daily basis.

CNG/LNG filling stations is shown in a map at Swedish Energy Association homepage.[75] In 2022, there are 219 CNG/CBG filling stations and 29 LNG/LBG filling stations in Sweden, where most of the stations are located in the south and middle of Sweden. The share of biomethane in the filling stations has continuously increased and in 2021 it was 96% for CBG and 65% for LBG.[76]

The use of biomethane as vehicle fuel has been targeted by the biogas sector to be 12 TWh in 2030.[77] Today around 1.5 TWh is used as vehicle fuel. An estimation of the future demand for LBG for heavy vehicles is around 4 TWh in 2040.[78]

Maritime sector

Today the use of bio-LNG for shipping is very limited although there is an increase for LNG as shipping fuel to comply to the new emission regulations by the EU. The Swedish part of marine fuel of LNG on an international bunkering market is hard to define, as there are many variables such as the fuel bunkered in Sweden, or the ship movement between Swedish and foreign ports. It is estimated that 25 TWh of LNG is being bunkered annually in Sweden. A possible development of mixing bio-LNG with LNG in shipping could mean, that for Swedish shipping close to 4 TWh LNG would be a possible potential for bio-LNG of the total 22 TWh possible bio-LNG production in Sweden by 2030.

Biogas in the industry sector

In Sweden, there are several on-going projects in the field of developing the biogas process further, for example reformation, power-to-x and liquefaction of carbon dioxide.

In Linköping, the biogas plant at “Tekniska verken” will start to capture and liquefy carbon dioxide that is removed during upgrading of biogas to biomethane. The project has received funding from the so-called Klimatklivet and is planned to start in 2024.[79]

---

[73] EBA 2020. ”Statistical Report of the European Biogas Association 2020.” Brussels, Belgium, January 2021. p. 105.

[74] https://bioenergitidningen.se/storsta-bestallningen-av-biogaslastbilar-i-sverige/ Visited March 23, 2023.

[75] https://www.energigas.se/fakta-om-gas/fordonsgas-och-gasbilar/tanka-gas/ Visited March 30, 2023.

[76] https://www.energigas.se/fakta-om-gas/fordonsgas-och-gasbilar/statistik-om-fordonsgas/ Visited March 30, 2023.

[77] https://www.energigas.se/library/2778/gasbranschens-faerdplan-2.pdf Visited March 30, 2023.

[78] Jivén, K., et. al., (2022) Can LNG be replaced with Liquid Bio-Methane (LBM) in shipping? Publ. No FDOS 28:2022. Available at https://f3centre.se/en/renewable-transportation-fuels-andsystems/ Visited Feb. 6, 2023.

[79] https://www.tekniskaverken.se/kontakta-oss/press/pressmeddelanden-och-nyheter/?id=3335892 Visited Feb. 7, 2023.

The Swedish chemistry company Perstorp is highly interested in biogas as a carbon source for methanol. In a project called Project air, the companies Perstorp, Fortum and Uniper is aiming to replace 200 000 tonnes of fossil methanol with biobased. Methanol is the starting compound for manufacturing of a lot of other chemicals and today natural gas is used to a large extent. The biogas will be gasified to syngas.[80]

In the metallurgic industry, hydrogen has become an option to replace fossil carbon, for example as a reducing agent in the steel process. The company H2greensteel, is aiming to produce 5 million tonnes of green steel by 2030 and will use large amounts of hydrogen. Biogas is a possible source to produce green hydrogen.[81] Höganäs is another company in the metallurgical sector that is looking into the possibilities to reform biogas to hydrogen.

SSAB in Oxelösund is building a fossil free steel manufacturing site that is planning to be finalized in 2026. The source for process heating, which today is fossil oil, will be substituted to LNG to start with and step by step substitute with LBG. An LNG-terminal is under construction in the port and will be ready in 2023 with a volume of 30 000 m^3. Then, a 2 km pipeline will serve SSAB with LNG. Hopefully, the Oxelösund port will enable transportation of LNG on train, which today is very uncommon. In 2026, the share of biogas in the LNG is aiming to be 30% of the total usage of around 600 GWh per year. The source for LBG is not yet decided but will probably be a combination of a production onsite and from other biogas plant(s).[82]

Gas grid

The Swedish biomethane market is to a large extent off-grid with several small local and regional grids or stand-alone biogas gas plants and filling stations. The gas pipeline infrastructure is limited to the south-western part of Sweden where the transmission network is connected to European gas network via Denmark. There is also a regional gas network in Stockholm, fuelled with locally injected biogas and shipped LNG.[83] Furthermore, there are local gas grids in many cities in the middle and southern parts Sweden; nine with a length of less than 5 km and ten with a length of more than 5 km.[84] To connect biomethane to the natural gas grid, the biomethane producer pays for the cost of the connection investment and is also responsible for gas quality measurements. At local/regional grids there may be other procedure (up to the grid owner).[85]

[80] https://projectair.se/en/about-project-air/ Visited Jan. 16, 2023.

[81] https://www.h2greensteel.com/articles/the-colors-of-hydrogen Visited Feb. 7, 2023.

[82] https://www.energigas.se/publikationer/tidningen-energigas/full-gas-mot-fossilfritt-stal/ Visited Feb. 14, 2023.

[83] Decorte, Mieke (EBA); Tessens, Sam (Biogas-E); et al. 2020. D6.1 | Mapping the state of play of renewable gases in Europe. Download at: https://www.regatrace.eu/wp-content/uploads/2020/02/REGATRACE-D6.1.pdf Visited March 23, 2023.

[84] https://www.energigas.se/media/boujhdr1/biomethane-in-sweden-210316-slutlig.pdf Visited March 23, 2023.

[85] Decorte, Mieke (EBA); Tessens, Sam (Biogas-E); et al. 2020. D6.1 | Mapping the state of play of renewable gases in Europe. p. 52. Download at: https://www.regatrace.eu/wp-content/uploads/2020/02/REGATRACE-D6.1.pdf Visited Feb 3, 2023.

In the taxation regulation and the sustainability criteria scheme, mass balancing is possible for biomethane in gas grids since 2011. It means that a user can buy and claim a share of biomethane from the gas grid even though it is a physical mix of natural gas and biomethane. It is a purchasing contract between the user and the supplier, when the supplier is responsible that the same amount has been injected to the grid. This green gas concept is applicable for both imported and domestic biomethane and is possible also between gas grids in Sweden that is not physically connected.[86]

In 2021, there was 14 injection points for biomethane in the south-west and Stockholm gas grids. The share of biomethane in the south-western gas grid was 32% and in Stockholm gas grid 78%, respectively.[87]

[86] Decorte, Mieke (EBA); Tessens, Sam (Biogas-E); et al. 2020. D6.1 | Mapping the state of play of r enewable gases in Europe. p. 52. Download at: https://www.regatrace.eu/wp-content/uploads/2020/02/REGATRACE-D6.1.pdf Visited Feb. 3, 2023.

[87] https://www.energigas.se/fakta-om-gas/biogas/statistik-om-biogas/ Visited Feb. 14, 2023.

Summary

Today, there are different main markets for biogas and biomethane in Estonia, Finland, Latvia and Sweden. 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. Then, there are more available options for the main product biomethane, either compressed or liquefied. CBG can be injected to the gas grid and LBG is effectively transported. Moreover, the capture and usage of the carbon dioxide is an upcoming potential. The market potential in both maritime and industry sectors, will probably most demand for liquefied biomethane, which is increasing in both Sweden and Finland. In the transportation field, the future trend is likely to switch from light vehicles and CNG/CBG use towards long-haul transports and LBG use. The biogas potential in all the countries is big and the European Union is pointing out biomethane as a key player in the REPower EU and Fit for 55.

The countries have different support schemes for biogas, which might be a factor for the 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.

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 traffic	Maritime	Industy	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 biomethane into the gas grid.
Finland	A lot of biogas plants upgrade and/or liquefies biogas.	Several LNG-ferries in traffic	Several ongoing projects, most in PtX and hydrogen as main product.	Gas grid only in the southern part. Possible to inject biomethane into the gas grid.
Latvia	One biogas plant is upgrading to biomethane. 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.
Sweden	Frontrunner in EU in long-haul traffic. 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, CO_2-liquefation during upgrading.	Gas grids only along the west coast and several local gas grids. Possible to inject biomethane into the gas grid.

Graphics and photos

All illustrations and figures are produced by BioFuel Region.

Photos of the IVECO, Scania and Volvo trucks are provided by respective company or sourced from respective media bank.

Best Ace

The project helps develop natural gas grid infrastructure and use biomethane efficiently in long-haul and maritime transports as well as in the industry sector.

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