The Nordic success story on biogas for mobility

IT'S TIME FOR EUROPE TO FOLLOW

Despite all the current efforts at the EU level, greenhouse gas emissions are not decreasing in the transport sector. Every gram of fossil CO_2 emitted today into the atmosphere, puts the Paris Agreement's global warming targets at risk. Emissions reduction must start now.

This requires a balanced approach where major technology shifts, such as electric and fuel cell vehicles, are combined with prompt introduction of climate-smart, affordable technologies that are available today, ready to be scaled up quickly. Biomethane, upgraded biogas, from waste and residues is indeed one of these technologies.

The problem is: EU regulation hampers any efforts to advance biogas for mobility.

A joint paper from the Nordic biogas and gas associations:

- Swedish Gas Association (Energigas Sverige)
- Finnish Biocycle and Biogas Association
- Biogas Danmark
- Energigass Norge

We call on EU policy makers to eliminate the regulatory obstacles by taking three constructive measures, all of which fit within the European Green Deal Framework:

EU Sustainable and Smart Mobility Strategy

Recognize biomethane as an important part of the solution to faster decarbonize the transport sector, and a cost-effective way of achieving global sustainable development goals.

Biomethane has an obvious role to play in heavy duty transport and shipping, where electrification is more difficult and expensive, but also in other segments (e.g. passenger cars, vans and buses) where more than one technology will be required to meet increasing climate ambitions in the wake of the Green Deal.

CO_2 emission standards for vehicles

Introduce into the regulation a level playing field, recognizing the contribution in emissions reduction achieved using biomethane and other advanced renewable fuels.

Today, the climate benefits of biomethane is not recognized within the CO_2 emission standards. Vehicle manufacturers are consequently discouraged from developing and offering cars and vans running on biomethane. Eventually the regulation is expected to have a similar effect on the heavy-duty segment.

In this context, the CO_2 emission standards, as they are designed today, are preventing Europe from exploiting the full potential and advantages of biomethane in transport. This is entirely inconsistent with the scientific findings, which are clear: Biomethane represents one of the absolute lowest greenhouse gas intensive options applicable to decarbonization of road transport (JEC Well-To-Wheels report v5). The current CO_2 emission standards are also contradictory to the revised Renewable Energy Directive setting a favourable framework for the uptake of biomethane in transport.

Leveraging on the CO_2 emissions reduction only at tailpipe level has clearly not been sufficient to ensure the shift to carbon neutral mobility. Furthermore, since the entry of full electric and fuel cell vehicles into the market, CO_2 emissions at tailpipe level do no longer function as a measure of vehicle energy efficiency. All in all, this adds to the list of good reasons to question the leveraging on the CO_2 emissions reduction only at tailpipe level.

Alternative Fuels Infrastructure Directive

Continue to require Member States to ensure minimum coverage of refuelling points – including both gas and electricity – and make sure infrastructure is used to distribute a growing share of renewable gas as well as renewable electricity.

When the CO_2 emission standards are modified to enable the industry to develop and offer vehicles running on biomethane, the Alternative Fuels Infrastructure Directive needs to ensure a well-developed refuelling infrastructure throughout the EU.

By setting ambitious targets for emissions reduction, renewable energy, and circular solutions – and by promoting an efficient cross-border trade of biomethane – a gradual increase of biomethane will be ensured in both refuelling points and vehicles.

Biomethane – the decathlon winner

Biomethane offers solutions to several human long-term challenges: climate, soil fertility, clean water, and good air quality. Biomethane turns a waste problem into a resource. Scientific findings show that biomethane contributes, directly or indirectly, to every one of the 17 UN Sustainable Development Goals[1].

Ten areas in which biogas and biomethane are high achieving:

1. Decarbonization and fossil fuel exit
2. Circular economy and resource efficiency
3. Clean air and improved health
4. Smart sector integration and green electricity
5. Sustainable agriculture and eco-farming
6. Biodiversity and sustainable soil
7. A healthy marine ecosystem and forest protection
8. Security of supply
9. Rural development
10. Green jobs and a green recovery

This makes biomethane unique compared to other alternatives in the areas of waste treatment and transport. Most technologies tend to solve one problem at a time. But biomethane is the decathlon winner who may not win every single discipline but performs excellent in all of them. This makes biomethane a particularly cost-effective solution in the transition to a sustainable society.

Furthermore, being based on proven technologies, biomethane is readily available, scalable and contributes to maintain a strong automotive industry in the EU.

Scientific findings are clear: Biomethane is top of the class

From all combinations of fuel/energy carriers and powertrains explored, biomethane represents one of the absolute lowest greenhouse gas intensive routes. This is concluded in a recently published Science for Policy report (JEC[2] Well-To-Wheels report v5) by the Joint Research Centre (JRC), the European Commission's science and knowledge service.

The study argues that greenhouse gas emissions are associated with both fuel production and vehicle use; hence it is only by considering the whole pathway (Well-To-Wheels) that the overall impact of fuel and vehicle choices can be seen. From that starting point the study aims to provide, in a transparent and objective manner, information to guide future choices of fuel and vehicle technologies towards the 2025+ timeframe, meaning evidence-based support to the European policy making process.

One of the key findings to consider in the revision of the EU transport regulation is the outstanding greenhouse gas emission reduction performance of biomethane. The climate benefits of using biomethane are, according to the study, similar to the use of renewable electricity and synthetic diesel (e-fuels). Even significant negative emissions can be derived from routes involving biogas or biomethane from manure, as shown by the graph on the next page.

Additional advantages of biomethane, like the contribution to the UN Sustainable Development Goals, were not included in the scope of the study but should of course be considered in the EU's regulatory challenges.

[1] The Role of Biogas Solutions in the Circular and Bio-based Economy, Biogas Research Center, 2016

[2] The JEC Consortium WTW study was carried our jointly by experts from the **J**RC (EU Commission's Joint Research Centre), **E**UCAR (the European Council for Automotive R&D), and **C**oncawe (the refining European association for environment, health and safety in refining and distribution).

General remarks from the [JEC Well-To-Wheels report v5]:

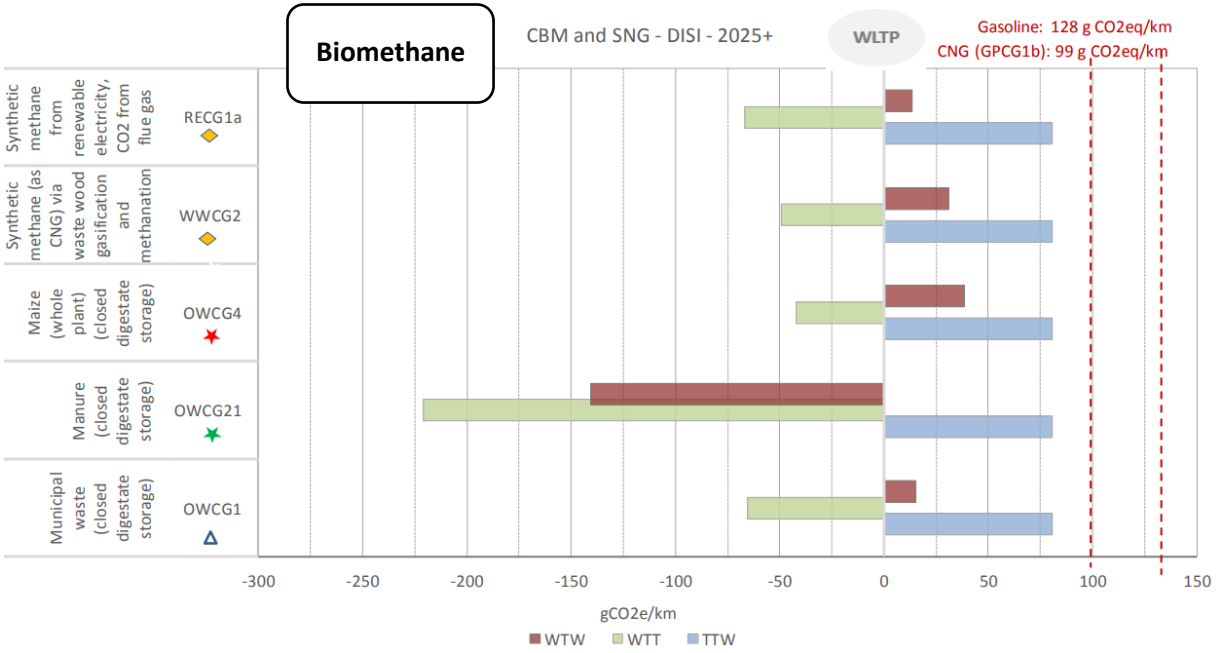
"From all combinations of fuel/energy carriers and powertrains explored, the **HVO pathway with the DICI Hybrid technology** (waste as feedstock) and the use of **CBM in a SI MHEV** represent the lowest GHG routes."

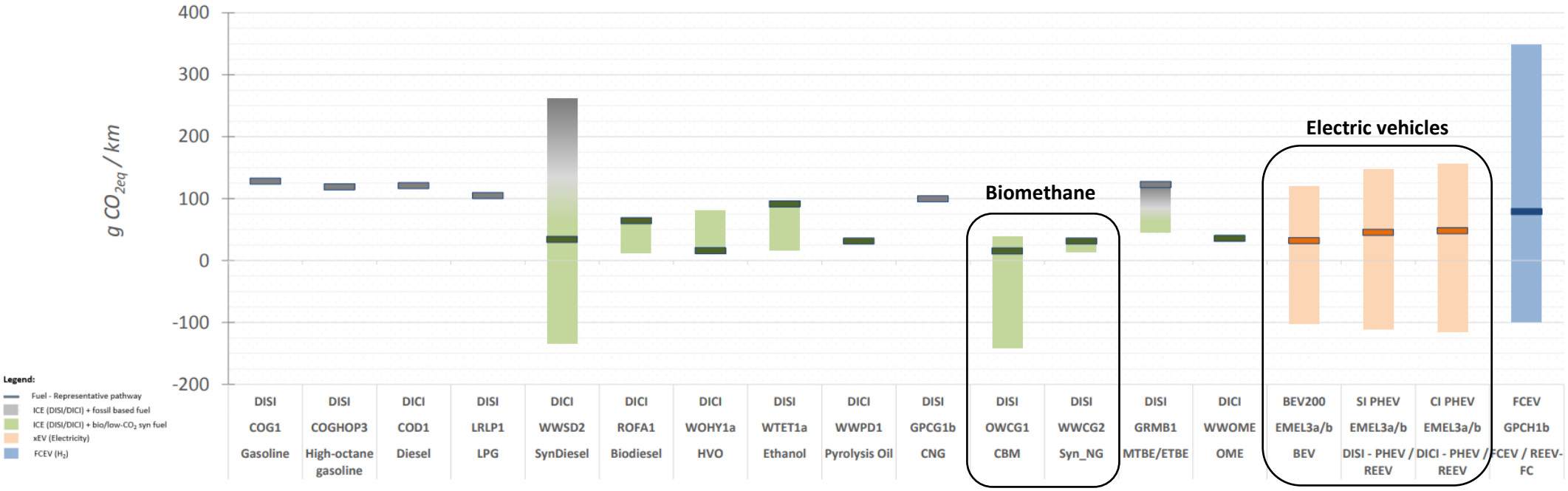
"The use of **renewable electricity for xEVs and FCEV** offer one the lowest WTW intensive combinations similar to the use of **biomethane and syndiesel (e-fuels) in DICI**."

"Significant negative emissions can be derived from routes involving biogas from manure due to the avoided CH_4 emissions."

"In case of electricity negative GHG emissions occur for electricity from biogas from liquid manure due to credits for avoided CH_4 and N_2O emissions from avoided storage of untreated liquid manure."

The graphs are from the JEC Well-To-Wheels report v5. All abbreviations are explained in the report (p. 123-125).





The Nordic success story is based on determined policy actions

In the Nordic countries, politicians have identified biomethane as a unique and valuable resource to society. A circular economy is being developed here, using a combination of state, municipal and private biomethane investments.

Please have a look at the appendices (1-4) to learn more about the Nordic examples.

Biomethane for transport in Sweden
The Swedish state provides investment subsidies and a premium for sustainable biomethane production. Refuelling infrastructure is subject to investment support.

In terms of end user incentives, the policy makers are equally dedicated. Purchase of gas driven vehicles are encouraged in passenger car segment as well as on the light and heavy-duty side. The incentives are created through a climate premium for trucks, a purchase bonus for cars and vans as well as strict environmental zones in cities, allowing only electric and gas driven vehicles.

By applying long-term tax exemption on biomethane, Swedish politicians ensure that vehicles are refuelled with renewable and sustainable biomethane, resulting in a world-leading biomethane share of 95 percent.

The recently launched governmental biogas inquiry suggests a national target on biomethane production, additional provisions, and long-term subsidies to exploit the full potential of biomethane and its broad and unique benefits to society.

Finland shows strong support for the development of the biogas sector
Biogas, biomethane and nutrient recycling are well present in the Prime Minister Marin's Government Programme for 2019–2023 (published in June 2019). The biogas has been linked with the tasks aiming at decarbonizing transportation and agriculture sectors, and with improving competitiveness of the Finnish food production amongst others. A national biogas action plan was published in January 2020.

The most important subsidy schemes targeted to the biogas sector are energy investment aid for biogas plants and that biogas/biomethane is exempt from excise duties. A new investment aid targeted to nutrient recycling will be available for applicants in the coming months. A new incentive scheme for the treatment of agricultural waste and residues in a biogas plant is also under development.

The existing supporting schemes of gas vehicles are consisted of an investment aid for new gas filling stations, investment aid for heavy duty vehicles and aid converting passenger cars to gas. Also, the extension of the national biofuel delivery obligation to biomethane is under preparation, which has been estimated to be a very relevant measure to increase the use of biomethane in road transport.

A working group (under the Ministry of Transport and Communication) has recently recommended to strengthen the role of biomethane in the transport sector by giving several specific recommendations for increased production and use.

Circular economy and sustainable food production in Denmark
In Denmark national legislation regarding energy policy, agriculture and circular economy has for decades driven the development of the Danish biogas sector. Co-digestion of livestock manure and organic residues from industry, households and agriculture is a second to none technology to meet national and international challenges and targets.

Denmark is a world leader when it comes to utilizing livestock manure in biogas plants – both ensuring a more sustainable food production with reduced impact on the surroundings due to leaching of nitrates and smell when livestock manure is used as fertilizer, and increasing the value of the manure for the farmers through increased yields. In Denmark 20 percent of the livestock manure is treated in biogas plants – and currently the biogas production substitutes more than 20 percent of the natural gas consumption.

The potential is, however, more than four times higher so that biogas can totally substitute the national gas consumption within the next couples of decades. Hereby, there is potential to supply the needs for renewable gas in both industry and heavy-duty transportation.

In Denmark there are only approximately 700 gas vehicles but a very big interest among transport companies to shift from fossil diesel to renewable gas.

Biomethane from Norwegian fish farms
Biogas production in Norway emerged primarily as a waste treatment option for sewage sludge. Due to a large share of hydropower in the electricity grid and low prices on electricity, there have earlier been few drivers for producing energy from waste resources in Norway.

However, the interest in biomethane has increased the recent years and is now used in heavy-duty vehicles, industry, and shipping. An important decision has been the newly definition of heavy-duty vehicles as toll-exempt vehicles.

Norway has an economic incentive system with support to farmers per tonne of manure supplied to a biogas plant. Investors of industrial-scale biogas plants can apply for investment support through the Enova programme. Farm-scale plants can apply for investment support through Innovation Norway.

In 2018 Biokraft opened the world's largest liquid biogas producing facility and it will produce 250 GWh when completed. The delivery is mostly made of organic by-products collected from salmon farms and a nearby paper mill. Several more production facilities for liquefied biogas are currently under planning or construction.

The Nordic example can be replicated – if there is political will

The Nordic region is a world leader in biomethane production and use for transport. But what we do in the Nordic countries can, and should, be done wherever there are organic waste and transport needs.

Everywhere in Europe, both in urban and rural areas, there are waste and residual feedstocks available for production of biomethane. Wherever there is livestock production there is also a need to reduce methane emissions from manure by producing biogas and biomethane.

The Nordic success story is not based on any particularly favourable conditions applying only to the Nordic region, but rather on a clear political will at local, regional, and national level.

Time to scale up to European level

Europe, and the rest of the world, need to do what we have done in the Nordic region, to accelerate the decarbonization of transport and achieve the Sustainability Development Goals in a cost-effective way. Several countries are already well on their way and making good progress. Countries like Italy, France and the Netherlands are following the Nordic example. In general, there is a growing interest all over Europe today in using biomethane as transport fuel.

A large part of the necessary investments has already been made. Around Europe, there are more than 4,000 refuelling stations ready to deliver biomethane to the fuel market, which 25 percent of them already do (to a variable extent up to 100 percent). The vehicle manufacturers have for several years developed efficient gas-powered vehicles. Together they offer many models to choose from.[3] Already today, these vehicles can easily run on 100 percent biomethane, without any modifications at all.

The potential is too significant to be overlooked

Biomethane will not cover the entire energy demand of the transport sector. Other sustainable technologies, such as electrification, hydrogen and liquid biofuels will be important as well. But the potential of biomethane is too significant to be overlooked in the context of the EU transport policy.

From today's production of 22 TWh, Europe has a potential of producing about 1,200 TWh biomethane in 2050.[4] That is enough to cover approximately 25 percent of today's road fuel consumption in Europe. When including the anticipated decrease in fuel demand – due to for instance increased efficiency, electrification and hybridisation – the contribution of biomethane would be even greater.

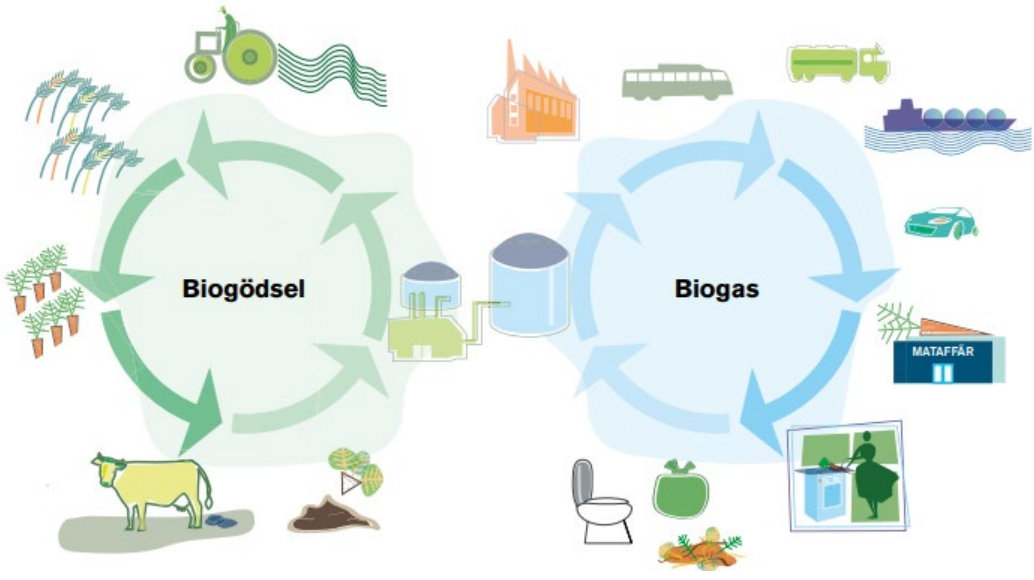
[3] NGVA Europe Vehicle Catalogue 2019: https://www.ngva.eu/wp-content/uploads/2019/08/NGVA-Europe_VehicleCatalogue_2019.pdf
[4] European Biogas Association, EBA.

Appendix 1: Sweden

The Swedish biogas journey began with natural gas. Already in the late 1980s, the first gas buses were introduced in Sweden. They were built on site and ran on natural gas. During the 1990s, more and more Swedish cities began to replace their diesel buses with gas buses, after which air quality improved markedly. Vehicle manufacturers then started to develop gas buses of their own. Almost at the same time, biogas got its big breakthrough. Now there was suddenly a market for biogas. Sweden started to build co-digestion plants, and biogas was upgraded to fuel quality; biomethane.

Sweden went from pioneer to world leader. Swedish engineers developed the technology, built up companies, and won customers all over the world. At this point, Sweden took its place as an international showroom for smart biogas solutions in the transport sector. Since then, many delegations from different continents have travelled to the small country in the north to bring Swedish experiences to their home countries. Swedish biogas expertise is now a highly sought-after commodity, worldwide.

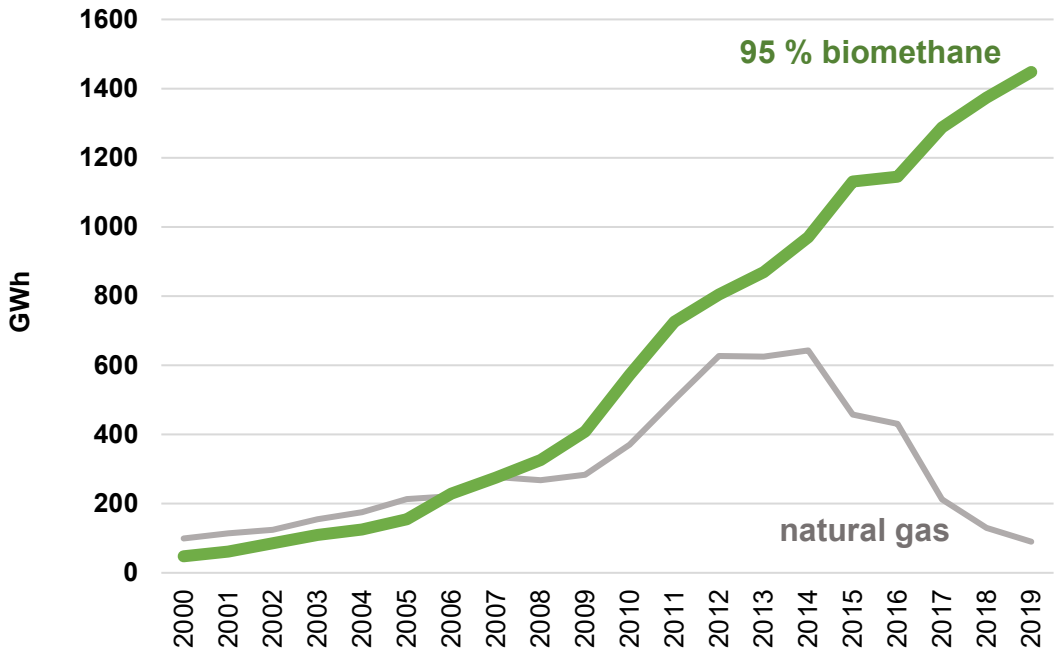
Local and regional cooperation laid the foundation for the Swedish success story. Biogas was identified early on as a unique asset to society. With this insight, Swedish cities began to develop cross-sectoral cooperation between waste, sewage, transport, and agriculture. Public and private actors worked together to establish local and regional circularity, with biogas production at the heart. Here, organic waste from households, restaurants, industry, and agriculture is converted into biomethane used to fuel city transport vehicles. At the same time, nutritious biofertilizer is produced and cycled back to ecological agriculture. It's renewable, it's sustainable and it's circular economy in practice.



With the help of natural gas, Sweden built a growing market for biomethane as a fuel. Biogas production, refueling infrastructure and gas-powered vehicle fleets are three essential parts of the biomethane puzzle. They all had to expand simultaneously, and natural gas helped grease the wheels during the critical build-up phase. During the early years of the market development, the security of supply of natural gas was a prerequisite for more users to make the leap to biomethane. After the arrival of gas buses, interest in biomethane grew from taxi fleets, the waste management sector and transport companies. Initially, the vehicles were powered by a mixture of natural gas and biomethane. As biomethane production grew, natural gas was gradually phased out. Today, the Swedish fuel in gas-

powered cars, vans, busses, and waste collection vehicles is virtually fossil-free. The biomethane share is 95 percent.

The graph below shows sales of biomethane and natural gas in road transport in Sweden.[5] It illustrates the important role of natural gas in early market development.



The biomethane market is growing rapidly in Sweden. The automotive industry is developing new solutions that make it possible and cost-effective to run long-haul heavy-duty vehicles on liquefied biogas (bio-LNG). Production and distribution of liquefied biogas is growing in parallel with the haulers shifting from diesel to biomethane. With the help of liquefied natural gas (LNG) Sweden is now en route to biomethane success again – but in much faster pace this time. Already today, the liquefied gas consists of almost 50 percent biomethane.

The interest in biomethane is spreading to industry, shipping, and power and heat sector. This is positive for the willingness to invest and the strong expansion of the biomethane production that Sweden wants to see. With waste and residues there are good opportunities to meet demand with sustainably produced Swedish biomethane – today and in the future.

Swedish research identifies biomethane production as an effective way to make high-quality products from waste and residues. Already with existing technology there are several ways to produce biomethane, from many different types of waste and residues. With technology development, innovations and a growing bioeconomy, even more production routes are created. This gives a certainty that the availability of raw materials does not have to become a limiting factor for increased biomethane production. With excess electricity from wind and solar, we can also, via hydrogen, get even more biomethane from the same amount of substrate (Power to Methane). In this way, we get not only a smart sector integration but a super smart integration of electricity, heat, gas, transport, waste management and agriculture.

[5] Data from Statistics Sweden (Statistikmyndigheten SCB)

Appendix 2: Finland

Biomethane production combined with wastewater treatment is a good practise of circular economy

The main purpose of the wastewater treatment is to remove nutrients and organic material from the wastewater before returning water back to natural waters. There is separate legislation regulating the wastewater treatment. The environmental standards of wastewater treatment are also becoming stricter all the time.

Sludge is generated during wastewater treatment. In Finland, about 1 million tons of sewage sludge (wet weight) is generated annually by municipal wastewater treatment plants. As large amounts of sludge are generated each year, their utilization requires attention. To meet the environmental requirements, the treatment of sewage sludge can be expensive. In a modern world, it is not only how to get rid of sewage sludge, but how to get most value out of it. The economics of treating the sewage sludge is consisted of treatment costs and the price of the end products. The end products can be renewable heat and power, biomethane and different kinds of the organic and mineral nutrients that can be used in industry or as fertilizers as well as soil improvers.

In Finland, about 80 percent of the sewage sludge is processed by anaerobic digestion. Other treatment options are for example composting or chemical treatment. In most cases at least two treatment processes are utilized together, usually digestion and composting. Pyrolysis of sludge is also studied in Finland for possible future treatment option. The role of anaerobic digestion is becoming more common because it is a cost-efficient way of treating the sludge. The biogas generated in anaerobic digestion can be utilized as a source for electricity production and/or for process heat at the wastewater treatment plant. In some cases, particularly in large volumes, it is economically wise to upgrade/clean the biogas to biomethane. The biomethane can then be sold, transported, and used outside the plant.

An excellent example of a modern wastewater treatment model can be found in Turku, a Finnish city at the Baltic Sea. From the sludge delivered from that plant, and other nearby plants, a Nordic gas company, Gasum, produces domestic liquefied biogas being the first operator in Finland to liquefy biogas so far.

Gasum's expanded biogas plant in Turku increases local and national availability of biogas for industry, maritime and road transport

The biogas plant in Turku was expanded and modernized in 2019-2020. The expansion of the plant was one of the Finnish government's Bioeconomy and clean solutions key projects. These projects seek to sustainably increase the share of renewable energy in Finland, particularly by increasing the availability of renewable energy. The Turku project boosts also the growth of the Finnish biogas market and promotes the development of the heavy-duty market fuelled by gas. The project also improves the opportunities to use local road fuel gas in the Turku region.

The biogas plant's feedstock processing capacity increased from 75,000 tonnes to 130,000 tonnes, and gas production doubled from 30 GWh to around 60 GWh a year. This is equivalent to the annual fuel consumption of 125 heavy-duty road vehicles or around 5,000 passenger cars. Similarly, water consumption at the plant decreased from 100,000 cubic meters to zero and the quantity of water being directed to sewer decreased from 120,000 cubic meters to 0-50,000 cubic meters.

Digestate is post-processed and two end-products produced. Aqueous ammonia solution (ammonia water) can be used for environmentally beneficial purposes such as nutrient source for wastewater treatment in the paper industry and for removal of nitrogen oxides

from flue gases at industrial production facilities. The ammonia water produced at the plant accounts for around 10 percent of Finland's total annual demand for ammonia water. The digestate solid fraction is stabilized and compost created at the plant is used for roadside landscaping in Turku, among other things.

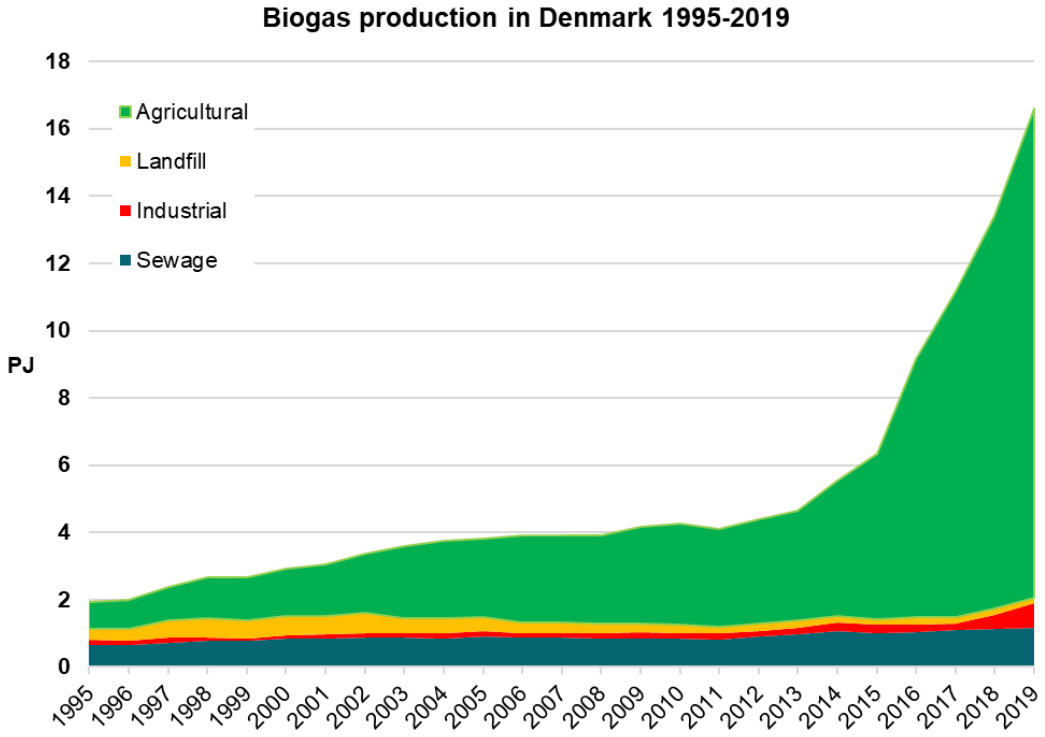
Through plant expansion, Gasum is also developing its network of gas filling stations in the Turku region, which is currently served by Gasum's three filling stations. Turku is also a participant in the EU's CIVITAS ECCENTRIC project, which is studying the best ways to build emission-free urban transport. Gasum has participated in the project by testing biogas-powered vehicles and the potential of biogas in logistics.

The number of biogas-powered garbage trucks operating in Turku are the even more concrete examples of biogas as part of a circular economy. In practice, these trucks run on the same waste that they transport.

Appendix 3: Denmark

The biogas sector – a driver in circular economy and sustainable food production

Denmark started to promote production of biogas from livestock manure, landfills, wastewater, and organic residues more than 35 years ago. In the early years, biogas collected from landfills and municipal wastewater treatment plants was the main source of biogas. But during the years co-digestion of livestock manure and organic residues from industry, agriculture and households have increased and now deliver more than 90 percent of the Danish biogas.



The co-digestion of livestock manure and organic residues makes it possible to digest the livestock manure in biogas plants reducing both the emission of greenhouse gases and the risk of leaching of nitrates to surroundings. At the same time, the energy potential in the organic residues and waste is being utilized and the nutrients are recirculated as valuable fertilizers in agriculture, substituting nitrogen in chemical fertilizers and phosphorous from scarce sources.

Until 2013 all the Danish biogas was utilized in the local CHP-plants delivering renewable electricity and district heating. Since 2014 the framework conditions opened up for upgrading the biogas into biomethane that is injected into the gas grid. This gives access to new markets and make biogas a storable renewable energy source that make use of the gas infrastructure to store and deliver biogas to distant costumers.

This symbiosis has resulted in more than 20 percent of the Danish livestock manure being digested in biogas plants in 2020. At the same time, the biogas production has increased to more than 20 PJ, whereby more than 20 percent of the natural gas consumption is substituted by renewable biogas.

The potential is, however, much bigger. A recent study from University of Southern Denmark for the Danish Energy Agency has concluded that the biogas potential from liquid slurry, deep litter, other kinds of livestock manure and in organic residues from households, industry and agriculture is 4½ times higher and can substitute the whole natural gas consumption. Biogas hereby can supply those sectors that are mostly challenged in electrification: industry and heavy-duty transportation. Especially when the CO_2 content in the biogas is utilized – either in industry or to store electricity from solar or wind power through methanation or other power-to-X processes.

Until now the use of biogas in the heavy-duty transportation has been blocked as the taxes on fuel and vehicles will increase if a transporter goes from fossil diesel to renewable and sustainable biogas.

In Denmark there are only approximately 700 gas vehicles but a very big interest among transport companies to shift from fossil diesel to renewable gas.

The Danish Parliament are still promoting further production of biogas, most recently by a new tender system that will replace the current feed-premiums for biomethane. Biogas is also a highly prioritized choice to meet the national climate target to reduce the overall greenhouse gas emissions with 70 percent by 2030. This is shown in a number of the climate-partnerships the government launched in 2019 with representatives from industries within the different sectors (food and agriculture, road transport, process industry, energy intensive industry etcetera), which in March 2020 tabled their route to meet the 70 percent target within their respective sectors.

Appendix 4: Norway

Biomethane from Norwegian fish farms

The large-scale production of farmed fish along the Norwegian coastline results in great amounts of sludge and silage each year. The sludge is a mixture of fish feed and faeces. The amount of sludge discharged along the Norwegian coastline equals sewage from 14 million people. Non-removal of the sludge can lead to toxic algal blooms and poor water quality for the fish. A transitioning into land-based fish farms ads new opportunity for collecting, production and utilization of biomethane from fish sludge and fish silage.

There are currently no regulations for collecting and treatment of sludge in open-water farming. An introduction of such regulations would give a great increase for the realistic potential of biomethane production. Today's biomethane production from fish farming is 39 GWh from fish silage.

Calculations for realistic biomethane production in 2030 is based on today's regulations and is therefore relatively small: Fish sludge 81 GWh and fish silage 188 GWh.[6]

Transitioning from open-water fish farming to land-based farms gives a whole new opportunity. The key difference is that the latter requires no antibiotics, while neither they nor their effluent comes into contact with the surrounding marine environment. Apart from generating minimal environmental impact, it will be possible to collect all waste products from and use them to produce biomethane. With little investment in existing fish farms, local energy can be produced at very little cost, thereby enabling fish farmers to generate additional revenue from biomethane made from fish residue or waste.

[6] Carbon Limits 2019, Ressursgrunnlaget for produksjon av biogass i 2030