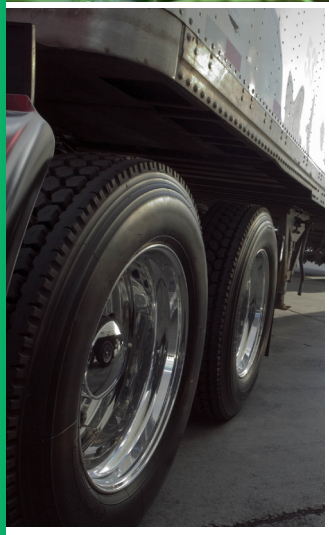
NATIONAL BIOGAS STRATEGY




PROPOSAL FOR

NATIONAL BIOGAS STRATEGY 2.0

APRIL 2018

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Foreword

April 2018

Biogas is a unique asset for society - and more important than ever. In practice, biogas is a circular economy, where waste produced by the community is transformed into renewable energy and biofertiliser. At the same time, biogas contributes to achieving society's environmental and climate goals. Security of supply, jobs and growth are other important socio-economic benefits.

In January 2018, the Swedish Government's new climate policy framework came into force. It consists of three parts; a new climate law, new climate goals and the creation of a climate policy council. This means that Sweden now has a long term and stable climate policy, with a stated goal of having zero net emissions of greenhouse gases to the atmosphere by 2045. Another important goal is to achieve a 70 percent reduction in emissions from transport by 2030.

However, the biogas sector does not have such long term rules in place. What will happen after 2020, when the current funding plan expires, is unclear. This uncertainty is making many players cautious in their investment choices.

A biogas committee was announced as part of the Swedish Government's budget. In anticipation of this report, we are now launching a new and updated National Biogas Strategy proposal. The purpose of the strategy is to contribute to achieving Sweden's established goals within the majority of prioritised policy areas through increased use of biogas within the transportation, industrial and co-generation sectors. The goal is that energy generated from biogas in Sweden shall amount to at least 15 TWh by 2030. This requires funding and action from several players; Government and Parliament, authorities, municipalities and regions, as well as the industry itself.

In addition to the Swedish Gas Association, several of the bigger players in the biogas industry have been involved in the development of the strategy, both in terms of funding and content. Therefore, the strategy is well established in the industry.

Financial backers of the National Biogas Strategy project:

- Swedish Waste Management Association
- Biogasbolaget
- E.ON
- Gasnätet Stockholm
- Göteborg Energi
- Purac
- Region Skåne
- Scandinavian Biogas
- SSAB
- Svensk Biogas i Linköping
- Swedegas
- Öresundskraft
- Swedish Gas Association

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Summary

Biogas is a unique asset for society and a prerequisite in order to enable Sweden to achieve many of the stringent climate targets set by the Swedish Government and the UN. It is part of a closed cycle where society's food waste, waste water and residues from agriculture, forestry and industry produce renewable propellants, electricity, heat, fuel and raw materials for industry, as well as biofertiliser. By producing and using biogas, society's resources are used in an efficient manner.

The biogas industry creates jobs, opens up new export opportunities and helps Sweden take the lead on climate issues. Biogas also ensures supply security as fuel and agricultural fertiliser are produced domestically Although biogas is principally used as fuel for cars and buses, it can also be used as fuel and raw material in industry, heavy transport and shipping. In practice, biogas is a circular economy and constitutes an important part of circular business development.

Consultancy company 2050 has calculated the social benefit of biogas, based on the 2 TWh production Sweden had in 2016. They came to the conclusion that it had a GDP value of about SEK 4 billion per year. The research shows that, by implementing a few simple measures, we can increase biogas production to up to 7 TWh per year. This corresponds to a GDP value of SEK 14 billion per year.

The Swedish Gas Association, working in conjunction with the biogas industry, has developed this proposal for a national biogas strategy. The overall goal is to achieve 15 TWh use of biogas by 2030 - 12 TWh for transportation and 3 TWh in industry. This would represent a GDP value of SEK 30 billion in domestic production. In order to achieve these volumes, and go even further in the next step, digestates and waste now generated by society must be better utilised during the cycle. Significant investment in new substrates, streamlining and new technology is essential. Forest-based and agriculture-based biomass are two important substrates. Larger production facilities and continued investment in the gas distribution network, including refilling stations, are also required.

Such development requires a determined strategy that involves many parties; Government and Parliament, authorities, municipalities and regions, as well as the industry itself. The current instrument, tax exemptions for customers, will cease to apply in 2020. The Swedish Government and Parliament should decide on new, long-term conditions that aim at least 10 years in the future. They must also ensure that Swedish-produced and imported biogas compete on equal terms. In addition, they should appoint a National Biogas Coordinator and introduce mandatory food waste collection requirements.

The Swedish Energy Agency should, in consultation with the relevant authorities and industry, ensure that objective, factual and coordinated information about the cumulative environmental and social benefit of biogas is made available. Municipalities and county councils in Sweden can contribute by taking the broad social benefit of biogas into account when procuring public transport services and other activities.

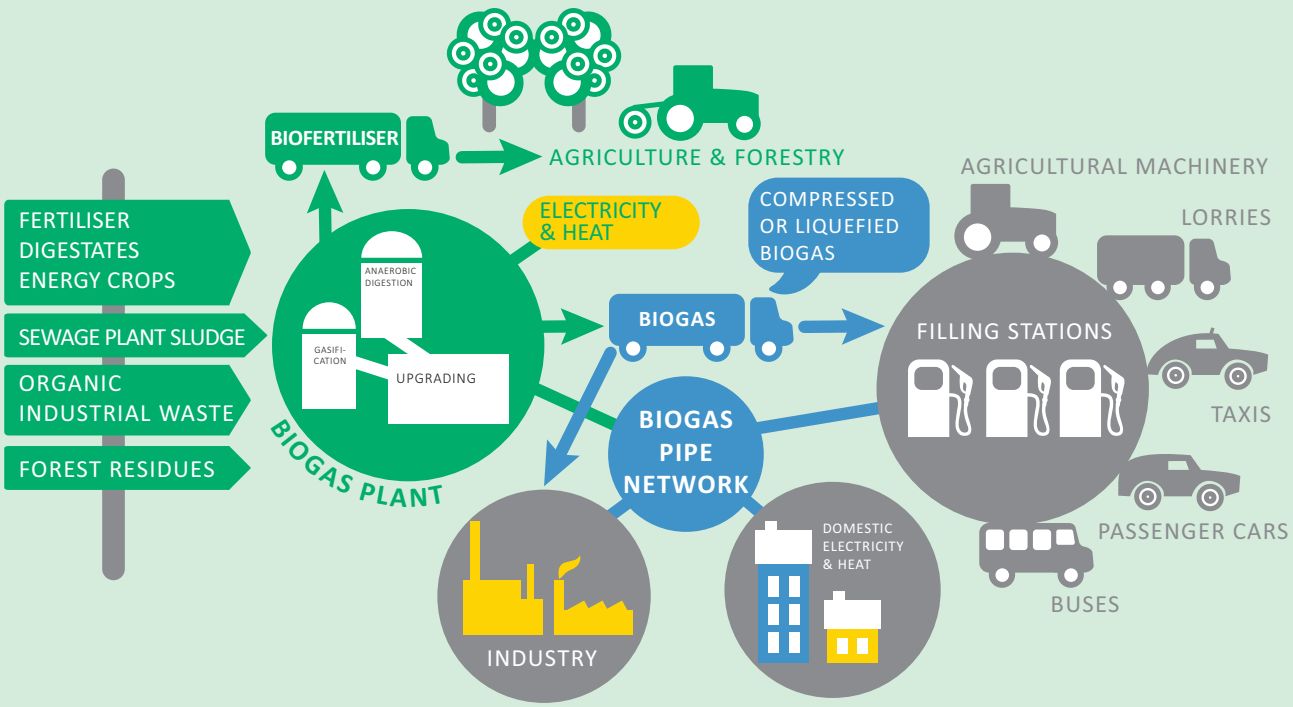
Sweden is at the absolute forefront of technology in terms of biogas. Therefore, we have a unique opportunity to drive biogas development forward. If we invest now, we can maintain and strengthen this position, creating export opportunities, security of supply, jobs and major environmental and climate benefit.

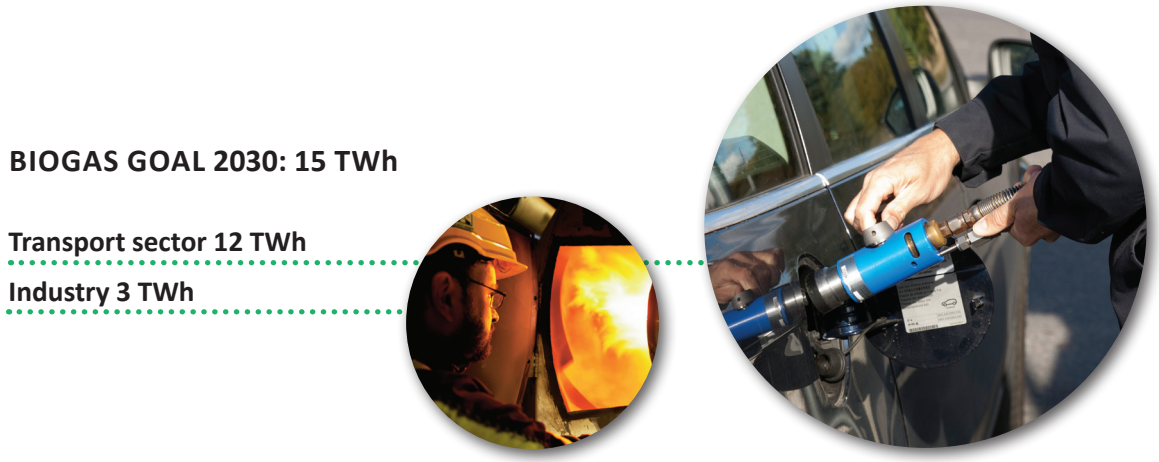
Contents

1. Goal and strategy

Biogas is an established energy product with the potential to form an important part in the renewable energy mix. Increased production and use of biogas and biofertiliser provides many benefits to society within the framework of the circular economy. In today's society, this sustainable industry is an absolute must.

However, there is still some way to go if it is to achieve its maximum potential. Clear goals and a determined strategy that involves many parties; Government and Parliament, authorities, municipalities and regions, as well as the industry itself are now required. Here are the industry's proposed goals and strategy for the development of biogas in Sweden up to 2030.





THE GOAL: BY 2030, AT LEAST 15 TWh OF BIOGAS SHALL BE USED IN SWEDEN

In order to fully utilise the benefit of biogas as a social resource, a national biogas goal is needed to act as a guide for political decisions and industry investments.

Therefore, the industry proposes that Sweden adopts the following national goals[1]:

- **By 2030, at least 15 TWh of biogas shall be used in Sweden.**

By achieving the national goal:

- biogas can become a crucial factor for success in achieving the Swedish environmental goals and contribute to the UN's global goals for sustainable development.
- organic waste and organic residues can form part of a circular economy to maximise the benefit derived by society from biogas and biogas production.
- Sweden's supply security can be increased through domestic production of biogas and biofertiliser, which becomes fuel for transport, raw materials and fuel for industry, as well as fertiliser for use in agriculture.

A use of 15 TWh biogas 2030 - 12 TWh for transport and 3 TWh in industry - is a significant increase compared to today. However, many reports show that there is potential to produce significantly more than that. For example, WSP states that 22 TWh biogas can be produced by 2030[2]. Later reports indicate that an even higher level of energy production from biomass is possible in the long term[3]. There are also new technologies with significant potential, such as Power to Gas, which convert surplus renewable electricity to biogas.

Researchers[4] believe that there are substrates from waste and residues corresponding to 7 TWh biogas where the best processing option from an environmental point of view is biogas and biofertiliser production. The collaboration platform Fossil Free Sweden[5] sees this volume as an important first step. The biofertiliser that can be produced from these waste volumes reduces mineral fertiliser imports by 10-15 percent[6]. If you include digestates from other substrates, imports of mineral fertiliser can be reduced still further.

THE STRATEGY: COORDINATED MEASURES THROUGHOUT THE VALUE CHAIN

Increased production and use of biogas and biofertiliser is necessary in a sustainable society. By using biogas and biofertiliser, we reposition ourselves to a circular economy, phase out fossil fuels and raw materials, reduce emissions of environmentally harmful substances and reduce the need for finite phosphorus resources in the form of mineral fertilisers.

The gas industry is well prepared for a transition to biogas, and has in recent years taken several steps to ensure a smooth transition to renewable gas.

However, fossil alternatives still occupy a strong market position and have a price advantage thanks to having many years' head start. Therefore, market forces are not yet able to drive this repositioning alone without the involvement of instruments.

Achieving the set goals requires action throughout the entire value chain; production, distribution and use. Digestibles, which in their most refined form can be used as biofertiliser, must also be included. The aim is transition to a circular economy and to realise the environmental and social benefits that biogas and biofertiliser offer.

Two priority measures: Equal terms and long-term conditions

The following two measures to ensure increased use and production of biogas urge:

Equal terms: The Swedish Government is encouraged to act to quickly ensure competition on equal terms for imported and Swedish biogas (see Chapter 7.1.1).

Long-term conditions: In order to achieve this goal, long-term and competitive conditions are required that apply for at least 10 years into the future. The Swedish Government is encouraged to take a decision on long-term conditions in good time before 2021 (see Chapter 7.1.2).

Promote biogas within ongoing policy processes

It is also very significant that the instruments and regulations that, at time of writing, are being addressed by the Swedish Government Offices and the EU are coming out in favour of supporting biogas development. This mainly concerns:

- **Tax exemption for biogas as a heating fuel:** The current state support approval applies up to and including 31 December 2018. An extension is required in order for the tax exemption to continue to apply until long-term conditions for biogas are in place.
- **A new national definition of "environmental car":** All cars that fall into the climate bonus vehicle category, including gas-powered cars, should be defined as "environmental cars". In addition, a tightening of the regulations is required in order to correct the current unfortunate situation where diesel-powered cars that are hazardous to both the environment and human health are classified as environmental cars.
- **EU negotiations on emission standards for light and heavy vehicles, and new rules for environmental requirements during procurements[7]:** It must be possible to include the climate benefits of sustainable, renewable biofuels.
- **EU negotiations in respect of the revised Renewables Directive[8]:** Ensure appropriate system boundaries and calculation methods in order for the overall climate benefit of biogas to be shown when calculating the fuel's climate performance.

TOTAL PROPOSAL FOR MEASURES IN ORDER TO ACHIEVE 15 TWh BIOGAS

The industry's overall proposals for measures that should be implemented within the framework of a national biogas strategy are presented below. For those who are interested, each proposal is described in more detail in Chapter 7.

Proposals for measures for the Swedish Government and Parliament

The Swedish Government and Parliament are responsible for ensuring that biogas and biofertiliser are regarded as important cornerstones in the development of a sustainable society. Effective instruments are required in order to ensure that the benefit of biogas as a resource is fully taken into account - and it is the responsibility of the Swedish Government and Parliament, working in conjunction with authorities and the industry, to design and implement these instruments.

Appointing a national biogas coordinator would make the work easier

As biogas affects several different policy areas, coordination between various departments and authorities is essential. Close dialogue between national, regional and local decision-makers and business is also required. By establishing a national biogas coordinator, political efforts can be coordinated, effective and have an impact throughout Sweden. A national coordinator facilitates the work to utilise the benefits of biogas as a resource for society.

The Government and Parliament should:	*Chapter*
Quickly ensure competition on equal terms for imported and Swedish biogas.	7.1.1
Analyse and decide on long-term stable and competitive conditions for biogas. Decisions should be taken in good time before 2021, as current state support approval for tax exemption on biogas for transportation fuel will no longer apply.	7.1.2
Improve the conditions for biogas by taxing energy instead of gas volumes.	7.1.3
Give the Swedish Energy Agency the task of drawing up and administering a gas origin guarantee register.	7.1.4
Improve the criteria for biogas use within industry and electricity and heat generation by enabling the reporting of biogas as a renewable within the EU's emissions trading scheme.	7.1.5
Change the regulatory framework so that green electricity certificates can be given for renewable electricity from biogas that is co-distributed alongside natural gas.	7.1.6
Introduce mandatory requirements for the collection of organic waste from households and businesses, requiring recovery of nutrients and energy.	7.1.7
Impose requirements on public services to reward the use of recovered plant nutrients during procurements.	7.1.8
Improve the conditions for biogas use in heavy lorry transports and parts of industry by ensuring that the green gas principle can be applied across aggregation forms without liquefaction steps.	7.1.9
Clarify the provisions in respect of tax deductions on electricity consumed during the production of energy products, so that deductions can be made once again when biogas is pressurized.	7.1.10
Create criteria for more efficient permit processes for new biogas plants.	7.1.11
Promote large scale production of biofuel from cellulose.	7.1.12
Investigate the possibility of introducing an investment fund for shipping to support investments in technologies that reduce the environmental and climate impact of shipping.	7.1.13
Implement measures for the conversion of the vehicle fleet, where gas vehicles should be promoted alongside other low carbon vehicles. a) Continued measures for broader market introduction of low carbon lorries. b) Promote electricity and gas-powered buses and ferries in public transport. c) Introduce instruments for reduced exports of used "climate bonus vehicles". d) Ensure stable and favourable conditions for climate bonus vehicles as a benefit car. e) Promote travel using a climate bonus vehicle within the framework of the travel deduction system.	7.1.14

Proposals for measures for authorities

Several authorities are involved in the future of biogas and biofertiliser in a variety of ways. In some cases, they act directly on behalf of the Swedish Government, but the authorities themselves can also take initiatives that strengthen the potential of these products to be developed and contribute towards achieving important environmental and social goals.

The Swedish Energy Agency, the Swedish Environmental Protection Agency and others should:	*Chapter*
Begin the work of analysing, in conjunction with players in the industry, how a biogas register with guarantees of origin for gas could be designed and implemented (primarily the Swedish Energy Agency in consultation with the Swedish Environmental Protection Agency).	7.2.1
Seek the opportunity to provide electricity certificates for electricity from biogas that is co-distributed with natural gas (primarily the Swedish Energy Agency).	7.2.2
Provide coordinated official information about the overall environmental and socio-economic benefits of biogas, focusing on informing companies and organisations that deal with the procurement of things such as fuels, vehicles and transports. (Ideally, this work will be led by the Swedish Energy Agency and anchored in consultation with industry players and relevant authorities, e.g. the Swedish Environmental Protection Agency, the Swedish Board of Agriculture, the Swedish Transport Administration and the Swedish Transport Agency).	7.2.3
Within the framework of the Swedish Energy Agency's coordination assignment for gas infrastructure, ensure that Sweden addresses the deficiencies that the EU Commission has identified in Sweden's alternative fuels infrastructure action plan in accordance with Directive 2014/94/EU (the "Infrastructure Directive").	7.2.4
Conduct annual reviews of emission factors when assessing climate measures. This applies, for example, to the emissions factors that the Swedish Environmental Protection Agency provides in its Klimatklivet climate protection initiative guidelines.	7.2.5

Proposals for measures for municipalities and regions

Decisions at local and regional level are crucial for the development of biogas. Many municipalities and regions currently convert their organic waste into biogas, which is then used in the local public transport system. This means that Sweden is a world leader when it comes to using biogas within the transport sector. In order for Sweden to maintain and develop that position, and to promote regional development, municipalities and regions should take overall responsibility for ensuring that waste converted to biogas is also used in the best possible way, e.g. to cover local energy and fuel requirements.

Municipalities and regions should:	*Chapter*
Introduce three environmental zones in urban environments in accordance with national regulations.	7.3.1
Apply a broader socio-economic perspective during procurements. Procurement documentation must take into account the broad socio-economic benefit of biogas (environmentally and economically). In instances where they do not, responsibility should be taken as a whole by imposing requirements on biogas use where appropriate.	7.3.2

2. Biogas – more important than ever

The production and use of biogas and its digestates is an important and central part of a circular economy and contributes to environmental and climate benefits throughout the entire chain. Therefore, biogas is a unique asset for society and plays an increasingly important role in the transition to a sustainable society.

GLOBAL AND NATIONAL ENVIRONMENTAL GOALS

At a summit held on 25 September 2015, the UN decided on Agenda 2030 with its 17 global goals, balancing the three dimensions of sustainable development: economic, social and environmental[9]. According to the Linköping-based Biogas Research Centre (BRC), biogas contributes, directly or indirectly, to all 17 goals[10]. The production and use of biogas and its digestates means, inter alia, increased energy and food security, reduced dependence on imported mineral fertilisers, local jobs, new business opportunities, and contributing to the export of technology and know-how.

In 1999, the Swedish Parliament adopted 15 environmental quality goals, and a 16th in respect of biodiversity was added in 2005.[11] Biogas makes a positive contribution to achieving at least eight of these environmental goals [12, 13, 14], see Figure 2.

Figure 2. National environmental goals that are positively impacted by the production and use of biogas.

The environmental quality goals also have a generational goal that is a target for environmental policy. To help achieve the generational goal and the environmental quality goals, 24 milestone goals have been adopted by the Swedish Government. One of the milestone goals involves increased resource retention in the food chain. By 2018, 50 percent of food waste from households, shops, restaurants and industrial kitchens must be treated biologically so that plant nutrients are extracted and at least 40 percent of the energy contained therein is utilised[15]. In practice, the trend towards increasing the proportion of anaerobic digestion and biogas contributes to the achievement of the milestone goal. Unfortunately, the Swedish Government has not set any new goals to apply after 2018.

Figure 1. Biogas contributes, directly or indirectly, to the UN's 17 global objectives for sustainable development.

CLIMATE POLICY FRAMEWORK

In 2017, the Swedish Government set out a new climate policy framework[16], consisting of a Climate Act, new climate goals and the establishment of a Climate Policy Council. This came into force in January 2018.

Climate Act

- The Swedish Climate Act establishes that the Government's climate policy shall be based on climate goals and how the work shall be pursued.
- Every year, the Swedish Government shall present a climate report in its budget bill.
- Every four years, the Swedish Government shall produce a climate policy action plan that will, inter alia, report on how climate goals will be achieved.

Goal

- By 2045, Sweden must have zero net greenhouse gas emissions to the atmosphere, and achieve negative emissions in the years thereafter. Emissions must then be at least 85 percent lower than in 1990.
- Emissions in Sweden outside the EU ETS (the EU's emissions trading system) should, by 2030, be at least 63 percent lower than in 1990, and by 2040 at least 75 percent lower.
- By 2030, emissions from domestic transport, excluding aviation, must be at least 70 percent lower than in 2010. Domestic aviation is not included in the goal as it is covered by EU ETS.

Climate Policy Council

- The Council shall assist the Government in an independent evaluation of how the Government's overall policy is consistent with the climate goals.

PREREQUISITE TO ACHIEVE THE GOALS

The biogas industry has reacted positively to the new Climate Act, which contributes to ensuring that Sweden has a long-term and stable climate policy. This is a prerequisite for increased use of biogas and facilitates investments in new production. Biogas has been produced in Sweden since the 1960s, and both production and use is increasing on a year by year basis. With the right prerequisites in place, the market may increase fivefold by 2030. As a result, biogas can contribute to the goal that, by 2045, Sweden shall have zero net emissions of greenhouse gases to the atmosphere.

CIRCULAR ECONOMY

Biogas is part of a closed cycle where waste produced by society, in the form of food waste, waste water and residues from agriculture, forestry and industry produce renewable propellants, electricity, heat, fuel and raw materials for industry, see Figure 4. The digestates formed as a co-product can be used as fertiliser, thus increasing the return of plant nutrition and providing the organic agriculture sector with biofertiliser. Both the use of the gas produced and the use of the digestates are important components of the work to end the cycle and create sustainable systems.

In its 2018 budget, the Swedish Government announced that a circular economy delegation would be appointed in order to stimulate the transition to a resource-efficient, circular and bio-based economy, see Figure 3[17]. One of the tasks of the delegation will be to address the issue of bio-based business development.

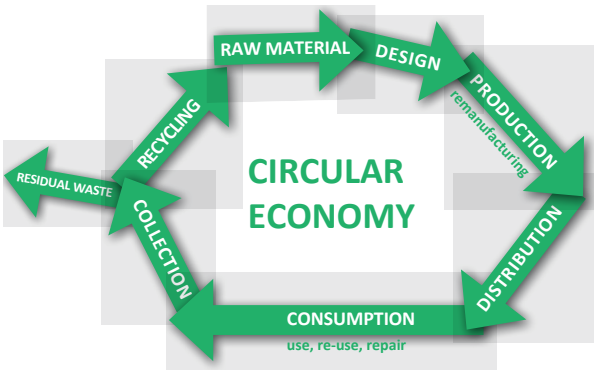


Figure 3. The circular economy creates value, which means that finite resources are not lost and that nutrients are returned to the biological cycle. All processes in the circular economy must be driven by renewable energy. Biogas has several advantages in respect of the circular economy when viewed from a value-creating economy perspective[18].

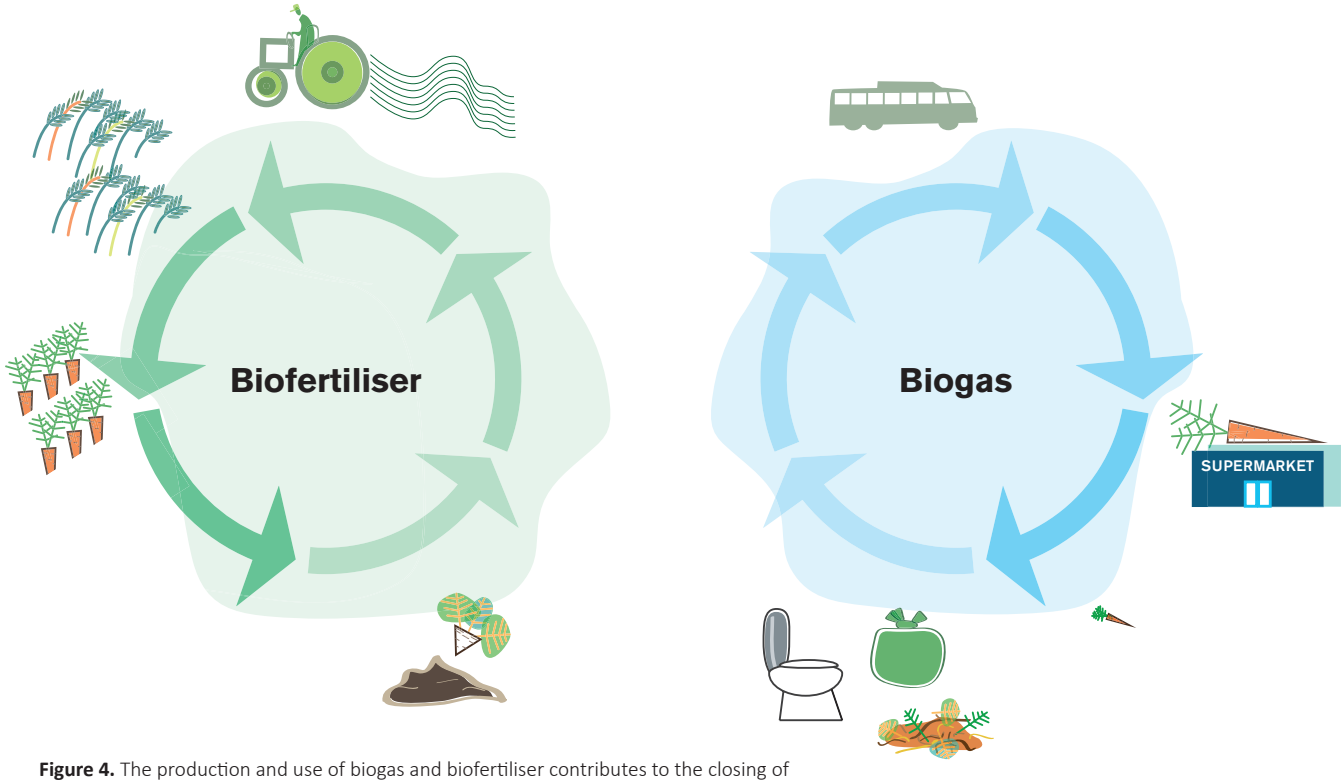


Figure 4. The production and use of biogas and biofertiliser contributes to the closing of the cycle between town and country, which is the foundation of a circular economy.

The biogas industry is a business that provides one service and two products. The service is the waste management that takes place when wastes and residues are processed and recycled. Without this service, the cycle, which is a criterion for the circular economy, does not work.

Figure 5. The position of biogas and biofertiliser on the waste staircase.

The two products, biogas and biofertiliser, mean that organic waste moves up the waste hierarchy, see Figure 5. The European Commission has stated that this is an advantageous and resource-efficient method of waste management that also contributes to increased energy self-sufficiency[19] and is part of the transition to a circular economy.

The biogas industry welcomes the work of the forthcoming delegation to stimulate the transition to a resource-efficient, circular and bio-based economy. The industry believes that biogas production plays a key role and constitutes the best treatment method for organic waste generated by society that cannot be prevented, prepared for reuse or processed for material recovery in earlier stages. Biogas production enables efficient waste management as both energy and plant nutrients are processed. In addition, it is a criterion for sustainable organic agriculture as there are few alternatives to biofertiliser.

SOCIAL BENEFIT OF BIOGAS

Biogas has many social benefits. In many cases, the biggest social benefits are experienced by players other than those who produce or use biogas and its digestates. Therefore, it is necessary to adopt a holistic view and make policy decisions that value the biogas based on environmental and social benefits (such as the processing of digestates, collection of food waste, sustainable agriculture, etc.) provided by biogas.

Consultancy company 2050 has calculated the social benefit of biogas based on the biogas production (2.0 TWh) Sweden had in 2016, and the areas in which biogas was used. The factors included in the calculation were:

- Climate benefit
- Improved air quality
- Value of plant nutrients
- Increased employment
- Increased security of supply
- Increased resource retention with food waste

The results show that the socio-economic benefit amounts to SEK 760 million per year, with a surplus to Sweden's GDP of SEK 4 billion per year[20]. The 7 TWh of biogas production, which researchers believe we can achieve relatively easily, would mean a GDP value of SEK 14 billion per year. If the use goal of 15 TWh were entirely produced in Sweden, it would correspond to a GDP value of SEK 30 billion per year.

The value of the benefits that are not included in the calculation, such as increased technological development and export opportunities, increased opportunities for sustainable food production, reduced noise and odour problems and a stronger Swedish security position with domestically produced fuel, must be added to the result.

Equivalent calculations have been made before for different biogas substrates and with the vehicle market as the biogas user[21]. These results indicate a social benefit that is on par with the above.

Climate benefit

Biogas is renewable and results in zero net emissions of CO_2 during combustion. Each carbon atom is part of a natural cycle where the amount released during combustion is equal to the amount previously removed from the atmosphere. The extent of the overall climate benefit depends on a number of factors; e.g. from which substrates the biogas has been produced, how it has been produced and what it is used for. The way in which the digestates are processed and used is also important.

In the best case scenario, CO_2 reduction is more than 100 percent[22], see Figure 6. This applies when biogas is produced from manure, as the methane emissions produced during manure handling are reduced at the same time as the biogas replaces fossil energy. Significant reductions are also achieved by the digestates from the biogas plant being used as fertiliser (biofertiliser) and by emissions from the mineral fertiliser it replaces being eliminated.

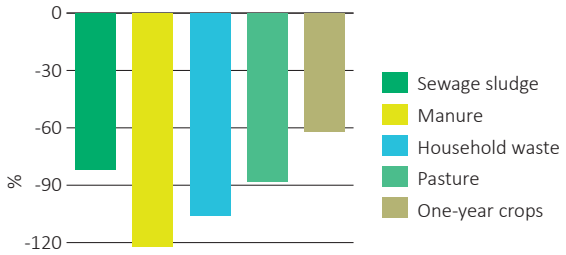


Figure 6. Reduction of greenhouse gas emissions for biogas produced from different raw materials compared to petrol and diesel produced from crude oil. Greenhouse gas emissions are calculated in accordance with ISO standards for life cycle analyses.[23]

The Swedish Environmental Protection Agency is responsible for Klimatklivet, a climate protection initiative, with an annual budget of SEK 700 million until 2020. Through Klimatklivet, support is given to the most cost-effective measures that reduce greenhouse gas emissions. In total,

over half of all funds in Klimatklivet in 2016 went to biogas initiatives[24].

Improved air quality

Biogas that replaces fossil energy contributes to reduced emissions of nitrogen oxides (NOx). Nitrogen oxides affect the formation of ground level ozone, which is hazardous to plants, animals and people.

In order to reduce emissions of NOx, tougher requirements in the transport sector in Europe are set to be introduced for both light and heavy vehicles. Many factors, such as driving style, fuel type and exhaust gas temperature, affect the emissions. Under actual driving conditions, modern diesel cars release more NOx than the vehicle certificate reports. Estimates from the Swedish Transport Agency show that NOx emissions from actual driving may be three to six times higher than the laboratory values[25]. Gas vehicles automatically reduce emissions of nitrogen oxides.

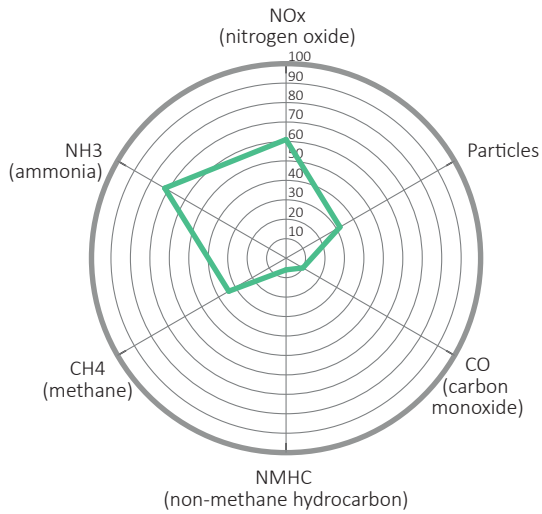
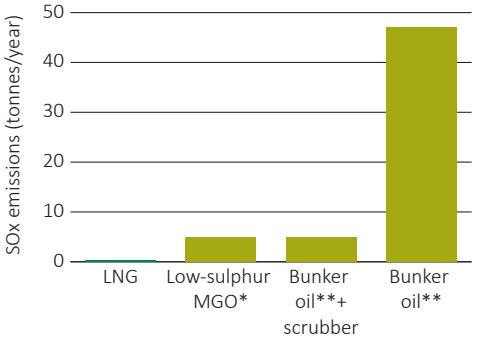


Figure 7. Emissions of various substances from Scania's gas engines (green line) in relation to Euro 6 requirements. Source: Scania

Most new vehicles are equipped with particle filters. However, this does not apply to gas vehicles. Biogas and natural gas are, by their very nature, fuels that are sufficiently clean that no additional cleaning is required in order to satisfy the requirements. Gas-powered heavy vehicles show emissions values that fall far below the Euro 6 requirements, see Figure 7.

Emissions of sulphur oxides, SOx, which lead to the acidification of soil and water, are almost zero from biogas[26]. Within shipping on the Baltic Sea and the North Sea, the new emissions requirement imposed by IMO (the UN International Maritime Organisation) of a maximum of 0.1 percent by weight has meant that liquefied natural gas, LNG, has become a very interesting fuel alternative. Sulphur emissions from LNG are very low, see Figure 8. By using gas, no additional cleaning is required on the ship. With the right incentive, LNG can be replaced by liquefied biogas, LBG.



* Low-sulphur fuel contains a maximum of 0.1 percent sulphur

** Conventional fuel/bunker oil contains maximum 1 percent sulphur

Figure 8. Comparison of sulphur oxide emissions from natural gas-powered and oil-powered ships. Source: DNV GL 2017

Plant nutrients in the cycle

Digestate produced by conventional waste plants retain all nutrients (phosphor us , nitrogen , potassium) found in the substrates that are introdu ced into the digestion chamber. The digestates close the nutrient and organic material cycle when they are returned to the soil and can thereby supplement or replace mineral fertiliser within agriculture and forestry. This leads to better housekeeping of finite resources (mainly phosphorus), but also to a reduced need for energy and fossil-intensive mineral fertiliser production and reduced dependence on imported mineral fertilisers.

In addition, certified biofertiliser is, with certain limitations, also approved for use in organic farming[27]. One of the starting points for the Swedish Government's work on the national food strategy[28] is the notion that organic food production in Sweden must increase. Increased biogas and biofertiliser production from waste and residues forms an essential part of this philosophy. Biofertiliser also increases the organic matter content of the soil[29], binding carbon and forming a carbon sink. It also makes arable land more open to absorb nutrients from biofertiliser compared with unprocessed manure. This reduces the risk of eutrophication of rivers, lakes and seas. Read more about biofertiliser in Chapter 6.

Increased employment

Increased domestic production of biogas leads to increased local employment through construction works, substrate collection, operation and maintenance of production facilities, distribution and supply, as well as consulting and sub-contractor services. Several regional and national calculations show that one job opening is created per GWh produced[30]. This means that meeting the goal of 15 TWh biogas by 2030 corresponds to 15,000 employed persons.[31] In addition, a number of indirect jobs will also be created[32].

Residual agricultural products, such as manure and crop residues, form a major part of the biogas potential available from anaerobic digestion. Increased production of biogas in agriculture, or with this sector as a substrate supplier, creates new potential revenue streams.

Increased security of supply and safety

The Swedish Armed Forces have clear requirements to work with energy, climate and security of supply[33].

Within the energy and climate area, the Swedish Armed Forces shall:

- contribute to more efficient energy use
- increase the proportion of energy derived from renewable sources and reduce dependence on fossil fuels
- reduce the emission of greenhouse gases

Different types of digestate

Biofertiliser is the digestate produced during anearobic digestion of substrates from feed and/or the food chain. Biofertiliser is, in most cases, a liquid fertiliser with a high water content (about 95 percent). It is rich in nitrogen and contains relatively little phosphorous.

Sewage is also a type of digestate, but is produced under anaerobic digestion of sewage sludge at water treatment plants. Biodegradable sludge, or organic matter as it is simply referred to, is usually dewatered and is therefore significantly drier than biofertiliser. Sludge contains a lot of phosphorus and mould, and a little less nitrogen, and therefore, if it is Revaq-certified, is used in agriculture, and then mainly as a phosphate fertiliser.

Both biofertiliser and sludge, depending on their quality, can be used as a source of plant nutrients. These two types of fertiliser are produced from different types of substrate, have different characteristics (biofertiliser consists mostly of nitrogen, while sludge contains mainly phosphorous) and are spread in different ways.

In terms of security of supply, the Swedish Armed Forces shall, inter alia, guarantee access to energy, primarily electricity and propellents. In a crisis or war situation, it is assumed that external energy supplies will be severely limited or not available at all[34]. This requires the defence sector to be in a position to handle such a situation. Domestic production of biogas can help guarantee access.

Biogas also contributes to the security of food supply. Swedish agriculture is currently dependent on imported fuel and mineral fertiliser, and is therefore in a vulnerable position. This is where biogas can play a crucial role.

Odour

Handling of organic waste/residues can cause bad odours, mainly through spontaneously released fatty acids, sulphur contaminants or ammonia. These occur naturally, regardless of the processing method.

The biogas process breaks down a whole host of foul-smelling substances contained in manure. It is principally volatile fatty acids that produce methane. Anaerobically digested manure produces less odour than non-digested manure during storage and spreading. Therefore, farmers are not so time-constrained in terms of when to spread their manure.

Noise

Noise affects health and well-being, and is high on the list of the more serious health effects in society. Gas-powered vehicles normally produce less noise. The latest gas engines are so quiet that they satisfy the requirements set out in noise limitation standard PIEK[35] and therefore can be operated in disruption-sensitive areas[36].

Even relatively small reductions in noise have positive effects on health. For example, the disruption costs (noise cost) for buses in urban areas are estimated to decrease by 25 percent for each decibel less noise a bus produces[37].

Local and regional economic benefits

Gross regional product (GRP) is the value of all goods and services in a particular region[38]. Since biogas is usually produced and consumed locally/regionally, this has an impact on GRP as tax revenues from the entire value chain stay within the region. As upgraded biogas has a relatively high refining value, it also, relatively speaking, has a potentially large impact on GRP. Estimates for Östergötland County show that the region's GRP will be positively affected to the tune of approximately SEK 300 million per year at a biogas production level of approximately 150 GWh[39].

3. Use

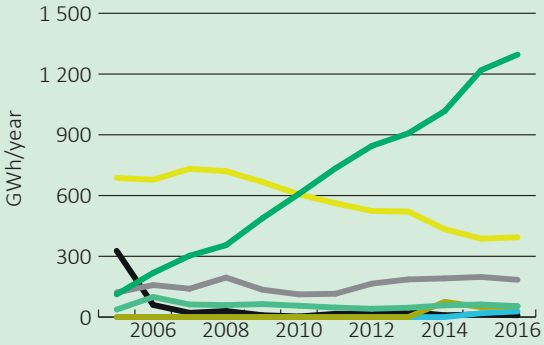


Figure 9. Change in biogas use 2005-2016. Applies to biogas produced in Sweden.
Source: Swedish Energy Agency 2017:07. Production and Use of Biogas and Digestates in 2016.

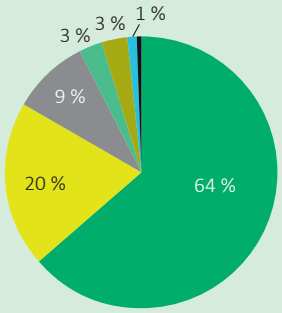


Figure 10. Biogas use 2016. Applies to biogas produced in Sweden, totalling 2.0 TWh.
Source: Swedish Energy Agency 2017:07. Production and use of biogas and digestates residues in 2016.

WHERE WE ARE TODAY

How biogas is used on the Swedish energy market depends, inter alia, on availability, price and taxes, as well as the general competition landscape. For many years, it is mainly the vehicle market that has experienced growth.

In 2016, 1.83 TWh biogas was used (excluding flaring), see Figures 9 and 10. To this must be added the volume of imported biogas, which has increased in recent years[40].

WHERE WE WANT TO GO: 15 TWh

The goal is that the total use of biogas shall be 15 TWh by 2030. It is an ambitious goal that requires significant action from both the industry and politicians. Gas use in the transport sector can then continue to grow and the industry is beginning its transition to greater biogas use.

HOW WE GET THERE

Stimulating continued market growth in both the transportation and industrial sectors is crucial for the future. Investing in biogas during public procurements, as well as a developed green gas principle, including both liquefied and gaseous gas, are two important measures. Efforts from both society, in the form of instruments and measures, and the industry are necessary.

Interest in, and use of, biogas within industry has increased over recent years. Some industries have completely transitioned from natural gas to biogas, whilst others have mixed biogas with natural gas in order to show that there is a desire for change. This development must continue.

THE SITUATION TODAY

In Sweden, biogas is primarily used as vehicle fuel in order to reduce oil dependency in the transport sector. Since vehicle fuel is heavily taxed, it is relatively easy to prioritise biogas and other renewable products.

Within the manufacturing industry, tax pressure is relatively low, which makes it difficult for biogas to compete only on the basis of its zero tax status.

Road transport - the most important market

In the early 2010s, sales of vehicle gas, i.e. the mix of natural gas and biogas, increased by approximately 30 percent per year. This rate of increase has now come to a complete halt, and in recent years there has been a slight decline, see Figure 11. Despite this, the number of gas vehicles in use has continued to increase, and now there are around 55,000 currently on the road. The amount of biogas in vehicle gas has increased over these years, both in terms of proportion and absolute volume, and in 2017 biogas constituted 86 percent of the energetic value of vehicle gas.

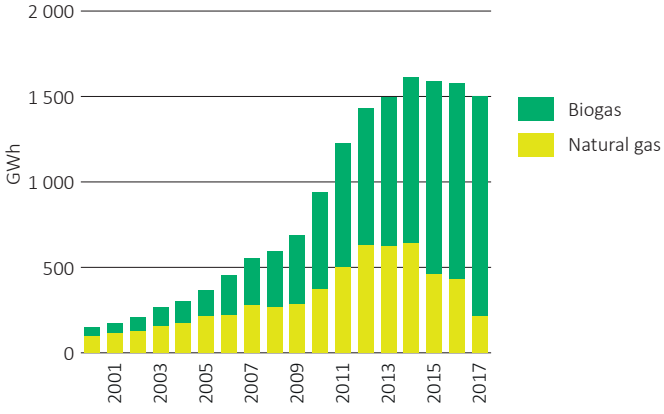


Figure 11. Vehicle gas sales 2000-2017, of which biogas (green) and natural gas (yellow). Source: Statistics Sweden and the Swedish Gas Association 2018

One of the reasons for the stagnating vehicle gas market is tougher competition from other renewable fuels. Figure 12 maps out how this trend has panned out over the past few years. HVO has experienced a very strong increase, not least within public transport, where competition has become even tougher.

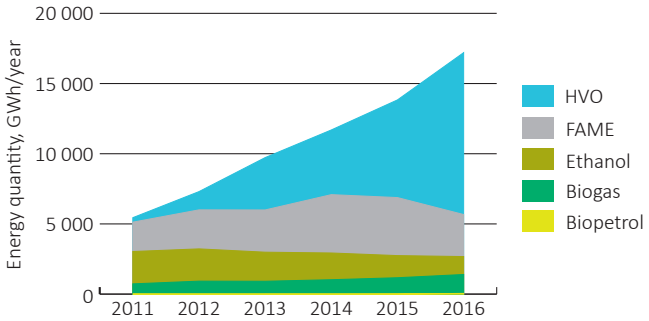


Figure 12. Evolution of the use of biocomponents in fuels 2011-2016. Source: Swedish Energy Agency 2017. Fuels 2016.

Despite this tough competition, the expansion of gas refilling stations has continued, and coverage is becoming better and better in an increasingly large part of Sweden, see Figure 13.

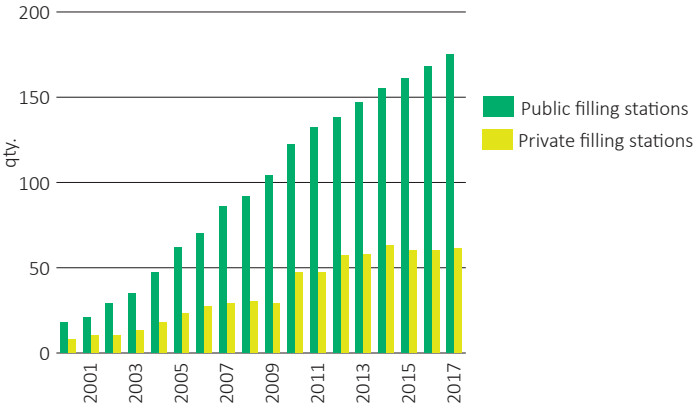


Figure 13. Number of gas filling stations in Sweden. Source: Swedish Gas Association 2018

In 2017, there were gas buses in 17 out of 21 counties, accounting for just over 15 percent of the entire Swedish bus fleet[41]. Increased gas use in public transport means the roll-out of an expanded vehicle refilling infrastructure and distribution network in bus depots, increasing the volume of gas on the market. This development also allows for the construction of more refilling stations for passenger cars, taxis and haulage vehicles.

Procurement as an instrument

There is now a great opportunity to influence the transport market through the procurement of public transport and taxi services. In 2014, public procurement amounted to SEK 634 billion, of which SEK 41 billion was in respect of public transport[42]. In relation to GDP, the figure has remained at about the same level since 2006. The Swedish Public Procurement Act primarily regulate how purchases are made and not what is purchased. Therefore, it is important that the biogas industry is able to show the full benefit derived from using biogas, including the use of digestates, in order to ensure that biogas is ascribed its true value during the procurement process. Procurements undertaken in recent years, including Kalmar Länstrafik, have shown that direct demands can be imposed requiring buses to be run on biogas.

In the conversion of the transport fleet, all renewable alternatives - HVO, RME, ethanol, biogas, hydrogen and electricity - will be required. Biogas makes a greater contribution to the regional economy, GRP, as it is usually both produced and used regionally. Biofertiliser is also usually used in the local area.

When procuring public transport, cleaning, own vehicle fleet and similar, direct conditions may be imposed on biogas as fuel. Of course, the criteria that exist in the municipality or region must also be taken into account. Requirements may be imposed in stages and the goal increased year by year. Some good guidance has been issued by BioDriv Öst[43].

Even in other types of procurement, such as distribution of goods, direct requirements may also be imposed on biogas as a fuel. Procurement requirements imposed on organically cultivated food favour the production of biofertiliser and, indirectly, the production of biogas.

Increased industrial interest

The industrial sector is a major energy consumer. In 2016, industrial activities consumed 134 TWh of energy, of which 15 TWh came from fossil energy sources, excluding coal and coke, see Figure 14[44]. To this can be added LPG, natural gas and oil, which are used as raw materials in the production of various different products.

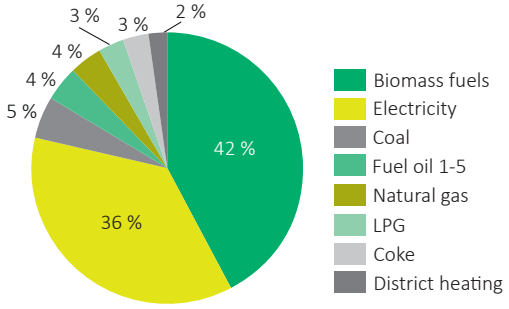


Figure 14. Industry's energy use 2016. Source Statistics Sweden

In recent years, oil use in industry has fallen sharply, see Figure 15. This has been achieved through a combination of streamlining and the replacement of oil by biofuel, LNG and LPG. The increased availability of liquefied natural gas means that energy gases are currently the single largest fossil product used in industry. There are still more than 3.5 TWh of oil used in industry[45], and it is believed that about 1.5 TWh can be replaced by energy gases[46].

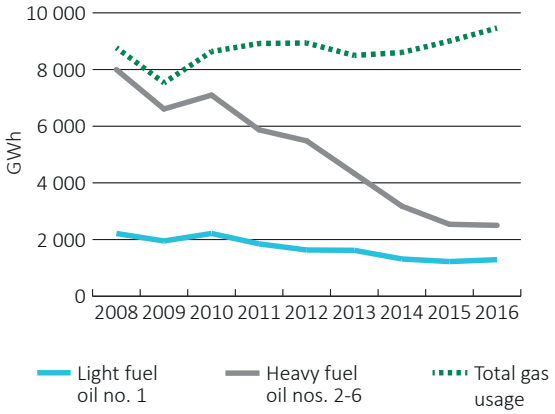


Figure 15. The development of energy gas and oil use within industry. Source: Statistics Sweden

In addition to clear and tough environmental requirements, governments' recent tax policies with increased energy and CO2 taxes have been an incentive for industry to act, see Figure 16. Industry within the EU ETS is not affected by these increases.

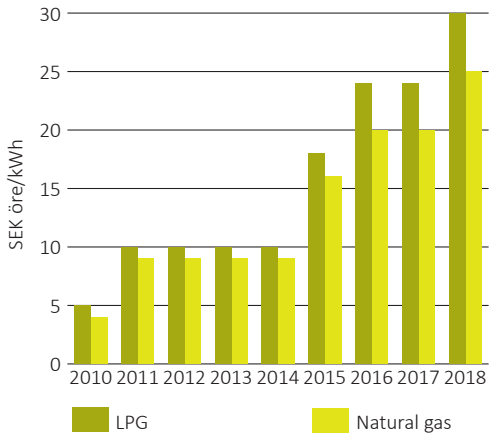


Figure 16. Historical development of total fuel tax (energy and carbon dioxide tax) for industries outside the EU ETS.

The use of biogas within industry has been limited, despite no changes in process equipment are required for those industries that already use natural gas. The reason is the tax and price landscape. Biogas is too expensive compared to natural gas (see Figure 17) as the manufacturing industry pays a limited energy and CO2 tax. For those industries that are affiliated with the EU ETS, the price of carbon dioxide emissions is currently low. With more restricted emissions allowances in the future, the price is set to go up, a development that has already started. This will make biogas more competitive.

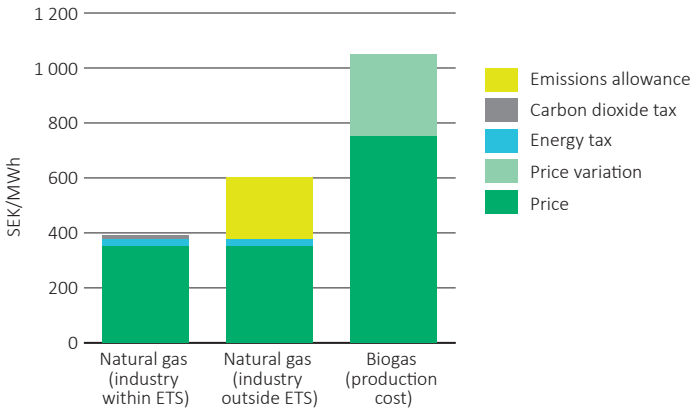


Figure 17. Comparison of the natural gas price to industrial customers within and outside the EU's emissions trading scheme and the production cost of biogas. The cost of producing biogas varies depending on aspects such as type of substrate and size of production facility.
Source: Natural gas: Statistics Sweden Energy Price Statistics 2017.
Biogas: f3 2016:16 Methane as vehicle fuel – a well to wheel analysis

During 2017, when biogas imports increased and it was possible to purchase biogas at a price on a par with natural gas, several industries along the Western Sweden gas network chose to switch to biogas. The lower price level is due to the double subsidy that occurs when the imported biogas receives a production subsidy in its country of origin and then also benefits from the Swedish tax exemption on biogas.

THE FUTURE

Biogas in all forms of transport

Transport includes everything from road transport to marine shipping. Biogas is a possible alternative for all modes of transport, but it is primarily in road transport and other forms of land transport where it may be assumed that there will be greater use by 2030.

The FFF investigation showed the need for an almost 80 percent reduction in the use of fossil fuels in road traffic by 2030[47]. In combination with the work of the Environmental Objectives Council (Miljömålsberedningen), this has resulted in the Swedish Government setting a target of achieving a 70 percent reduction in climate emissions by 2030, with 2010 being the base comparison year[48].

Gas use can increase within all types of road transport - cars, buses and heavy transports. One relatively new segment is heavy goods vehicles. All major heavy goods vehicle manufacturers now produce gas alternatives. It is a trend that is reflected in many countries both in Europe and globally. For example, 1,200 LNG lorries were sold in Italy during 2017. The corresponding figure in France was 1,450[49]. As Sweden is home to two of the world's largest lorry manufacturers, Volvo and Scania, the Swedish market may become a shopping window for these lorries, which can be run on LBG from the outset.

Public transport is also set to be an important market for vehicle gas in the future. Gas buses were introduced on the Swedish market in the majority of urban areas in the early 1990s in order to reduce the problem of particulate and nitrogen oxide emissions. A circular regional economy makes it vital that the proportion of gas buses on the road increases from the current level of 15 percent.

The goal of 12 TWh biogas that the industry had previously set for the transport sector by 2030 is still on track despite the slowdown in recent years. The right incentives, coupled with a strong LBG lorry market, are important factors in order for this to be achieved.

Part of the hydrogen evolution

Almost all hydrogen manufactured industrially is done by reforming natural gas. This is a highly efficient process, which can also be reproduced on a small scale. Therefore, it is entirely possible that biogas could be reformed, at a reasonable cost, into hydrogen at an existing filling station. This means that no special hydrogen distribution system is required. The overall efficiency of a value chain from biogas to traffic work, via reforming to hydrogen and a fuel cell, is highly competitive. Future generations of electric cars can therefore be powered by biogas.

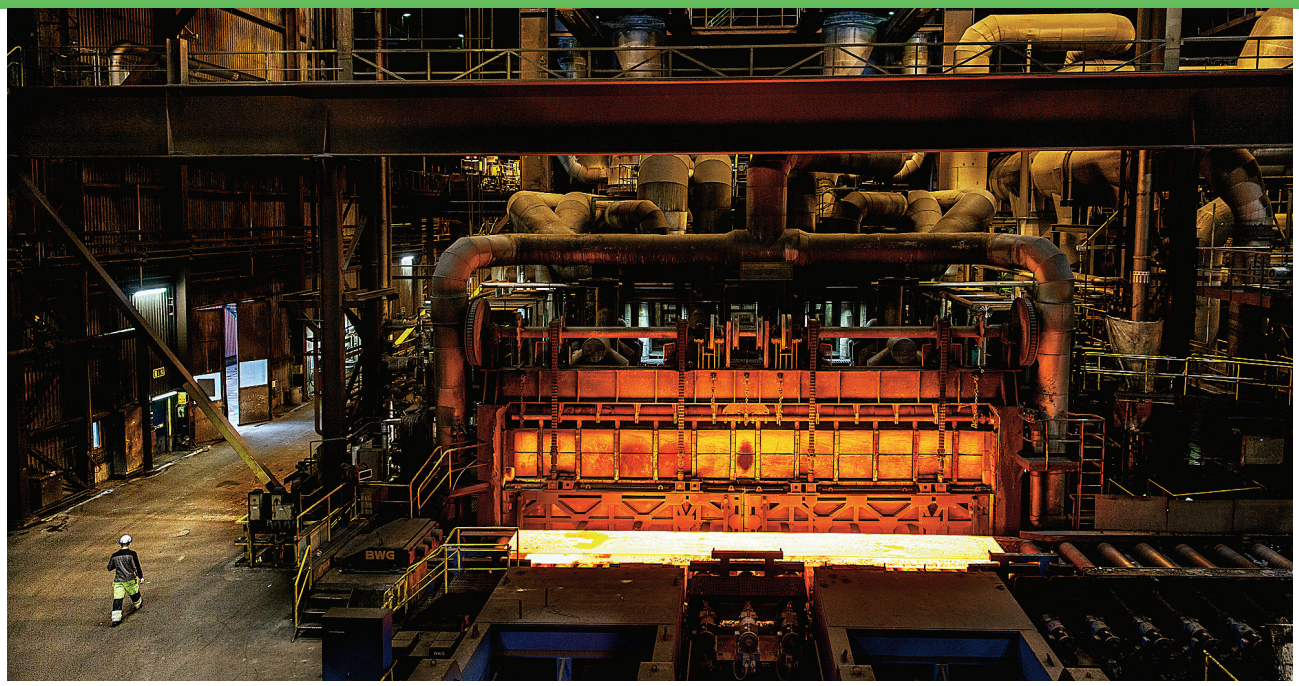
Shipping and aviation

Biogas is not currently used in shipping or aviation. Both sectors are energy-intensive and dominated by fossil fuels, so there is considerable need for renewable alternatives. At present, biogas production is insufficient to enable the entire Swedish shipping fleet to convert to biogas. But there is great user potential, particularly within near shore shipping and inland waterways, if biogas production is increased in the future. The shipping industry has expressed a great interest in using biogas, but as the industry is exempt from energy or CO2 taxes, there is very limited scope for introducing effective instruments that will encourage biogas use.

In the case of aviation, current developments mean that the possibility of transition to biogas is a very small one. There are currently no aircraft in service that use any form of gas.

Industry needs biogas

The Swedish Parliament's new climate policy framework, as well as the EU's requirement to reduce CO2 emissions by 40 percent by 2030, will have a significant impact on industry. Swedish industry has taken an aggressive stance. For example, LKAB, SSAB and Vattenfall have come together to start the HYBRIT initiative, which will see blast furnaces replaced by new technology and coal replaced by hydrogen[50].



In Oxelösund, SSAB is switching to scrap-based production (as part of the HYBRIT initiative), increasing the need for externally supplied energy. SSAB believes that the only realistic alternative at present is LNG, transitioning to LBG as a next step.

The majority of industries want to increase the proportion of renewable energy they use in their processes. For example, the chemicals industry has a vision for sustainable chemistry that is to be achieved by 2030[51]. Some industries are mixing a small volume of biogas into the natural gas they use in order to demonstrate that there is a willingness to transition to renewable gas.

Parts of energy-intensive industry need access to high value fuels such as biogas or renewable LPG in order to achieve their objectives. Many industries also see customer value in a renewable fuel supply, which speaks to an increased demand for biogas. Often, the application for renewal of environmental permits, or increased production capacity under prevailing environmental conditions, is a driving factor in increasing the proportion of renewable energy used in the processes.

With the demands placed on industry, a goal of 3 TWh of biogas by 2030 is an important first step. Industry is willing to change, so depending on conditions, much higher levels can be reached.

An important complement within electricity and heating

Plannable power

The Swedish Energy Commission's agreement means, inter alia, that Sweden will have 100 percent renewable electricity by 2040[52]. No date has yet been set for the ending of nuclear power in Sweden, but the industry itself has decided to close four nuclear power plants in advance.

The transition of the power system towards more wind and solar power, combined with the phasing out of nuclear power, requires more storage options and dispatchable power generation. This is where gas power, provided using biogas, can play a key role. Partly as storage capacity for surplus electricity generated through Power to Gas (P2G), as well as load and output balancing of electrical systems, as gas turbines and gas engines can quickly start and reach high power.

Heat - peak load

In the heating segment, use of fossil fuels is not particularly high, barely 7 percent at national level in 2016[53]. But around Sweden there are many smaller plants that are put into operation during periods of cold weather, “peak loads”. Many of these plants use oil, diesel or other fossil-based products. Local authorities that employ a clear climate and environment approach have started to review the fuel choices they make. One of these is Linköping Municipality, which has taken the decision to be completely fossil-free by 2020. This means that the fuel used in the smaller heating plants in the municipality must be changed. The Fossil-Free Skåne initiative has also decided to go in this direction.

4. Production

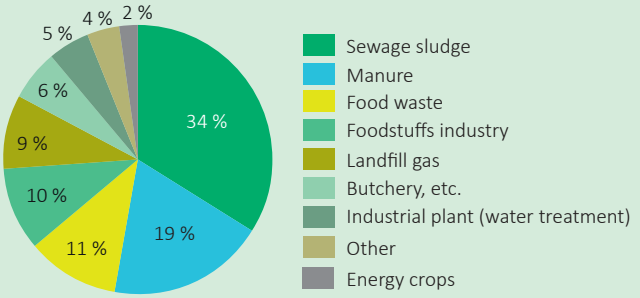


Figure 18. Proportion of biogas produced in Sweden from different substrates. Source: Swedish Energy Agency 2017:07. Production and use of Biogas and Digestates in 2016.

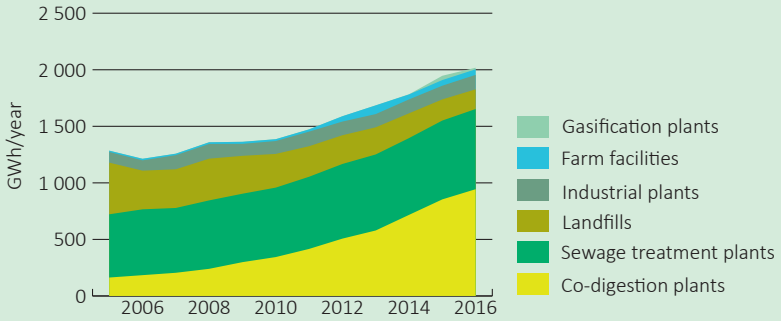


Figure 19. The development of biogas production in Sweden from various plant types. Source: Swedish Energy Agency 2017:07. Production and use of biogas and digestates in 2016.

WHERE WE ARE TODAY

In Sweden, 2.0 TWh of biogas was produced in 2016, of which two thirds were upgraded[54]. The proportion of biogas upgraded to vehicle gas or fed into a gas network is constantly increasing. Most organic materials can be used as substrates and decomposed, or gasified, in a biogas plant, see Figure 18.

The increase in production that has taken place over recent years has almost exclusively come from co-digestion plants, where food waste from households, manure and industrial biowaste are decomposed together, see Figure 19.

OUR FIRST STAGE GOAL: 7 TWh

Swedish biogas production can increase significantly. In a first stage, move from 2 to 7 TWh with only substrate from available waste and residues that, for environmental reasons, are particularly suitable for anaerobic digestion[55].

Yet more potential is reported in several studies. WSP sees a realisable biogas potential of 22 TWh by 2030[56]. Other reports set out fuel potentials that are in parity with, or above, that level[57, 58].

HOW WE GET THERE

Efforts are required from society in the form of instruments and other measures in order to quickly get up to a production of 7 TWh, to then go still further in the next stage. All digestates and waste generated by society must be used in the cycle. Significant investment in new substrates, streamlining current processes and technological development is essential.

THE SITUATION TODAY

During the past few years, production volume has increased slowly but surely, with co-digestion plants primarily being responsible for this increase, see Figure 19.

Fossil Free Sweden, together with a number of researchers, estimate that there are substrates, in the form of waste and digestates, corresponding to 7 TWh of energy, making them the best source for the production of biogas. This figure is based on a report from Lund University, where a volume of 6.2 TWh[59] is noted. Added to these estimates is biogas from areas of cultivated ley of just over 1 TWh, which does not conflict with EU ILUC regulations[60], see Table 1. A level of around 7 TWh may be a realistic figure.

Table 1. Biogas potential from substrates that, for environmental and resource reasons, are best suited for biogas production

Substrate	Biogas potential (TWh)
Manure	2.8
Waste, food industry	1.1
Cultivation residues	0.8
Food waste	0.8
Sewage sludge	0.7
Total 1	**6.2**
Additional ley cultivation	>1
Total 2	**approx. 7**

To go from the current level of 2 TWh to 7 TWh is a big jump, but a clear step in a resource-efficient and circular society.

There is now competition for certain types of digestate and waste. At the same time, there is a desire in society to reduce the occurrence of waste, which is, of course, a positive development. However, there is still a huge amount of waste that is not dealt with in an optimal manner, meaning that there is potential for increased biogas production.

In 2016, only 38 percent of food waste was processed in digesters. The goal for 2018 is 50 percent.

THE FUTURE

More industrial production

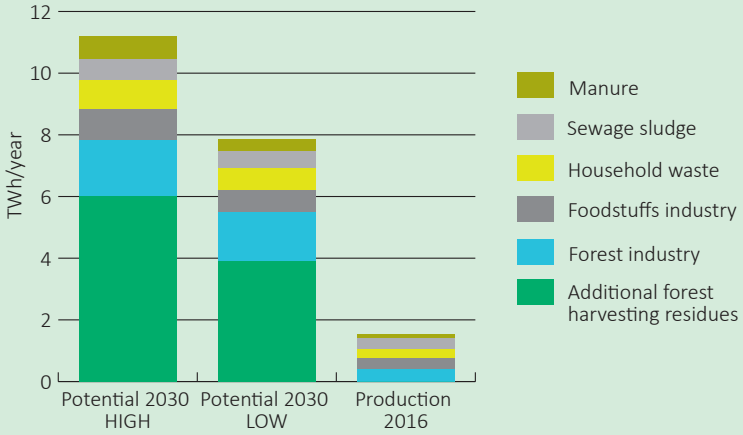
Biogas is produced in everything from small farm and waste water treatment plants producing a few gigawatt hours, to large plants with a capacity of up to 150 GWh. Many small farm plants or waste water treatment plants primarily produce electricity for own use. At present, it is not usually financially viable to upgrade the gas produced, but small-scale upgrading plants are becoming increasingly more competitive.

In order for the industry to evolve to the next level and get a more industrial perspective, bigger plants, with capacities of around 250-300 GWh, are essential. By doing this, both the fixed and variable costs associated with production can be reduced, as well as the total production cost per GWh. Process development and improvement are best done in larger and more industrial facilities.

With larger facilities and greater raw materials requirements, it may be more important that plants are located closer to the raw materials than to the customers. The liquefaction of biogas to LBG then becomes the next natural step. In the future, customers will also start demanding biogas in liquid form. This applies to both the transport market, with the entry of heavy gas vehicles, and industry, which is benefited by being able to store biogas in liquid form. In the long term, being able to produce biogas in liquid form will also play a critical role in its adoption within marine shipping.

It is also important that new producers join the market. The paper and pulp industry is closely related, since it owns the raw material and can use biogas or syngas in the process.

Figure 20. Biofuel potential by 2030 from digestates and waste that is not linked to arable land. "HIGH" and "LOW" refer to different assessments of the availability of raw materials or the proportion of such material that may become available for use in biofuel.
Source: Lund University 2017. Biofuels and land use in Sweden.



There is significant potential for further digestion of industrial forest sludge and for biorefineries where a significant quantity of various raw materials and end products can be included.

Large future production potential

Sweden is already a world leader in using waste and digestates to produce biogas. However, several reports indicate that there are other digestates that are capable of being used to produce biogas.

A report from Lund University estimates that the potential for biomass in Sweden is 42-53 TWh per year by 2030, and 71-90 TWh by 2050[61]. This potential is based on an increased supply of forest and agriculture-based biomass. The potentials are equivalent to 20-25 TWh of biogas by 2030 and 35-45 TWh of biogas by 2050, provided that all biomass is used for biogas production. Of these potentials, 2 TWh are included in the potential presented in Table 1.

Two other reports, from WSP and Envirum, report possible potentials by 2030 of the same magnitude. WSP reports a realisable biogas potential of 22 TWh by 2030, where waste and digestates, as well a small amount of energy crops such as ley or hay are included[62].

Lund University estimates the potential of biofuels from non-farmland based waste and digestates to be 11 TWh, see Figure 20, and the potential of farmland-based biomass that does not risk ILUC, to an additional 10 TWh of biofuel, see Figure 21[63]. In addition to the 7 TWh identified for environmental reasons as being particularly suitable for digestion into biogas, see Table 1, there is available and realisable biomass, which does not compete for land or with other industry, for the production of a further 14 TWh biogas or other biofuels by 2030 .

It is reasonable to assume that a large part of this biofuel potential will be biogas, as techno-economic studies show that biogas production is usually the most energy-efficient and inexpensive option compared with other biofuels.

Aquatic biomass

Aquatic biomass such as blue mussels, algae, sea squirts and reeds may be used to absorb nutrients from sea water, resulting in cleaner seas. Using these substrates for biogas production also affords the possibility of returning nutrients to agriculture via biofertiliser.

Cultivating aquatic biomass is effective per surface and does not compete with the use of agricultural land. This is why it supported in EU legislation. A demonstration project is currently being conducted outside Lysekil involving the large-scale cultivation of sea squirts for biogas production. The potential for inland coastal waters in Sweden amounts to approximately 2 TWh biogas per year[64].

Biogas production from algae has a potential of 0.6-1.5 TWh, but this scenario is only achievable in the far future, after 2030[65]. Plans are in place to conduct a demonstration project where algae is cultivated for biogas production in a location outside Trelleborg.

Gasification

Sweden is at the vanguard of the gasification of biolfuels. GoBiGas is still, three years after opening for business, the largest biofuel gasification plant in the world, and, by the end of 2017, more than 5,000 visitors had passed through

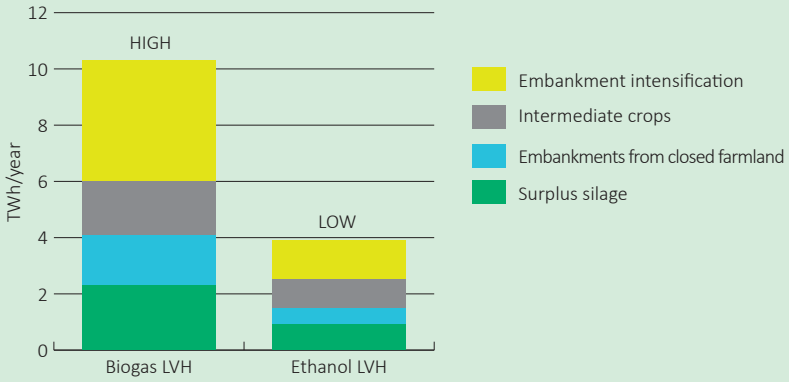


Figure 21. Potential for biofuels from ILUC-free raw materials from farmland by 2030. "HIGH" represents biogas potential.
Source: Lund University 2017. Biofuels and land use in Sweden.

its gates. The project has demonstrated continuous production of biogas with a high level of efficiency, up to 65 percent, and a CO2 reduction of more than 80 percent The project has been completed under prevailing market conditions, and the plant is now set to be put into mothballs.

Small plants of 1-6 MW are also under development in Sweden. These can be relatively easily built direct at the site where the gas shall be used. A primary target group is larger industrial plants. The gas that is manufactured may be syngas, non-upgraded biogas or upgraded biogas. In many contexts, syngas is sufficient, but a broader use for the industrial or vehicle sectors requires that gas must be upgraded.

Two examples are Meva Energy and Cortus Energy, who are building demonstration plants in Piteå and Höganäs respectively. Cortus Energy's plant in Höganäs is 6 MW, which corresponds to approximately 50 GWh during one year, and will be operational by mid-2018. This is the first plant to be installed for a functioning industry.

Power to Gas, P2G

Completely different technologies for producing renewable methane are also being developed. Of these technologies, Power to Gas is the one that is most developed. It produces methane from surplus electricity. Using electrolysis, hydrogen is produced, which can then be stored. This hydrogen can then either be converted back into electricity or, with the addition of CO2, converted to methane. Separated CO2 from upgrading plants can be used to produce additional biogas[66] using the P2G technology.

In Germany, there are 30 or so test plants of this type. In Sweden, a development project is currently underway on Gotland[67]. The next step will be to build a test plant. For an island such as Gotland, with its large wind power capacity and limited possibility to supply electricity to the mainland, P2G may be an interesting alternative. It creates storable, high value energy from surplus variable, renewable electricity production. At the same time, carbon dioxide is also used.

5. Distribution

WHERE WE ARE TODAY

Biogas in Sweden has grown on local markets, where production has increased in line with market developments. Nowadays, it is more regional. Gaseous fuels are now mainly distributed in three ways; in pipe networks, in liquid form on lorries and in gaseous form on lorries (flaking).

Compared to other European companies, the Swedish gas distribution network is limited. Natural gas and biogas are energy gases with very similar characteristics and are therefore distributed using the existing gas infrastructure.

WHERE WE WANT TO GO

A well functioning biogas distribution network must be available throughout Sweden, via the Western Swedish gas network or other regional/local networks, or by lorry or rail in liquid or compressed form. Swedegas, which owns and operates the Swedish gas transmission network, aims, by 2030, to have 30 percent of the gas distributed in its gas network to come from renewable sources, increasing to 100 percent by 2050. Gasnätet Stockholm also aims to have 100 percent biogas in its network in the future.

HOW WE GET THERE

Expanded biogas production with major industrial plants and stronger demand throughout Sweden will push development forward. This is especially true of the market outside of the current gas distribution network.

Continued investment is required in order to develop gas distribution throughout Sweden, including the building of refilling stations. Even well-developed logistics, both for liquid and gaseous biogas, requires that the green gas principle works between the various aggregation forms.

Pipe network
Gas is transported in a gas pipeline network along the west coast and in local and regional network structures in various parts of Sweden. When transporting larger quantities of gas, a pipe network is a secure, efficient and environmentally-friendly transport method as it does not rely on road transport for distribution. A producer that is connected to a gas network can sell biogas to all customers that are connected to a gas network in accordance with the green gas principle. Pipe networks make it possible for gas to be continually deposited and minimise the need for flaring. The West Sweden network transports an average of 1100 MWh of energy per hour.

Liquid methane
LNG and LBG are gases that are cooled to about -162°C and transported in liquid form. Cooling reduces the volume of the gas around 600 times. This means that gas can be transported over longer distances more cost-efficiently. In Sweden, there are currently two import and storage terminals for LNG, in Nynäshamn and Lysekil, as well as a production facility for LBG in Lidköping. Distribution of LNG/LBG requires a separate distribution chain as the gas must be transported in liquid form in isolated tanks until it is used. A lorry carrying LNG/LBG holds 350 MWh of energy.

Flaking
Flaking means that the gas is transported on lorries with prepared gas bottles, made either from steel or composite. Flaking has low investment costs and transport is cost-efficient over shorter distances, up to 10-15 km and in smaller quantities, due to logistical challenges. For larger production volumes, the number of transports required increases significantly. Flaking of biogas is therefore mainly applicable to smaller, local and, to some extent, regional distribution solutions. A lorry carrying composite gas bottles (pressure 250 bar) holds 43 MWh of energy.

THE SITUATION TODAY

Efficient distribution from larger production facilities

The Gobigas project in Gothenburg chose a strategic location close to the gas transmission line on the west coast. By doing so, the biogas they produced could be fed directly into the transmission network, something that had not been done before. The distribution of liquid gas by lorry also allows the co-distribution of fossil and renewable gas to the same customer. This method of distribution is currently done for liquid gas and industrial customers. Sweden currently has one production facility for liquid biogas, located in Lidköping, and all LBG is transported from there by lorry. More LBG plants are planned within the framework of Klimatklivet.

An improved gas infrastructure, in the form of local and regional gas networks and liquid methane terminals, is necessary in order to ensure access and security of supply for customers. Developing and expanding the gas market as a whole, including natural gas, is essential for realising the potential of biogas. This does not stand in opposition to the long-term goal that biogas shall replace natural gas on the Swedish gas market.

It is socio-economically efficient to utilise the existing infrastructure to distribute biogas where such exists within a reasonable geographical distance. Increased introduction of biogas into the gas networks will improve the security of supply. Since the 1990s, upgraded biogas has been injected into the distribution networks on the Swedish west coast.

Distribution of biogas via gas networks gives the producer access to a larger market. In addition, gas can be stored in the network and even out any fluctuations between production and demand. In 2016, the proportion of biogas in the west coast transmission network was about 10 percent. If biogas that is injected into the distribution networks is included, this increases to 15-16 percent. Gasnätet Stockholm already has about 60 percent biogas in its network.

Filling station infrastructure is undergoing continual development

The expansion of the gas refilling station network has continued, even when gas vehicle sales have stagnated. At the beginning of 2018, there were 175 public refilling stations in Sweden, see Figure 22, and around 60 private stations. Six of the public refilling stations offer liquid gas. With the support of Klimatklivet, more liquid biogas refilling stations are being built.

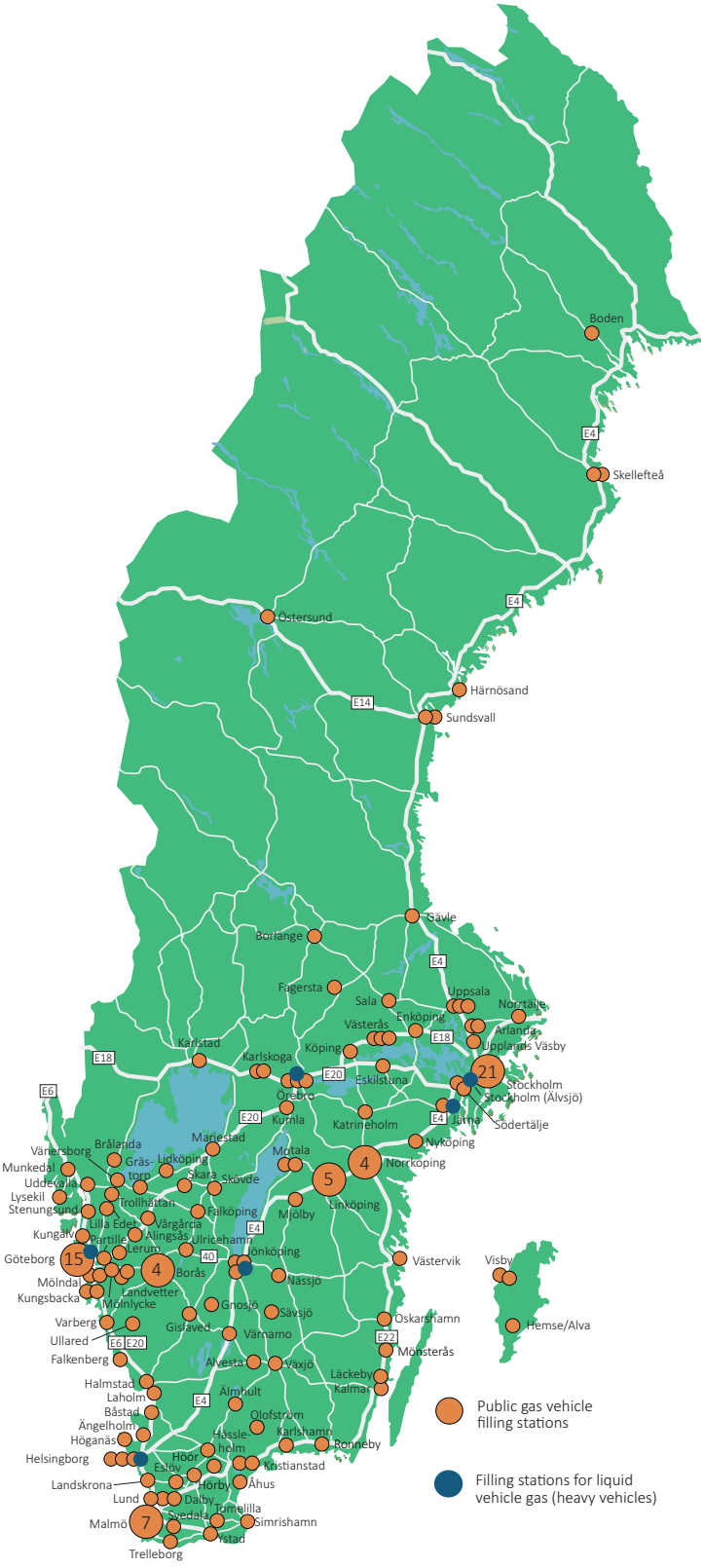


Figure 22. Public refilling stations in Sweden, January 2018.
Source: Swedish Gas Association

Developing the green gas principle

The green gas principle is important for the development of biogas from both a taxation and a market perspective. Fundamentally, biogas and natural gas have the same chemical composition, consisting primarily of methane. The difference is that biogas is renewable, whilst natural gas is fossil-based. By upgrading biogas, it becomes possible to distribute both gases using the same infrastructure.

The green gas principle gives biogas producers and consumers that are connected to a gas network the opportunity to buy biogas virtually in the same way as they buy renewable electricity, see Figure 23. The principle is based on biogas having its tax exempt status and sustainability credentials established in agreements, and not via the way in which it is physically delivered.

The principle also applies when gas networks are not physically connected. A company can import biogas into a network somewhere in Sweden and sell it to a customer who takes it out from another gas network in Sweden as long as an agreement is in place. This corresponds to the principle in the Swedish Sustainability Act, where a company can move sustainability characteristics between volumes in different stores as long as this has been defined as the same "place". In this context, "place" is defined as being within Swedish borders.

Having confidence in the functionality of the green gas principle means that the biogas distribution system can be expanded in an efficient way. This increases market access to biogas for all players. An effective infrastructure can also give end customers a lower final price.

In order to make a broader and more developed biogas market possible, there must be an evolution in the way the green gas principle is applied. It must be possible to apply

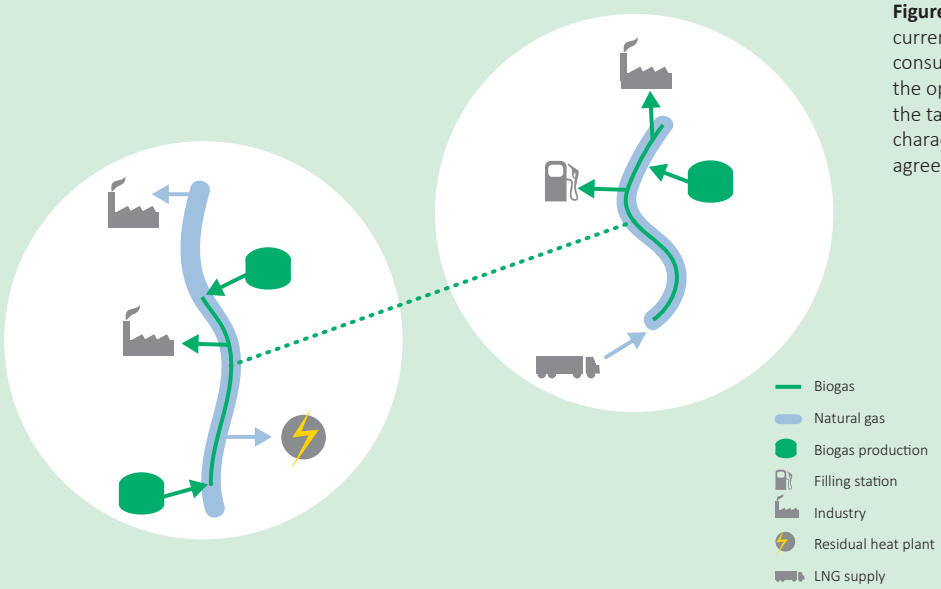


Figure 23. The green gas principle, in its current form, gives biogas producers and consumers connected to a gas network the opportunity to buy biogas virtually as the tax exempt status and sustainability characteristics of biogas are established by agreements.

the green gas principle within EU emissions trading (see Chapter 7.1.5) and the electricity certificate system (see Chapter 7.1.6). If the tax legislation is also amended so that green gas exchanges can take place across aggregation forms without a liquefaction stage, the distribution system will be made even more efficient (see Chapter 7.1.9).

THE FUTURE

Only biogas in gas networks

Sweden has a relatively large proportion of biogas in its gas networks, but the goal is even higher. In order to realise this, a number of relatively large biogas plants must be built in close proximity to either a distribution or transmission network. These may be large anaerobic digestion plants, bio refineries or gasification plants. A plant that produces gas directly to an industry, and, at the same time, supplies gas to the network is an interesting combination.

More local or regional networks

As more biogas plants are being built and more customers are buying biogas, there is a greater possibility of achieving profitability by expanding a small gas network. This can be done either locally at municipal level, or through a regional network that covers more customers, production facilities and, possibly, an LNG terminal in order to balance supply and demand. A terminal can also receive LBG from plants not connected to the gas network. Despite the small scale, it is possible to achieve a high level of flexibility.

Thought has been given to establishing regional networks in various parts of Sweden. Åhus and North-east Skåne, as well as Gävle/Sandviken are two places where investigations are being carried out or have been carried out.

Liquefied biogas is becoming increasingly available

Increased biogas production, larger biogas plants and an industrial approach on the part of producers means more advanced logistics. More producers are seeing a future in liquid biogas. A realistic transport distance for a lorry carrying biogas in gaseous form is up to around 200 kilometres. In the case of liquid biogas, this distance increases up to 500 kilometres. At present, biogas is transported by road, but in the future, rail transport may also be a viable option.

Continued expansion of the refilling station network

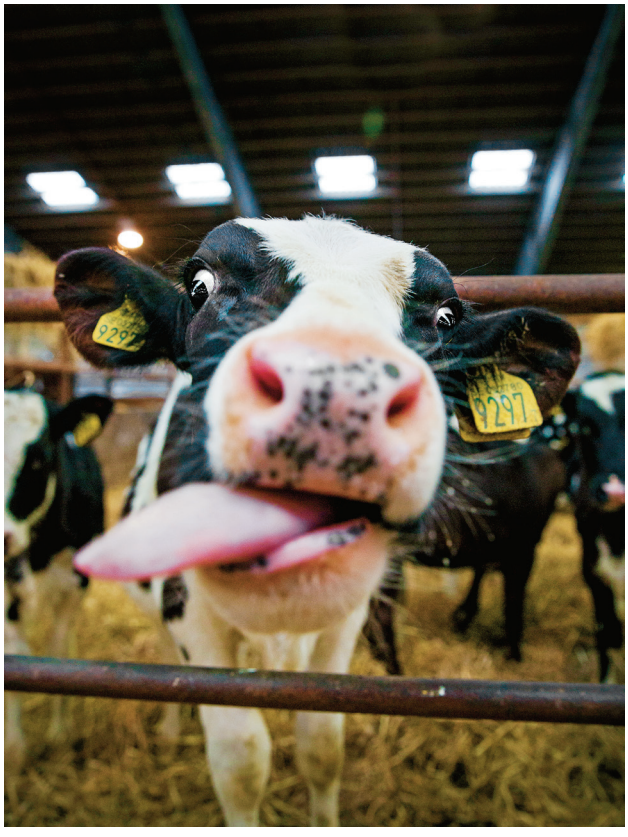
The gas market for heavy vehicles may take a massive leap forward in the coming years. Therefore, more liquid gas refilling stations are required. Previous studies have shown that, as a first step, about 25-30 such refilling stations at strategic locations throughout Sweden would be sufficient to cover needs[68]. This growing market and expansion may then help increase the rate of expansion for the rest of the vehicle market.

6. Biofertiliser

WHERE WE ARE TODAY

In 2016, about 2 million tonnes of biofertiliser were produced from co-digestion plants and farms[69]. Biofertiliser maintains a very high level of quality, and there is great confidence in it among farmers, food buyers and food producers alike[70]. Increasingly more biofertiliser is also being approved for organic farming.

Despite this, biofertiliser usually implies a cost for the producer and it may be difficult to receive remuneration for the environmental and social benefit that biofertiliser contributes.



WHERE WE WANT TO GO

By initially realising the production of 7 TWh of biogas from waste and residues, 10-15 percent of all mineral fertilisers can bse replaced with biofertiliser. The total socio-economic value of converting waste and manure into biofertiliser will then be around SEK 1.5 billion per year.[71]

HOW WE GET THERE

There is a need for legislation that requires mandatory collection of food waste from households and businesses. Increased focus on eutrophication also provides incentives for the wider use of biofertiliser.

At the same time, the status of biofertiliser must be raised and it must be possible to receive remuneration that is proportionate to the benefit enjoyed by society. In addition, it is also important that the technology involved in the production process is developed in order to reduce the amount of water and to tailor the nutrient content of the biofertiliser. Several such projects are underway and the industry is to play a key part in driving this development.

What is biofertiliser?
Biofertiliser is defined as a fertiliser that is produced after the anaerobic digestion of organic matter from the food and/or feed chain, such as food waste, manure and digestates from the food industry. Biofertiliser contains all the nutrients that are added to a biogas plant via the incoming substrate. Through digestion, some organically bound nitrogen is converted into easily soluble ammonium nitrate, which is thus readily available for growing crops.[72]

Quality assurance

Practically all biofertiliser is returned to farmland as an organic fertiliser. Since there are no national regulations governing the production of biofertiliser in Sweden, the majority of all co-digestion plants are affiliated with Certified Recovery and must therefore be compliant with certification regulation SPCR 120[73]. During 2016, up to 80 percent of all biofertiliser produced in co-digestion plants was quality assured and certified.

HOW MUCH BIOFERTILISER CAN BE PRODUCED?

Based on the 7 TWh biogas produced from waste and residues as previously defined in Chapter 4, calculations have been made of the socio-economic value of replacing mineral fertiliser with biofertiliser[74]. Only waste and residues of a quality that means that they can be converted into biofertiliser have been included in the calculations. Large amounts of nutrients can also be found in sludge digestate where the current use of Revaq-certified organic matter contributes phosphorous, nitrogen and mould to agriculture. There is a potential to increase the amount of sewage sludge used in agriculture from the current level of 25 percent of production to 40 percent[75]. Sewage sludge is excluded from the social calculations in this chapter.

The calculations include:

- Food waste
- Waste from the food industry and slaughterhouses
- Manure from beef and pork production

Table 2 below shows how much plant nutrition it is estimated that the substrates above contain. Since all the nutrients supplied to the digestive chamber containing the incoming substrate are also found in biofertiliser, it means that the corresponding amount of mineral fertiliser can be replaced.

Table 2. Amount of replaced plant nutrients from mineral fertiliser in tonnes in a production of 7 TWh biogas. Source: Envirum 2018. Environmental Benefit and Socio-economic Value of the Production and Use of Biofertiliser.

	Nitrogen	Phosphorous	Potassium
Food waste	3,060	470	1,330
Slaughterhouse waste	1,730	260	750
Industrial waste	2,910	420	1,190
Manure	17,410		
Total (tonnes)	**25,110**	**1,150**	**3,270**
Mineral fertiliser	165,000	12,000	29,000
Replaced mineral fertiliser	15%	10%	11%

BIOFERTILISER HAS MANY ADVANTAGES

Converting waste and residues to biogas reduces climate impact as it removes the more energy and fossil-intensive mineral fertiliser. Manure from beef and pork production is already being used on farmland as a plant nutrient source, so this does not entail any replacement of mineral fertiliser. However, digesting manure into biofertiliser does have positive environmental effects as digested manure reduces acidity levels and is less eutrophying than uncomposted manure. In addition, production of biofertiliser generates lower particulate emissions.

Taking the climate impact, acidification, eutrophication and particulate emissions into account, estimates indicate that the socio-economic value of producing biofuel from waste, residues and manure amounts to between SEK 1.3 and 1.7 billion per year[76].

Benefits that are not ascribed a socio-economic value

Biofertiliser has a whole host of benefits to which it is difficult to give an economic value, but are still very important. Chapter 2 briefly describes how biogas has less odour than uncomposted manure, which is very valuable to a farmer during storage and spreading. Composting manure also results in increased killing of weed seeds and parasites, as well as salmonella (if biogas is hygienised). Another positive, if economically difficult to measure, benefit is the addition of carbon. This additive increases the fertility of the soil, which in the long run, produces better harvests, particularly in soils with a low organic matter content.

7. In-depth section about proposed instruments and measures

THE SWEDISH GOVERNMENT AND PARLIAMENT

7.1.1 Competition on equal terms for imported and Swedish biogas

It is very urgent that domestic and imported biogas are given the opportunity to compete on equal terms. Many other European countries are choosing to promote biogas through the provision of production subsidies. When imported biogas, which receives significant production support in, for example, Denmark, is also exempt from tax when sold in Sweden, it can be traded at a significantly lower price than Swedish biogas. The price of biogas is driven down to levels that do not even cover production costs, with losses incurred as a result.

Such a situation has arisen in Sweden. If no action is taken, parts of the Swedish biogas production industry risk being forced out of business. It is believed that the problem will continue to grow as more and more existing agreements expire.

In order to quickly establish equal competition in the short term, an initial first step should be to extend the current manure gas subsidy to substrates other than manure. This subsidy may be designed as a sort of cycle premium and cover biogas produced from substrates such as organic waste and residues, where nutrients are returned to the farmland, thereby creating a cycle. In order to ensure equal competition terms, the total support level in the value chain should correspond to approximately the level applied in Denmark. In such instances, the current budget for manure gas support should be increased, at least temporarily, before long-term instruments are put in place.

Without competition on equal terms, biogas production is unlikely to increase in Sweden. On the contrary, it is more likely that the distortion of competition, if it is allowed to continue unabated, will lead to reduced biogas production in the future and to the loss of significant public and private investment.

7.1.2 Long-term stable and competitive conditions for biogas

In order to optimise the use of biogas as a resource, long-term instruments are required in order to promote both increased demand and increased production of biogas and biofertiliser. Decisions on long-term conditions should be taken in good time before 2021, as current state aid approval for tax exemption on biogas as transport fuel will no longer apply. It needs to be made clear to market players how the instruments will look like at least ten years in the future. Therefore, the instruments also need to work well in relation to EU regulations, both in the near future and in the long term.

The purpose of the long-term conditions should be to ensure that at least 15 TWh of biogas is used in Sweden by 2030, which is considered to be the potential for user in the medium-term perspective. The production potential is significantly greater than that, and a realisation of that production potential will help to solve many environmental and social problems (see Chapter 2). Therefore, the instruments should also ensure that the production potential is realised and that Sweden becomes a net exporter of biogas and other biofuels.

As a first step, the instruments should work to ensure that the waste and residues that, for environmental reasons, should be converted into biogas and biofertiliser are fully utilised as substrates for biogas production. Researchers[77] have identified that this should initially provide around 7 TWh biogas, with the potential to expand production to other substrates and, in this way, satisfy an increased demand for biogas.

The design of long-term instruments needs to be investigated in detail, where several models are analysed in respect of, inter alia, cost-effectiveness and the consequences for both production and use. An analysis also needs to be conducted into how instruments can be combined for best efficiency and without coming into conflict with, for example, state aid rules.

At present, there are probably two ways to go - continued tax exemption or some form of support targeted at the biogas value chain - funded through the treasury or in some other way. The solution could also be a combination of both of these approaches.

The criteria for, and the market effects of, an instrument differ between different areas of use of biogas. For example, what tax rates are applied in different sectors have a major impact on the overall support level required in order to increase biogas use in each sector. The need for support also differs depending on the substrate.

7.1.3 Better conditions for biogas by taxing energy content instead of gas volumes

Energy and carbon tax on natural gas is based on the used gas volume (SEK/Nm^3) at a fixed theoretical energy content (11 kWh/Nm^3). As biogas has a lower energy content, it needs to be combined with LPG when it is distributed with natural gas in the gas network. Otherwise, natural gas consumers near a biogas entry point would have been affected by higher taxes, simply because the tax was based on consumed volume instead of energy content.

Adding LPG increases costs for biogas producers.

The Swedish Gas Association has therefore suggested that the Swedish Government amend the provisions of the Swedish Energy Tax Act so that natural gas is taxed based on its energy content instead of volume consumed.

It is deemed that only a relatively minor amendment to legislation will be required and that no major changes to the Swedish Tax Agency's control activities will be necessary. The legal change should therefore be implemented immediately in order to promote increased biogas supply to the gas networks and improve the economic situation of biogas players.

7.2.1 A national biogas register with origin guarantees

In many countries, trade in biogas takes place via some form of biogas register with origin guarantees (sometimes referred to as biogas certificates). These are not currently available in Sweden today, but in the proposal for a revised Renewable Energy Directive[78] (REDII), Member States are required to introduce origin guarantees for gas.

Introducing such a system in Sweden could not only contribute to a more developed national biogas market, but also to the issue of cross-border trade. Therefore, it is vital that the Swedish Government tasks the Swedish Energy Agency with the establishment and administration of origin guarantees for gas as soon as the revised Renewable Energy Directive has been finalised at EU level.

The Swedish Energy Agency is responsible for the administration of origin guarantees for electricity, and it is therefore only natural that the Swedish Energy Agency is given this task. However, it is desirable that the industry be given the opportunity to actively participate in analysis, requirements imposition and anchorage throughout the entire process.

Through the Swedish Gas Association, the industry has begun a needs analysis, and this work must be allowed to continue in dialogue with authorities and government ministries.

It is important that the system is designed so that:

- it can be used for the requirements imposed through REDII in respect of
  (a) origin guarantees for renewable gas;
  (b) traceability requirements in the sustainability criteria and
  (c) the EU database for transactions of advanced biofuels.
- it can handle all biogas, both biogas fed into the European gas network and regional networks, but also biogas produced in off-grid plants.
- the green gas principle can be applied within the EU ETS and, if possible, within the electricity certificate system.
- it is compatible with other countries' systems in order to facilitate cross-border trade.

7.1.5 Ability to report biogas as renewable in EU emissions trading

In order to broaden the biogas market to major industries and electricity and heat production, businesses within EU ETS need to be able to report biogas as renewable, even when biogas is co-distributed with natural gas. This is not currently possible, which is a hindrance for increased biogas use.

As emissions trading is expected to be an increasingly powerful instrument - with rising emissions allowances - it is important to eliminate this obstacle as soon as possible.

It is believed that the solution is to implement a nationally legislated system for the recording of biogas volumes. Therefore, the Swedish Government should task the Swedish Energy Agency with developing such a biogas register (see measure 1.4).

7.1.6 Enable the granting of electricity certificates for renewable electricity from biogas that is co-distributed

In accordance with current regulations, electricity certificates are not granted to plants that produce electricity from biogas that is co-distributed with natural gas. Removing that restriction will contribute to the creation of conditions for renewable gas power to be a complement to intermittent power generation - something that will be needed in order to ensure a reliable power system in the future.

7.1.7 Mandatory requirements for the collection of organic waste from households and businesses, requiring recovery of nutrients and energy

In a sustainable society, organic waste from households and activities is processed in a biogas plant where the waste is converted into two socially useful products - biogas and biofertiliser. This provides increased access to domestically produced renewable energy, while enabling organic food production as the supply of biofertiliser increases.

There is a national goal for the collection and processing of food waste[79], but it is not a mandatory goal. The goal for 2018 will probably not be achieved. Therefore, a mandatory requirement for the collection of organic waste from households and businesses should be introduced. This collection requirement may be gradually tightened and should be combined with requirements in respect of the recovery of both nutrients and energy.

The starting point should always be that the cost of waste processing shall be borne by the consumers and businesses that produce the waste. The cost of collection and processing must not be borne by biogas or biofertiliser as products. Given that the cost is allocated to waste collection, a mandatory requirement may contribute to putting biogas producers in a better financial situation.

Previous studies[80] have estimated that the requirement could lead to an increase in profits for most biogas plants of about SEK 50-100/MWh. This applies provided that there is available processing capacity, which in this example was deemed to be the case for a typical plant in Sweden.

7.1.8 Reward the use of recovered plant nutrition in public procurement

Requirements should be imposed on publicly-controlled businesses to reward the use of recovered plant nutrients in preference to fossil-based mineral fertilisers during procurements. Such a requirement could be applied to things such as food purchases, and is viewed as a step towards a more circular economy.

Public players should also work with information initiatives promoting biofertiliser as a good environmental choice. There may also be a certain signal value if public players themselves increasingly use recovered plant nutrition in their own land.

7.1.9 Application of the green gas principle across aggregation forms without liquefaction steps

One barrier to a broader and developed biogas market is that the green gas principle (see Chapter 5) is still not fully developed in the regulations in respect of sustainability and tax exemption.

It should be possible to significantly increase both the production and use of biogas if biogas could be fed into a pipeline somewhere in Sweden and subsequently sold in liquid form to customers elsewhere in Sweden without the biogas being subjected to any liquefaction step. However, the interpretation of current regulations is that the liquefaction step must be in place for sustainability characteristics and tax exemption status to be able to follow biogas all the way from producer to customer.

A legislative amendment is required to the Swedish Energy Tax Act (1994:1776) in order to enable efficient distribution of biogas to heavy goods vehicle transports and parts of industry where biogas has significant potential to grow and eventually phase out liquefied natural gas (LNG). In instances where biogas production takes place in close proximity to a gas network, the liquefaction step may currently be viewed as an unnecessarily expensive and energy-intensive step in order to introduce biogas on these markets.

The industry is currently in a position where the biogas distribution system is developing and taking shape. If the authorities enable green gas exchange across the aggregation forms, without the liquefaction step, the highest possible level of efficiency in the system is achieved. If the authorities reject that opportunity,

the industry will have to invest in liquefaction plants - which is not really necessary if the green gas principle works - in order to reach new markets.

In light of this, it is imperative that legislators and authorities take a position as soon as possible on how the rules on the green gas principle will work in the future, so that the industry can make the right investments from the outset.

7.1.10 Tax exemption on electricity use in the production of upgraded biogas

Until 2016, biogas producers were exempt from tax on the electricity consumed in high-pressure compressors during the production of upgraded biogas. Some electrical energy is required when the pressure is increased, but in relation to the total climate and environmental benefits of biogas, the environmental impact of the process is negligible. On the other hand, electricity use means costs for the producer.

A ruling issued by the Supreme Administrative Court in 2016 stated that the electrical power required for pressurisation cannot be regarded as being consumed in the manufacturing process, which is a prerequisite for exemption. Instead, the Court stated that pressurisation is part of the gas distribution process. This is justified, inter alia, because there is no specific CN number for upgraded biogas. Without a specific CN number, the upgraded biogas is considered to be the same product as before pressurisation, where no manufacturing has been carried out.

This is the interpretation that is now applied, which means that, from 2017 onwards, Swedish biogas producers will be required to pay higher taxes for the production of upgraded biogas. This is an unfortunate development that counteracts the overall ambition to increase biogas production. For a more consistent environmental policy - and to improve the financial situation of Swedish biogas producers - measures need to be implemented so that the Swedish Tax Agency can return to the previous interpretation, which allowed tax-exempt electricity use during the upgrading stage.

7.1.11 More efficient licensing processes for new biogas plants

Drawn out and expensive licensing processes often constitute a significant financial and administrative burden for a planned biogas plant. In order to promote increased biogas production, the licensing process needs to be shortened and licence assessment needs to be consistent throughout Sweden. County Administrative Boards sometimes make different assessments and the results of the trials have different outcomes, despite being subject to the same legislation.

To increase biogas production, the Swedish Government must allocate resources to the County Administrative Boards so that applications for the construction of biogas plants can be processed efficiently and in a short period of time. This is comparable to wind farms for which County Administrative Boards have received increased resources, and where coordinated information initiatives from the Swedish Government (www.vindlov.se) create the conditions for more efficient licensing processes.

7.1.12 Promote large scale production of biofuels from cellulose

In Sweden, there is plenty of cellulose-rich material present in forest residues and straw. State reports, authorities, researchers and business[81] have pointed out that this potential should be exploited in order to achieve large-scale production of biofuel in Sweden. In this context, the production of biogas from cellulose has been described as one of several promising approaches[82].

The state report on fossil-free transportation, *Fossilfrihet på vägen* (SOU 2013:84) suggested that Sweden introduce a "price premium model" that guarantees a price premium on the production of cellulose-based biofuels during the first 12 years of a plant's production. This subsidy, which is technology-neutral and may be gradually stepped down, is necessary in order to enable investment in new technologies in a situation where oil price tends and political changes create an uncertain market situation.

The price premium model, or an equivalent system, can turn Sweden into a net exporter of biofuel. At the same time, biogas production can be large-scale. This promotes the biogas system as a whole, where production, infrastructure and use are developed in parallel.

7.1.13 Investment fund for reduced environmental and climate impact from shipping

The Swedish Energy Agency has proposed that an investment fund for shipping should be investigated. Correctly designed, and implemented in combination with other instruments proposed in this strategy, such an investment fund can create conditions for increased biogas use in shipping.

In Norway, there is an NOx fund, which is based on industry players, including shipping lines, paying a fee to the fund, after which they are exempt from paying nitrogen oxide tax. Monies paid into the fund are used as contributions to investments to reduce the emission of nitrogen oxides. As it is often cost-effective to implement investments in shipping, many shipping industry projects have been granted a subsidy.

How the fund could be designed in Sweden needs to be investigated, but it would be desirable, in this way, to promote investments that reduce both greenhouse gas emissions and other air pollution from vessels.

7.1.14 Measures for the conversion of the vehicle fleet, where gas vehicles should be promoted alongside other climate-adapted vehicles

a) Continued measures for broader market introduction of climate-adapted lorries

For a broader market introduction of, inter alia, gas-powered lorries, measures need to be taken to overcome obstacles such as uncertainty about vehicle flexibility and residual value. These measures can be phased out as the vehicle fleet and the number of filling stations increase, but they will be important during the development phase.

Through support from the state funded support programme for local climate investments, *Klimatklivet*, parts of the additional cost can be financed when purchasing a lorry powered by alternative or renewable fuels, e.g. biogas. It is an important support that is welcomed by the biogas industry, and the type of investment support should remain for as long as the need exists.

However, investment support for vehicles cannot constitute the entire solution. There are several other instruments and regulations that must be employed in concert with each other. For example, biogas support systems, and design of environmental zones, road tolls and congestion charges.

b) Promote electricity and gas-powered buses and ferries in public transport

Public transport is an important piece of the puzzle for increasing the production and use of biogas in Sweden. Large parts of existing biogas production are built around public transport as the single largest sales market and as a growth engine for other markets.

A stable demand for biogas in public transport is an important prerequisite for continued expansion to other areas of use. Therefore, it is important that instruments do not hamper the use of biogas in public transport, which the "electric bus premium" does as it only covers electric buses, electric hybrids and trolley buses. The electric bus premium means that there is currently a distortion of competition to the detriment of biogas-powered buses. In order not to hamper biogas use in public transport, the premium should be extended so that there is an electricity and gas premium for buses and ferries in public transport.

c) Instruments on the second hand market to reduce exports of used climate bonus vehicles

Among climate bonus vehicles[84] there is a common problem that needs to be resolved quickly so that bonus malus and other measures on the passenger car market will have the intended effect. A significant proportion of climate bonus cars are exported abroad after only a few years in Sweden. Of the deregistrations made in 2016, the proportion of exports was almost 100 percent for electric cars and charging hybrids. For gas cars, the figure was about 80 percent.[85]

According to Government agency Transport Analysis, the growth of climate bonus cars will be significantly hampered if the high proportion of exports persists. Transport Analysis believes that exports can be seen as a signal that demand for these vehicles on the second hand market is too low in Sweden.

Therefore, instruments need to be designed that provide the right price signals on the second hand market and also make used climate bonus vehicles a good choice for the wallet. Since the malus on petrol and diesel cars ceases after three years of operation, the bonus-malus system will not provide that price signal. A cost-neutral way to reduce exports could be to eliminate vehicle tax on climate bonus vehicles and extend the malus period for malus cars.

d) Stable and favourable conditions for climate bonus vehicles as a benefit car

For gas cars, as well as electric and hybrid vehicles, a 40 percent reduction in benefit value applies up to and including the income year 2020. This reduction is important in order to stimulate the introduction of these cars, and it also acts as a driving force for increased biogas use.

The problem is that the provisions have been extended for a few years at a time and they have not followed the length of the lease, which is usually three years. This has caused market uncertainty and an unevenness that has hampered development.

The reduced benefit value system should therefore be reviewed and modified so that it still promotes all climate bonus vehicles and is predictable over time, which we suggest be for the period 2021-2030.

e) A travel deduction system that promotes travel using climate bonus vehicles

The travel deduction system should promote low climate impact journeys. Therefore, the travel deduction should be linked to the bonus-malus system. Travel using a climate bonus car may, for example, entitle users to higher travel deductions. Another option is that the lowest cost level for deductions is lower for travel using climate bonus vehicles than for journeys using malus cars.

How the provisions are to be designed and checked needs to be investigated, e.g. in conjunction with when the travel deduction system as a whole is reviewed.

AUTHORITIES

7.2.1 Design of a national biogas register with guarantees of origin

It is vital that, as soon as possible, the Swedish Energy Agency begins the work of analysing how a biogas register with guarantees of origin for gas could be designed and implemented in Sweden. Developing such a register of origin guarantees can be time consuming, and it is important to create time for dialogue and anchoring in the industry. Therefore, an initial analysis should begin, conducted in conjunction with the industry, even before it has been formulated as an assignment by the Swedish Government.

The background as to why there a national biogas register with guarantees of origin is required is described in more detail under measure 1.4.

7.2.2 Seek the opportunity to provide electricity certificates for electricity from biogas that is co-distributed

The Swedish Energy Agency should, in its role of regulatory authority for electricity certificates, work to ensure that the current biogas distribution method (co-distribution with natural gas) is approved within the regulatory framework for electricity certificates. The Agency should therefore promptly inform the legislator about necessary adjustments to the regulatory framework (see also measure 1.6).

7.2.3 Information about the overall environmental and social benefit of biogas

Biogas helps solve many different social problems. It is a great force, but it is rarely valued in procurements and other contexts where focus is often on solving one social problem at a time.

Industry organisations and biogas stakeholders are constantly working to inform about the overall environmental and social benefit of biogas, but there is also a need for objective and coordinated information from Swedish authorities.

The properties of biogas, which make it an important resource for society are justification for relevant authorities to do coordinated work to inform the public about the benefits of biogas.

The aim would be to raise awareness of the benefits of biogas in a broader perspective than just the fact that it is beneficial to the environment. The primary target group would be companies and organisations involved in procurement of things such as fuel, vehicles and transports. Such information efforts would facilitate, inter alia, public transport authorities' ability to apply a broader overall view of environmental and social benefits during procurements (see measure 3.2).

7.2.4 Coordination of infrastructure development

Within the framework of the Swedish Energy Agency's mission to coordinate the development of renewable transportation fuel infrastructure, the starting point should be Directive 2014/94/EU of the European Parliament and of the Council on the deployment of alternative fuels infrastructure (the "Infrastructure Directive"). The Directive imposes requirements on Member States' national action plans, but the Swedish Action Plan has been criticised by the EU Commission for not fully satisfying the requirements of the Directive.

The Swedish Energy Agency should therefore produce a document for responding to the criticisms that can be used to update the Swedish National Action Plan. In dialogue with Finland and Norway, the Swedish Energy Agency should identify areas in Sweden where there is no infrastructure. Proposals for infrastructure development objectives should be produced and the process of achieving

the goals needs to be clarified. Synergies between land and sea transport, as well as industry's gas use need to be exploited and developed.

In dialogue with industry, the Agency should also contribute to increased understanding of why some infrastructure projects are not implemented, despite funding being granted. A crucial factor is understanding drivers in order to develop markets and create demand.

7.2.5 Annual review of emission factors when assessing climate measures

In state co-financing of climate measures, the application process often includes an assessment of the cost-effectiveness of the measures. The emission factors for greenhouse gases used therefore greatly affect the ability of a measure to obtain state co-financing.

Emission factors are usually based on data reported in accordance with the Swedish Sustainability Act and the Swedish Fuel Act. Reporting provides different results from year to year, partly due to changes in raw materials composition and technologies employed, and partly because the regulations have been clarified and amended over the years.

In order to capture the annual changes, it is desirable that an annual review is undertaken of the emission factors used in the assessment of the cost effectiveness of climate measures. Where appropriate, differentiation should be made based on the different raw materials and production routes. Efforts should always be made to ensure that as wide a system perspective as possible is taken.

Klimatklivet is one example where an annual review of the emission factors provided by the Swedish Environmental Protection Agency in its guidance should be carried out.

MUNICIPALITIES AND REGIONS

7.3.1 Introduce environmental zones in accordance with national regulations

Biogas contributes to better air quality in Swedish cities, as both heavy and light gas vehicles produce very low exhaust emissions. For example, in the case of nitrogen oxides, which are hazardous both to health and the environment, gas vehicles provide near zero emissions, not only in laboratory environments but also under actual driving conditions. Therefore, Swedish municipalities should take advantage of the opportunity available from January 1st 2020 to introduce three different environmental zones in their urban environments, where only electric vehicles, fuel cell vehicles and gas vehicles that are compliant with the Euro 6 requirements are permitted in the strictest zone in accordance with the national environmental zone regulations.[86] These emissions can be reduced cost-effectively while stimulating the production and use of biogas.

7.3.2 A broader socio-economic perspective during procurements

In recent years, a common procurement model has been used during procurements within public transport. The model has been developed by the Partnership for Improved Public Transport, whose members include the Swedish Public Transport Association and the Swedish Association of Local Authorities and Regions. The model states that tenderers are free to choose any fuel that is compliant with the sustainability criteria. In several instances, this has resulted in biogas being replaced by biodiesel.

However, the sustainability criteria were not produced in order to form the basis for procurement. The criteria only cover climate benefit, and then in a simplified perspective without the system expansion required in order to describe the total climate benefit of biogas.

In order to achieve better environmental control, the procurement basis should also incorporate a broader socio-economic perspective in addition to climate benefit. Public transport authorities should, in the course of their procurement activities, be aware of the cost-effectiveness of biogas, which is based, inter alia, on converting local and regional waste into a resource to cover the local and regional demand for fuel. This perspective is not addressed under the current procurement model, which, in the worst case scenario, results in a local resource in the form of biogas going to waste.

The procurement template needs to be reviewed so that the broad social benefits of biogas (environmental and economical) are taken into consideration when public transport and other forms of travel or services are procured in regions and municipalities.

As long as the procurement model does not value environmental and social benefits in a broader perspective, it is important to emphasise that municipalities and regions can still take responsibility for the whole by requiring biogas to be included in procurements. It contributes to regional development as waste management is then linked to the municipal and regional needs for energy and fuel.

Appendices

A. GLOSSARY AND ABBREVIATIONS

Biofertiliser	Digestate from co-digestion plants (biogas plants that can digest different types of organic matter, such as source-sorted food waste, slaughterhouse waste, manure and energy crops) or farms plants.
Biofuel	Vehicle fuel produced from biomass.
Biofuel quota obligation	Those who are subject to a quota shall ensure that a certain proportion of the volume of fossil fuels that are subject to a quota requirement consists of biofuel. Companies that are subject to tax on fossil fuels are also subject to a biofuel quota obligation.
Biogas	A fuel produced from biomass and whose energy content is predominantly derived from methane.
Circular economy	Based on reusing, repairing and regarding waste as a resource - doing more with less. A circular economy strives for products that are sustainable, recyclable and where non-renewable materials are replaced with renewable ones.
CNG/CBG	Compressed natural gas/Compressed biogas. Vehicle gas.
Digestate	Product formed after digestion of biomass and contains water, non-degraded material, nutrients and microorganisms.
EU ETS	EU Emissions Trading System, the EU's emissions allowances trading scheme.
Gasification	Technology where syngas (carbon monoxide and hydrogen) is formed by the controlled heating of biomass. Biogas can be produced by methanising syngas.
Green gas principle	Biogas fed into the gas network in one place can be taken by a user in another part of the network or in another network. The transfer is virtual and biogas purchases are confirmed via a trading agreement.
HVO	Hydrogenated Vegetable Oil is a biofuel produced from vegetable oils or animal fat. It can be mixed with diesel or replace diesel in diesel engines.
Intermediate crops	Crops that are planted and harvested between the standard growing seasons.
LBG	Liquefied biogas. Cooled, condensed upgraded biogas.
Liquid methane	The umbrella term for liquefied natural gas, liquefied biogas and other condensed renewable methane. The term is primarily used in technical contexts.
LNG	Liquefied natural gas. Cooled, condensed natural gas.
Natural gas	A gas mixture that predominantly contains methane of a fossil origin.
Power to Gas, P2G	A technology that allows the surplus electricity produced from renewable sources such as solar and wind power to be converted into hydrogen or methane.
RME	Rapeseed Methyl Ester is a biofuel made from rapeseed oil. It can be mixed in diesel.
Sludge/sludge digestate	Digestate from anaerobic digestion of sewage sludge at water treatment plants.
Upgraded biogas	Biogas that has been refined to natural gas quality with at least 97% biomethane.
Vehicle gas	A gas mixture (consisting mainly of compressed natural gas and biomethane CNG/CBG) used as fuel for methane-powered vehicles.

B. FIGURES AND MAGNITUDES, TWh

Swedish biogas production 2016	2.0
Swedish upgraded biogas production 2016	1.3
Use of biofuel 2016	17.1
Road traffic total energy use 2016	89.1
Industry total energy use 2016	142
Industry use of biogas 2016	i.u. *
Realisable potential for biogas production, total (WSP, 2013)	22
Realisable biogas target 2030, use in the transport sector	12
Realisable biogas target 2030, use in industrial sector	3
Realisable biogas target 2030, total use	15

* Official statistics are not available

Conversion table

	TWh	GWh	MWh
1 TWh	1	1 000	1 000 000

C. NOTES

1. The proposal is based on the findings of the FFF Committee's report (Fossil Freedom on the Road, SOU 2013:84) that 12 TWh biogas can be used in the transport sector by 2030, as well as industry estimates stating that biogas usage in industry may reach approximately 3 TWh in the same year.
2. WSP 2013. Realistic Biogas Potential in Sweden 2030 by Anaerobic Digestion and Gasification.
3. Lund University, Environmental and Energy Systems 2016. Potential for Increased Supply and Disposal of Domestic Biomass in a Growing Swedish Bioeconomy.
4. Lund University, Environmental and Energy Systems 2016. Potential for Increased Supply and Disposal of Domestic Biomass in a Growing Swedish Bioeconomy. This report identifies 6.2 TWh from anaerobically digested biogas. Pål Börjesson has since identified an additional 1 TWh biogas from field cultivation that does not conflict with EU ILUC rules.
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27. Swedish Waste Management Association 2018. https://www.avfallsverige.se/kunskapsbanken/certifierad-atervinning.
28. http://www.regeringen.se/regeringens-politik/en-livsmedelsstrategi-for-jobb-och-hallbar-tillvaxt-i-hela-landet/.
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30. Compilation and processing by Swedish Gas Association. Kan Energi 2012, Employment within the Biogas Sector in Västra Götaland. WSP 2011, Biogas, Employment and Growth in Biogas East Region.
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32. 2050 Consulting 2018. Socio-economic Value of Biogas.
33. Swedish Armed Forces 2017. Swedish Defence Sector Environmental Guidance Document, Appendix 1
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35. http://www.piek-international.com/english/register/suppliers/default.asp?page=detail&id=100.
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NATIONAL BIOGAS STRATEGY

Biogas is more important than ever. It is part of a closed cycle where waste produced by society, in the form of food waste, waste water and residues from forestry and industry produce renewable products such as propellants, electricity, heat, fuel and raw materials for industry and plant nutrition.

Biogas is, in practice, a circular economy and crucial for achieving Sweden's environmental and climate objectives. And time's running out: In order to achieve the use goal of 15 TWh by 2030, long-term conditions need to be in place no later than by 2021.

A new biogas report was announced as part of the Swedish Government's budget. In anticipation of the report, the Swedish Gas Association, together with leading industry players, presents a new, updated proposal for the Swedish National Biogas Strategy.

PARTICIPATING ORGANISATIONS AND COMPANIES

Avfall Sverige · Biogasbolaget · Energigas Sverige · e.on · gasnätet Stockholm AB · Göteborg Energi · Purac · Region Skåne · Scandinavian biogas · SSAB · SvenskBiogas · Swedegas · Öresunds Kraft

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