

State of the art on bioenergies

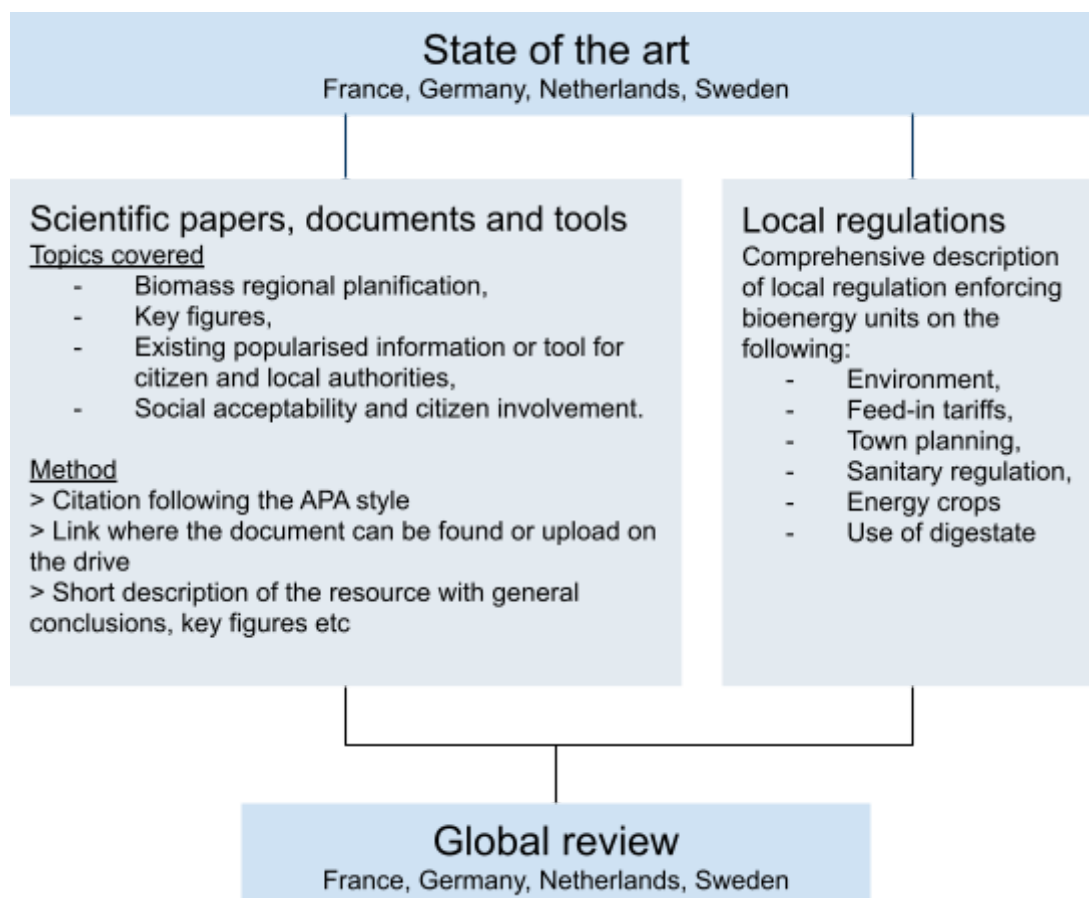
Introduction

This state of the art aims to give a general overview on all resources related to biomass and bioenergies that could be useful to BIOZE tools and objectives. This state of the art will be conducted in the following geographical areas, with a focus on each partner's region : France, the Netherlands, Sweden, Germany.

The state of the art will cover the following topics for each geographical areas:

- Biomass regional planification with targets for biogas and woodfuel,
- Key figures on bioenergy units, used and available biomass deposits,
- Existing popularised information or tool for citizen and local authorities on biomass and bioenergies,
- Social acceptability and citizen involvement,
- Local regulation relative to bioenergies (feed-in tariffs, energy and environment laws, etc),
- Global review of the available resources for BIOZE

Each resource this state of the art will be referring to will be cited following the APA style : Author last name or Organisation. (Year). *Report title: Subtitle*. Publisher name. URL



France

Biomass regional planification

DREAL Bretagne. (2019). Schéma Régional Biomasse de Bretagne.
www.bretagne.developpement-durable.gouv.fr/IMG/pdf/srb_vf_2_.pdf

The Biomass Regional Scheme defines for Brittany the main guidelines and actions to be implemented by 2030 to promote the development of production and recovery of biomass likely to have an energy use, while ensuring the respect of the multifunctionality of natural areas, including agricultural and forestry areas.

The report gives the following targets :

- the use of 25% of total manure in Brittany for biogas production by 2030 (6.7 millions of tons per year),
- the use of 30% of available cover-crops for biogas production by 2030 (1.6 millions of tons per year),
- the limitation of 10% of agriculture area (AA) for energy crops at a farm level.

Région Normandie. (2020). Le Schéma régional d'aménagement, de développement durable et d'égalité des territoires (SRADDET) de la région Normandie.

www.prefectures-regions.gouv.fr/normandie/content/download/70626/458734/file/RAPPORT%20SRADDET%20ADOPTION%20DEFINITIVE.pdf

The Regional Plan for Planning, Sustainable Development and Territorial Equality (SRADDET) of the Normandy region gives among other targets for the development of renewable energy by 2030 :

- 34,6% of renewable energy share in final energy consumption,
- 10% of total renewable energy covered by biogas, for a total of 2747 GWh/yr
- 18% of total renewable energy covered by woodfuel (domestic wood heating not taken into account), for a total of 5080 GWh/yr

Région Bretagne. (2020). Le Schéma régional d'aménagement, de développement durable et d'égalité des territoires (SRADDET) de la région Bretagne.

www.prefectures-regions.gouv.fr/normandie/content/download/70626/458734/file/RAPPORT%20SRADDET%20ADOPTION%20DEFINITIVE.pdf

The Regional Plan for Planning, Sustainable Development and Territorial Equality (SRADDET) of the Normandy region gives among other targets for the development of renewable energy by 2040 :

- Multiply the production of renewable energy by 7, from 7000 GWh in 2016 to 45000 GWh in 2040,
- 26% of total renewable energy covered by biogas, for a total of 11935 GWh/yr,
- 8% of total renewable energy covered by woodfuel, for a total of 3838 GWh/yr

Key figures on bioenergy

AILE (2022). Cartes et chiffres clés en Bretagne.

aile.asso.fr/biogaz/la-filiere/carte-chiffres-cles-methanisation/

Report on key figures of the biogas sector for Brittany region, with details on feedstocks, energy production, types of plant, etc.

[Biomasse Normandie \(2022\). Etat des lieux Métha'Normandie.](#)

www.methanormandie.fr/la-filiere-en-normandie/etat-des-lieux/

Report on key figures of the biogas sector for Normandy region, with details on feedstocks, energy production, types of plant, etc.

[Plan Bois Energie Bretagne \(2020\). Chiffres clés fin 2020: Plan Bois Energie Bretagne.](#)

Report on key figures of the wood boiler sector for Brittany region.

Existing popularised documents and tools

[CLER \(2021\). Les clés d'une méthanisation durable.](#)

Report to provide technical support to region's officials on the key factors to develop a sustainable biogas sector.

[AILE \(2019\). Les externalités de la méthanisation: Synthèse des intérêts et points de vigilance.](#)

Technical tool on biogas projects' positive and negative impacts, with scientific citations.

[OEB \(2019\). ESTIGIS: Estimer le potentiel énergétique de biomasse fermentescible de son territoire avec Estigis.](#)

Technical tool for local authorities which give an estimation on biomass deposits with tonnage, type of deposit and municipality.

[Biomasse Normandie \(2020\). Y a-t-il assez de bois pour l'énergie en Normandie? \(Is there enough wood for energy in Normandy?\)](#)

Popularised info sheet answering the question: "Is there enough wood for energy in Normandy". Can be used for the FAQ tool (activity 3).

[FIBOIS Grand Est \(2022\). Le kit des élus: bois énergie.](#)

FAQ sheets on wood energy answering several typical questions with charts and key figures.

[CEREMA, CIBE \(2021\). Le bois énergie, une solution pour les collectivités: Pourquoi et comment les développer?](#)

50-page guide for local authorities on wood energy, highlighting officials' roles on the development of bioenergies.

[AMORCE \(2021\). Guide L'écu, la méthanisation, et le biogaz.](#)

Extensive guide covering the role of officials in the development of new biogas projects.

[ATEE, Solagro, France Gaz Renouvelable \(2020\). Infometha. www.infometha.org](#)

Website providing popularised information on biogas impacts on agriculture, the environment, society and the energy sector.

Social acceptability and citizen involvement

[Bourdin, S., & Nadou, F. \(2020\). The role of a local authority as a stakeholder encouraging the development of biogas: a study on territorial intermediation. Journal of Environmental Management, 258, 110009.](#)

Scientific paper on the role of local authorities as facilitator of biogas projects

[Niang, A., Torre, A., & Bourdin, S. \(2022\). How do local actors coordinate to implement a successful biogas project?. Environmental Science & Policy, 136, 337-347.](#)

Scientific paper on the local coordination between stakeholders to set up a biogas project

[Bourdin, S., Colas, M., & Raulin, F. \(2020\). Understanding the problems of biogas production deployment in different regions: territorial governance matters too. Journal of Environmental Planning and Management, 63\(9\), 1655-1673.](#)

Scientific paper on the role of territorial governance in the success of biogas projects



Bourdin, S., Raulin, F., & Josset, C. (2020). On the (un) successful deployment of renewable energies: Territorial context matters. A conceptual framework and an empirical analysis of biogas projects. *Energy Studies Review*, 24(1).

Scientific paper on the role of territorial characteristics to explain the social acceptability of biogas projects

Mancini, E., & Raggi, A. (2022). Out of sight, out of mind? The importance of local context and trust in understanding the social acceptance of biogas projects: A global scale review. *Energy Research & Social Science*, 91, 102697.

Scientific paper doing a literature review on social acceptance of biogas projects

Mazzanti, M., Modica, M., & Rampa, A. (2021). The biogas dilemma: An analysis on the social approval of large new plants. *Waste Management*, 133, 10-18.

Scientific paper doing a literature review on social acceptance of biogas projects

Local regulation on bioenergies

Biogas

Biogas units are required to comply with several French regulations:

- the rules of town planning, by the deposit of a building permit in town hall,
- the Environment Code, which notably sets a 15% ceiling for energy crops in the ration of biogas units commissioned after January 1, 2017, via Decree No. 2016-929 of July 7, 2016.
- sanitary regulations, by holding a sanitary approval issued by the DDCSPP of the territory. This sanitary approval follows in particular the HACCP method and the principle of "going forward".
- the respect of the environment, by being classified ICPE (Installations Classified for the Protection of the Environment). There are three ICPE regimes with different requirements, depending on the annual tonnages and types of materials received on site: declaration, registration and authorization.
- compliance with the energy code, via regulated feed-in tariffs adapted to the type of energy production (electricity or biomethane). These tariffs set the feed-in price for the energy produced over a given period of time as well as the rules for biogas production.
- the regulations governing the use of digestate, generally via a land application plan that details the characteristics of the plots of land that can be used for organic effluent, and the conditions for land application according to the regulations to which the farm is subject (ICPE and nitrate regulations, for example). In some cases, if the operator requests, the digestate can be sold as an organic fertiliser on the EU market: in this case, it must comply with the rules defined in the Digestate specifications.

Woody biomass energy

- The list of eligible biomasses that can be burned is governed by the 2910 ICPE regulation,
- The ICPE regulation also sets maximum levels for certain compounds such as metals or other chemical compounds (mercury, arsenic, cadmium, chromium, chlorine, etc),



- The materials used, in particular for flues, must comply with several standards, including NF DTU 24.1,
- A decree of the French law fixes the regulatory thresholds of rejections allowing to limit the dust and fine particles released in the atmosphere, and thus to limit the impact of the boiler room on the quality of the air. These thresholds vary according to the installed capacity of the boiler.

Global review for France

The development of biogas and woody biomass energy in France has really taken off in the last ten years only. As the sector of bioenergies is quite recent, the regulations and feed-in tariffs rapidly adapted themselves in the past few years to the level of maturity of these sectors.

As French electricity is mainly dedicated to nuclear, wind and solar power, the political schemes and grants are pushing bioenergies to replace fossil natural gas, either with biomethane injected into the national gas grid (which is well developed), or with local heating networks.

Each region has its own biomass scheme that states the share of biomass dedicated to energy production for 2030. At the local level, things are far more contrasted as some local authorities have launched a planification of renewable energies, including bioenergies, when others are not proactive at the moment.

For those local authorities, some French tools on bioenergies already exist, but are either guides with general guidelines or technical tools that do not deal with bioenergies specificities. This is where BIOZE tools, along with the workshops should be quite effective.

Netherlands

National biomass planification

[Climate agreement with letter to Parliament, Minister of Climate and Energy, dated 28.6.2019](#)

The Agreement is between a wide range of parties in the Netherlands (industry, government, local governments, transport, NGO, branche organisations, including BEON) to reduce emissions by 49% by 2030 (compared to 1990), as was internationally agreed in Paris in 2015. It includes measures to be taken in the field of built environment (space heating), industry, electricity and agriculture and land use.

As regards to biomass it acknowledges the important role biomass plays in the energy transition. Biomass, however, should be from sustainable sources. It is agreed that the government will come up with a sustainability framework. Parties agreed that the SER-council should advise the government in this matter.

[SER-report on the use of biomass “Biomass in balance”, Sociaal Economische Raad, 2020, https://www.ser.nl/-/media/ser/downloads/adviezen/2020/biomassa-in-balans.pdf?la=nl&hash=6E441F5E399C6398278A5B07D28E9146](https://www.ser.nl/-/media/ser/downloads/adviezen/2020/biomassa-in-balans.pdf?la=nl&hash=6E441F5E399C6398278A5B07D28E9146)

Important basis for the use of biomass in the Netherlands. The report has been prepared for the government and all parties that signed the Climate Agreement on how to deal with biomass. It strongly advises to focus on high value applications (chemicals, materials). It acknowledges that there are applications that should be stopped (e.g. most low temperature heating) and that there are applications that could be considered as intermediate solutions (e.g. transport, high temperature use in industry). If there is an alternative for these applications, these alternatives should come first. The government should adjust current policies and promote the use of biomass for chemicals and materials.

The report has become the basis for the national policy on biomass and regional and municipal policies. The report has also become the basis for the BEON Code of Conduct.

Biomass regional planification

[Biomass policy province of Overijssel - Policy letter to the Provincial Council, 15 March 2022.](#)

The province supports bio-energy projects directed at:

1. high temperature heat with cascading for (process) industry where there are no alternatives in the longer term.
2. high temperature heat with cascading as a bridging application where alternatives will eventually become available.
3. Temporary application and peak and backup facility for space heating in heat networks.
4. Low temperature heat where there are no alternatives in the long term.

No support will be provided to the use of biomass, financially or otherwise:

- if other renewable heat sources are available,
- if processes can be electrified,
- for electricity production.



RES-Twente. Renewable heat resources for space heating. Regionale Structuur Warmte. Annex to RES-1.0 Report (2022).

Regional plan to reduce the use of mineral gas by extending the heating network from the current heating plant to two additional cities. Heat will come from regional waste and biomass combustion plant Twente (demolition wood and organic municipal waste). Urban areas that will not be connected to the heating grid will be heated using (green) gas and (hybrid) heating pumps.

Frans Feil, BEON-presentation and analysis Twente bio-energy and heating situation (2022)

Analysis shows current mineral gas use by industry and houses and renewable energy potential from waste and wood and green gas from manure.

Key figures on bioenergy

Corbey et al. (2020) Biomass availability in the Netherlands.

<https://www.klimaatakkoord.nl/documenten/publicaties/2020/06/29/routekaart-nationale-biogrondstoffen>

This report highlights the availability and potential for renewable energy applications, emphasising responsible management for sustainability and contributing to the country's renewable energy goals.

Boosten, M., J. Oldenburger, J. Kremers, J. van den Briel, N. Spliethof, D. Borgman. (2018) Beschikbaarheid van Nederlandse verse houtige biomassa in 2030 e 2050. Wageningen, Stichting Probos.

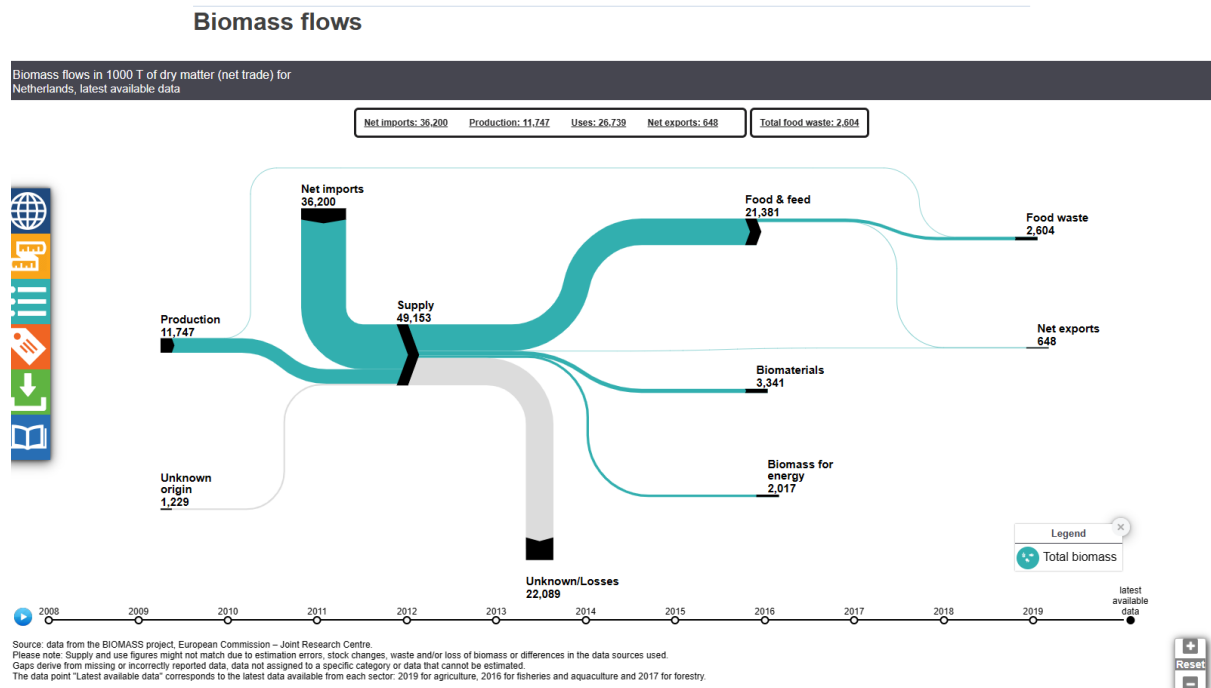
http://probos.nl/images/pdf/rapporten/Rap2018_Beschikbaarheid_NL_verse_houtige_biomassa.pdf

This report, published in 2018, states the availability of fresh woody biomass resources in the Netherlands.

Biomass flows in the Netherlands and other countries in the EU

JRC Biomass Project, Data-Modelling platform of resource economics.

[Biomass flows \(europa.eu\)](https://europa.eu)



Social acceptability and citizen involvement

Maarten Arentsen, University of Twente. Social acceptability and citizen involvement in bio-energy plants in the Netherlands. Study carried out in combination with BEON.

This report examines public perception and citizen engagement in bio-energy projects in the Netherlands, highlighting the importance of stakeholder involvement for social acceptability and sustainable development.

Enexis (2022). Brochure for farmers considering a biogas.

[projecthttps://www.stichtingbeon.nl/wp-content/uploads/2022/01/Enexis_2bcm_brochuregroegasacceptatieFINAL_interactief.pdf](https://www.stichtingbeon.nl/wp-content/uploads/2022/01/Enexis_2bcm_brochuregroegasacceptatieFINAL_interactief.pdf)

This report gives a list of guidelines for farmers on how to involve citizens in manure digestion project development.

Local regulation on bioenergies

Biogas

Biogas units are required to comply with several Dutch regulations. These are summarised in the INFOMIL-guidelines for dung handling at farm houses.

Global review for the Netherlands

Biomass availability in the Netherlands

The Roadmap for biomass materials (Corbey et al 2020) prepared for the National Climate Agreement shows a total potential of 24 million tons of biomass materials available in the

Netherlands. The figure below shows that there is a wide range of different biomass materials, and that biomass is certainly not only made of wood.

When looking at the use of woody biomass for energy generation in Table 1, it turns out that used wood (so-called A, B, and C wood) is the largest source of woody biomass in the Netherlands. It also appears that a lot of fresh woody biomass is used as firewood.

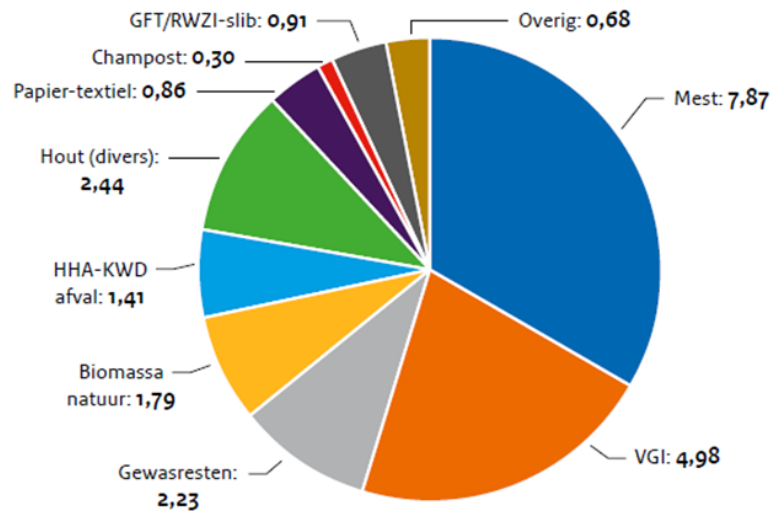


Figure 1: Available bio-resources in the Netherlands (in million tons dry matter. Bron: Corbey et al. (2020).

Type of wood	Quantity (kton ds)	(%)
Firewood households	692	23%
- from forestry	270	
- from countryside	169	
- from urban areas	253	
Fresh woodchips for bio energy	564	19%
- from forests	132	
- from countryside	183	
- from urban areas	200	
- from tree nurseries and fruit trees	49	
Wood residues timber industry	400	14%
Demolition wood (A, B en C-wood)	1300	44%
Total	2956	100%

Table 1: Woody biomass resources (kton d.s./jaar). Bron:HaskoningDHV – PBL in Corbey et al. (2020)

It is striking that the amount of wood from forests is relatively modest at 402 kton. Landscape maintenance and the urban environment are just as important sources of fresh wood and firewood. The import of wood pellets amounted to 300 kton in 2018 and can increase to 3 Mton/year under the energy agreement.

Availability of woody biomass in Overijssel



The potential for sustainably harvestable woody biomass (chips and shreds) from forest, landscape and urban environment in Overijssel amounts to 68,400 tons of dry matter per year. Of this potential, 76% is already being exploited.

EU Country Report

Implementation of Bioenergy in The Netherlands, Country Reports, IEA Bio-energy. (2020). Edited by: Luc Pelkmans, Technical Coordinator IEA Bioenergy with contributions from: Elke van Thuyt, Wouter Siemers, Bauke Ketelaar, Rene Wismeijer, Kees Kwant. (Netherlands Enterprise Agency – RVO).

Highlights of the report

- Renewables made up 7.3% of total energy supply in the Netherlands in 2019. More than 60% of renewable energy was from biomass.
- The Netherlands is a small, densely populated country with high energy demand from industry. Primary domestic biomass resources are limited, so an important share of the feedstocks comes from residues and waste, as well as imports.
- Natural gas is the dominating fuel in the Dutch energy system, representing 60% of Dutch power production and over 70% for heat production (through direct use and in distributed heat).
- Bioelectricity was the major source of renewable electricity up to 2012. After a decline post 2012, it has again increased in 2019. The role of wind and solar power in Dutch electricity is rapidly growing.
- Heat and transport fuels are still dominated by fossil fuels. Bioenergy/biofuels are the main sources of renewable energy in these sectors.
- The role of biofuels in transport has been relatively stable between 2007 and 2017 at around 3%.



Sweden

As the Swedish partner, West Sweden Energy Agency has a focus mainly on biogas while the general bioenergy field is also of great importance (e.g. in region Västra Götaland the bioenergy sector constitute 10% of energy input (some 5400 GWh) and biogas almost 5% (almost 3000 GWh). Hence, the woody biomass energy sector will not be treated in the following section.

Biogas regional planification

From Biogas Väst, the regional platform for biogas development (www.biogasvast.se)

Västra Götaland is, next to Skåne, the region with the greatest potential for the production of biogas from the digestion of waste. Even within the gasification of forest raw materials, Western Sweden is a world leader in research and development. An important reason for West Sweden's leading position is the strong cooperation between different actors in the biogas chain, which has been built up through Biogas Väst ever since the network started in the late 1990s

Thanks to a well-developed infrastructure, eight out of ten residents in the county have a gas filling station in their municipality. A uniquely high proportion of the biogas produced in the region is upgraded and used for vehicle gas. In total, over 95 percent of the vehicle gas sold in 2020 was renewable biogas.

Also on the production side, Western Sweden is at the forefront:

- GoBiGas in Gothenburg was the first major gasification plant built in the world. Now not in operation.
- In 2012, liquid biogas was produced for the first time in Sweden — and it happened in Lidköping.
- The gas sold by FordonsGas Sverige AB is the world's first Nordic Ecolabelled fuel.
- Within agriculture, a successful cluster model has been developed with three good examples (Brålanda, Vårgårda-Herrljunga and Falköping) and more are in the works.

A regional plan for biogas development for 2017-2020 was published by the Regional County Administration. This was prolonged for 2021-2022. An updated version for 2023 and beyond is under development

Energigas Sverige. (2018). National Biogas Strategy.

<https://www.energigas.se/publikationer/rapporter/national-biogas-strategy-2-0/>

The national biogas strategy from the business organisation "Energigas Sverige" (energy gas Sweden) states the aim of 15 TWh Biomethane by 2030.

Key figures on bioenergy

Biogasstatistik, Energigas Sverige.

<https://www.energigas.se/fakta-om-gas/biogas/statistik-om-biogas/>

Just under 2.2 TWh of biogas was produced in Sweden in 2020

Swedish biogas production increased by 2.4 percent in 2020 to a total of 2,161 GWh (Table S 1). The production of biogas increased at co-digestion plants (+81 GWh) and farm plants (+7 GWh), but fell at other plant types. In total, 52 percent of the biogas was produced in co-digestion plants and 33 percent at sewage treatment plants. There are a total of 282 biogas production facilities in Sweden.

Biogas is mainly produced from various types of waste and residual products such as sewage sludge, food waste, manure and waste from the food industry & slaughterhouse. More and more biogas is produced from manure. A total of 77 facilities use manure as a substrate and the amount of manure digested has increased by 5 percent to 1.2 million tons in 2020.

2.6 million tonnes of digestate for fertilizer in agriculture

In addition to biogas, the digestion facilities also produce a digestate that can be used as fertilizer in agriculture. In total, just under 3 million tons of digestate (wet weight) were produced at Swedish biogas plants in 2020, of which 2.6 million tons (87 percent) were used as fertilizer in agriculture. From co-digestion facilities and farm facilities, basically all digestate (biofertilizer) was used as fertilizer. From the sewage treatment plants, 43 percent of the rotting residue (rotting sludge) was used as fertilizer.

Almost two-thirds of the biogas is upgraded

The long-term trend of an increasing amount of biogas being upgraded continues, after a temporary decline in 2018. The biogas is upgraded to be used as vehicle gas or fed into the gas network. Of the biogas produced, 65 percent went to upgrading (1401 GWh) and 19 percent was used for heat production (Table S 2). Electricity production continues to be at a low level, but increased slightly. The share of biogas that goes to flaring is a total of 11% of production, at the same level as in 2019.

Existing popularised documents and tools

Energigas Sverige (The Swedish Gas Association)

The Swedish Gas Association is a member-funded, industry association dedicated to promoting a greater use of gas energy. They work towards a safe, environmentally responsible and efficient utilization of gas and acts as a voice for all gases where safety, technical matters, marketing and advocacy are key elements.

Through the trade organisation, the Swedish Gas Association, and within the framework of Fossil Free Sweden, the Swedish gas industry has drawn up a roadmap to show how energy gases can contribute to promoting fossil-free competitiveness. The roadmap is the result of the commitment and collaboration that has emerged between many of the companies and organisations responsible for the following vision: all energy gases used in Sweden will be completely fossil free by 2045 at the latest.

On their website (<https://www.energigas.se/in-english/>) you can find relevant publications, facts, news and alike in relation to energy gases in general and biogas in specific.

Amongst others you can find the following publications in English:

- Biogas - from refuse to energy

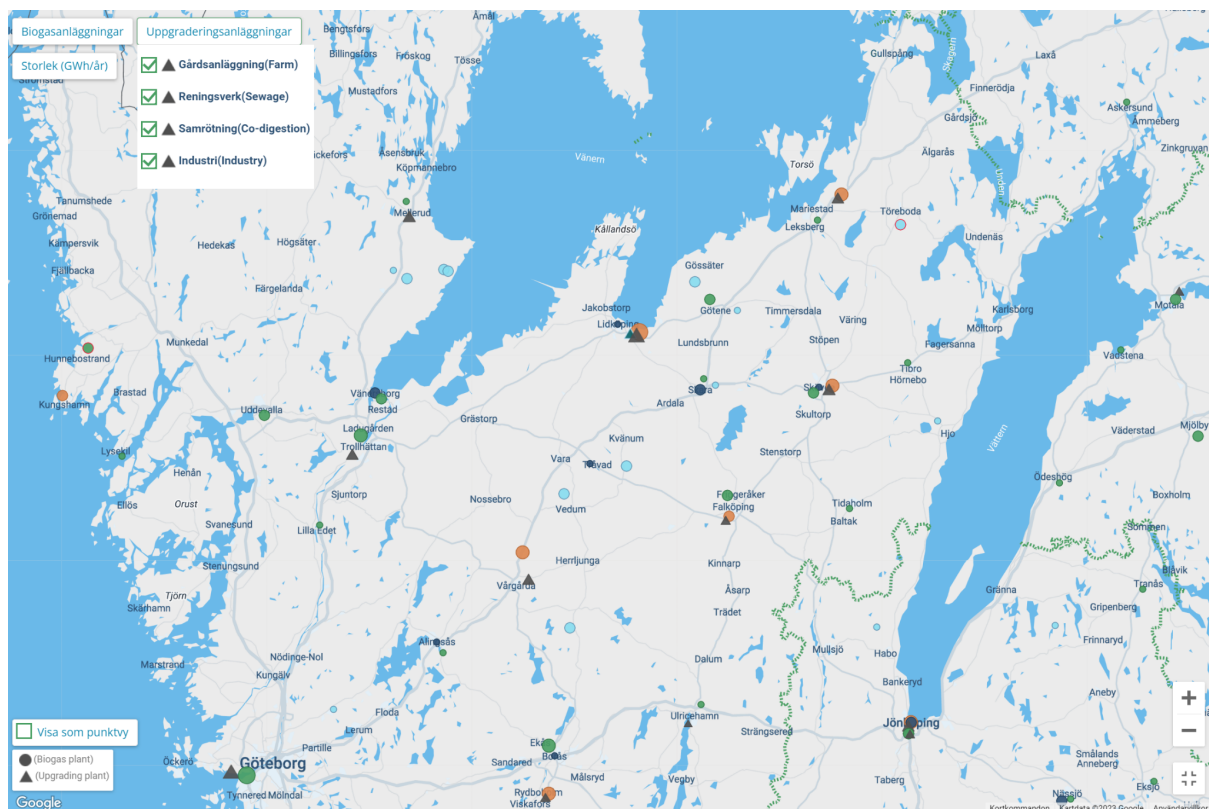
<https://www.energigas.se/library/1559/igu-biogas-report-2015-webb-2.pdf>

- Biomethane in Sweden – market overview and policies
<https://www.energigas.se/media/wm1osxcb/biomethane-in-sweden-230112.pdf>
- National Biogas strategy 2.0
<https://www.energigas.se/publikationer/rapporter/national-biogas-strategy-2-0/>

Biogas Map

This interactive map shows all the different types of biogas plants that exist in Sweden in 2021. There are a total of 281 plants around Sweden that produce biogas. The map also shows facilities where biogas is upgraded or liquefied and the approximate size of the facility.

<https://www.energigas.se/fakta-om-gas/biogas/karta-biogasanlaggningar/>



Biogas Väst

The regional hub for biogas development in West Sweden.

Biogas Väst develops new collaboration opportunities and takes initiatives for technical and business innovations that strengthen the position of the West Swedish players in the field.

We do this by:

- Collaborate: We arrange regular breakfast meetings where we discuss the latest in the biogas field.
- Facilitate development by identifying common issues and connecting actors in the network.
- Project initiatives: initiate new projects and innovations in areas such as technology, business models and risk management.
- Dissemination of knowledge: facilitate the dissemination of knowledge and, if necessary, produce new information. Highlighting good examples and initiatives from Västra Götaland.



Biodriv Öst

BioDriv Öst simplifies the transition to fossil-free transport and sustainable regional development. Through expert support and collaboration, they help the public sector and companies reach their sustainability goals. They are non-profit making and work with everything from strategic issues to concrete efforts.

On their website: <https://biodrivost.se/> you can find a range of information, facts, statistics and alike regarding biogas and other renewable fuels.

Social acceptability and citizen involvement

For bioenergy to be sustainable, a number of aspects must be taken into account. It is about avoiding negative effects on the environment and people in all countries and effectively reducing emissions of greenhouse gases.

In order for the production and consumption of biomass for energy or other purposes to be sustainable, it must not

- cause deforestation or otherwise reduce carbon stocks at the landscape level
- reduce biodiversity, for example trees that have a key function should not be used
- reduce the long-term production capacity of the land
- degrade the quality of soil and water
- cause harmful emissions of pollutants.

Sustainable bioenergy must too

- cause lower emissions of greenhouse gases than fossil-based systems already in the medium-term perspective and in the longer term cause clearly lower emissions
- ensure good working conditions and that local populations are not negatively affected by production.

The Swedish Environmental Protection Agency conducts and coordinates Sweden's environmental work. Together with many others, we work to preserve biodiversity, reduce climate impact and contribute to a resource-efficient society. See more on: <https://www.naturvardsverket.se/en>.

More information regarding sustainable bioenergy can be read on:

[https://www.naturvardsverket.se/amnesomraden/klimatomet-stallningen/omraden/klimatet-och-energin/hallbar-bioenergi/](https://www.naturvardsverket.se/amnesomraden/klimatomstallningen/omraden/klimatet-och-energin/hallbar-bioenergi/).

Other important national agencies in relation to social acceptance and citizen involvement are:

- The Swedish National Board of Housing, Building and Planning. Amongst others they are supervising the municipal and country planning. <https://www.boverket.se/en/start/>
- The Swedish Board of Agriculture is Sweden's expert authority in the areas of agriculture, fishery and rural areas. <https://jordbruksverket.se/languages/english/swedish-board-of-agriculture>

Local regulation on bioenergies

There are no local regulations in relation to biogas or biomethane. Permits in relation to the environment are regulated by national law. Spatial planning is local and thus involves permits for land use, buildings and local environmental impacts such as sound and odor and smell. This is regulated within each municipal planning procedure and comprehensive and detailed planning.

Global review for Sweden

Biomethane in Sweden. Linus Klackenberg, Energigas Sverige, 20230112.
<https://www.energigas.se/in-english/>

In Sweden only about 3 % of the total energy supply of 606 TWh is energy gases, which is rather low compared to many other countries in the EU. Of the total energy use (377 TWh) about 3 % is energy gases, mainly used in industry.

The use of energy gases in 2019 is 18,6 TWh of which approx. 80 % fossil gases (14,7 TWh Natural gas, LPG and LNG) and about 20 % biogas/biomethane (3,9 TWh). Biogas and LNG use has increased, and natural gas use has decreased over the last 10 years. Most of the biogas is upgraded and used in the transport sector.

The share of renewable energy in transport was 23 % of total 91 TWh in 2018. The recent years' large increase of biofuel use is mainly due to a rapid increase of HVO at the Swedish market since 2011. The total use of methane in transportation (CNG/CBG) is about 1,5 TWh or 1,8 % share of total energy use in the transport sector. The average biomethane share in the methane mixture in transportation was 95 % in 2019.

Production and use of biogas and biomethane

There were 280 biogas plants producing in total 2,1 TWh of biogas by 2019, an increase by 3 % from 2018. Most of the biogas is produced from different types of biowaste and residues in co-digestion plants (49 %) and from sewage sludge in 138 wastewater treatment plants (35 %). The use of biomethane for transportation has increased rapidly over the last 10 years, whereas the use for heating has decreased. In 2019 64 % of the produced biogas was upgraded to biomethane mainly used as transportation fuel.

There were 68 biomethane upgrading units producing about 1.3 TWh biomethane 2019. About 0.5 TWh of this is injected to the south-western gas grid (connected to the European gas grid) and in the Stockholm gas grid. There are in total 14 injection sites. The rest is used locally or trucked to filling stations.

There is also one LBG plant producing 51 GWh LBG 2019 (part of the 1.3 TWh biomethane produced). Another LBG-plant has started producing during 2020 and at least one more during 2021. More LBG plants are planned.

Biogas and biomethane is mainly produced by various organic wastes and residues, such as sewage sludge, organic household waste (food waste), manure, waste from food industries and slaughterhouses.

Total use of biomethane and biogas including imports

The biogas export is still very small. The import of biogas through the gas grid has increased rapidly since 2015 from about 0.2 TWh 2016 to 1.8 TWh 2019. About 2/3 of the import is from Denmark. Most of the import is used for substituting natural gas in industry and heating.

The total biogas use in Sweden 2019 including imports is estimated to 4 TWh of which 3.2 TWh is biomethane. The total biogas use has increased 12% from 2018 and has more than doubled compared to 2015.

The biomethane market in Sweden

The Swedish biomethane market is to a large extent off-grid with several small local and regional grids or stand-alone biogas gas plants and filling stations. A large part of the biomethane in Sweden is transported on the road as compressed gas (200/260 bars) and to a small but steeply increasing extent as liquefied gas (LBG). Local and regional gas grids gain more attention aimed to connect industries, cities and biomethane production plants with an LNG-terminal at the coast.

The gas pipeline infrastructure is limited to the south-western part of Sweden where the transmission network is connected to the European gas network via exit Dragör (connection with Denmark). There is also a regional gas network in Stockholm, fuelled with locally injected biogas and shipped LNG.

Most of the biogas (64 %) is upgraded and used for road transport due to favourable support systems. The market for biomethane as transportation fuel is now rather developed in Sweden but is highly dependent on increased policy incentives and long-term support systems to take the next step. The use of methane in transport increased rapidly up to 2014 to have stabilized at around 1.6-1.7 TWh the last years. The biomethane share has however continued to increase and was 95 % 2019.

The number of gas filling stations has increased from less than 20 in 2000 to about 195 stations by the end of 2019, plus 60 non-public stations. The number of gas vehicles developed during the same period increased from just a few hundred to 53 982 by the end of 2019. In total 2 618 of these were buses (about 18 % of all buses) and 1 034 trucks (incl. approx. 140 LNG trucks) and the rest passenger cars and other light vehicles.



Germany (Focus on Lower Saxony)

Biomass regional planification

There is no central or regional planning for bioenergy use in Germany. Bioenergy must contribute to meeting climate protection targets, which aim at 80% renewables for electricity by 2030. Hitherto unused biogas and woody biomass energy potentials should be exploited more completely. Concerning the latter there are currently political efforts to protect forest areas by stopping any wood harvest there, and to use wood primarily as a material and then as an energy source only. Another political goal is to increase the use efficiency of woody biomass energy by replacing small, old and unclean stoves with modern efficient and clean combustion plants.

Currently (May 2023) a new Building Energy Act (GEG) is under discussion, according to which the installation of wood heating systems in new buildings shall become prohibited. For wood heating systems, such as pellet heating systems, the requirements have been tightened to the same extent as they currently apply to subsidies. Exceptions are only to apply in the case of coupling with solar systems for hot water preparation and for use in "old buildings". In addition, the system must be equipped with a dust filter. Now there is massive resistance to the new GEG on the part of heating and forest owners.

Similarly the development of the biogas sector is primarily dependent on legal, ecological and economic requirements. At the same time, however, further technical development of the sector is necessary to increase efficiency and economic viability, but also environmental compatibility. To this end, the Federal Ministry of Food and Agriculture (BMEL) is funding a large number of research and development projects as well as demonstration and investment projects.

In recent years, the expansion of biogas production on the basis of maize has been halted and the aim is to increase the use of liquid manure and other organic waste streams. The current energy crisis made the need for renewable energy resources more obvious, whereby biogas is playing a special role of increasing importance: It shall be further developed for flexible use for electricity generation in case of lack of wind and solar power.

Buhr et al. (2012). Handlungsempfehlungen für eine natur- und raumverträgliche Optimierung der Biogaserzeugung. Institut für Umweltplanung der Leibniz Universität Hannover and 3N-Kompetenzzentrum. www.ml.niedersachsen.de/download/78010/Handlungsempfehlungen_fuer_eine_natur-u._raumvertraegliche_Optimierung_der_Biomasseerzeugung.pdf

The recommendations for action for an environmentally and spatially compatible biogas production are aimed at farmers and plant operators, agricultural consultancies, planning and agricultural consulting companies, planning and approval authorities.

Fehrenbach et al. (2019). BioRest:Verfügbarkeit und Nutzungsoptionen biogener Abfall- und Reststoffe im Energiesystem (Strom-, Wärme- und Verkehrssektor) - Abschlussbericht. Umweltbundesamt.

https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-09-24_texte_115-2019_biorest.pdf



Biomass as a relevant contribution to renewable energy is only available to a limited extent due to the scarcity of land. The discussion has therefore shifted to the preferred use of biogenic waste and residues. The objective of this project was to investigate the potential with which this group of substances can be made available to the energy system if ambitious environmental restriction criteria and criteria for material management are applied overall and which are the pathways to be prioritised. In a first step, a total of 24 residues and wastes were considered in a literature study. Overall, the restrictive analysis shows an annual potential of a maximum of around 210 million tonnes of biogenic waste and residues with an energy content of a maximum of 920 PJ.

19 technologies (incineration, gasification, fermentation, fermentation and transesterification) were considered. In a second step, 19 technologies were considered to make waste and residues usable in the most energy-efficient way, taking into account their respective material properties.

In the third step, the materials and technologies were first combined according to their technical suitability into meaningful application paths and then assigned which part of the energy system (electricity, heat, transport) can be served by them. The possible combinations of input paths and energy products to be prioritised were finally evaluated on the basis of ecological, economic and technical criteria.

The result is an overall utilisation concept for waste and residues using technologies to produce energy products, which recommends a focus on the use for process heat in some proportions also as fuel for aviation and sea transport. Small shares are attributed to the production of electricity. This concept is kind of an allocation plan for the ecologically sensible use of available biogenic waste/residues in the energy system, but does not represent an integrated scenario for the energy system.

Key figures on bioenergy

3N (2023). Biogas in Niedersachsen - Inventur 2021

https://www.3-n.info/media/4_Downloads/pdf_WssnSrcv_Srcv_Biogas_BiogasinventurNiedersachsen2021.pdf

In Lower Saxony, biogas is increasingly taking on the role of a climate-friendly system service provider in the renewable electricity, heat and mobility sectors as well as in the agricultural sector. At the end of 2021, Lower Saxony had a constant 1,676 predominantly agricultural biogas plants with a total rated electrical output of 890 MW were in operation. These plants generate 13.5 % of the renewable electricity in Lower Saxony and deliver 26% of the heat generated from renewable energy. Around 34 % (462 MWe) of the installed capacity is now used for the flexible provision of electricity in line with demand. Almost every second plant has already been overbuilt and has doubled its capacity on average.

FNR (2020). Bioenergy in Germany - Facts and figures 2020.

https://www.fnr.de/fileadmin/allgemein/pdf/broschueren/broschuere_basisdaten_bioenergie_2020_engl_web.pdf

This online-broschure (in English!) contains plenty of well illustrated (but slightly outdated) information on bioenergy production and use in Germany.



Kralemann M., Röther T. (2022). Holzenergienutzung in Niedersachsen - Bestandserfassung und Klimaschutzwirkung holzbefuerter Anlagen 2021. 3N Kompetenzzentrum, 36 S.

https://www.3-n.info/media/4_Downloads/pdf_NwsTrmn_PM_Holzenergie%20Nds_2022.pdf

In 2021, there were 1,213,173 wood log boilers, 33,258 pellet-fired boilers and, and 3,057 wood chip boilers in operation in Lower Saxony. The pellet and woodchip boilers recorded the largest increase - due to their higher output they have a disproportionate share in the displacement of heating oil and natural gas. When individual stoves are replaced by automatically fired boilers, this increases the from renewable energy sources and, at the same time, reduces dust and CO emissions. In the power range above 1 MW, 60 systems were in operation. Heating plants dominate with 40 heating plants, often for process heat generation in industrial plants - an application that is not possible with solar collectors and heat pumps. 20 plants are CHP plants that provide both thermal and electrical energy. Fuel consumption in 2021 amounted to 2.18 million m³ of logs, 170,000 t of pellets and 1.22 million m³ of wood chips. The plants above 1 MW use 1.46 million t of fuel, of which 61 % waste wood and residues from wood processing. In total for all plants, this corresponds to 3.7 million t of fuel or 12.5 MWh of final energy.

<https://www.unendlich-viel-energie.de/ein-wichtiger-baustein-fuer-die-urbane-waermewende-biogas-aus-bioabfaellen>

Data and case studies regarding the use of biowaste for biogas production in German cities

IWR (2023). Aktuelle Stromerzeugung in Deutschland. <https://www.iwr.de>

Daily updated data on power generation in Germany, especially based on renewables

Schütte, A. (2022). Biogas in der Landwirtschaft - Stand und Perspektiven. Ankündigung Biogaskongress Bonn, 11. und 12. September 2023.

<https://veranstaltungen.fnr.de/biogaskongress/start>

Announcement of the German Biogas Congress (Sept. 2023) with some data

Social acceptability and citizen involvement

Germany's "Energiewende" started off as a grassroots movement in the 1970s. One could easily argue that the German public has gotten their politicians and business leaders to accept the transition – not the other way around. In 2005, the village of Jühnde became Germany's first "bioenergy village." It gets 100% of its electricity and more than 50% of its heat from a biogas unit powered with local energy crops. Signed on the project's tenth anniversary, the Jühnde Declaration of 2015 complains, however, that its success can no longer be repeated since the 2014 EEG (Renewable Energy Law) made it much harder for biogas units to run profitably. What it says about bioenergy is also true for community energy projects in general: "Bioenergy projects generally start off as volunteer efforts." The policies mentioned above are the result of discussions and ecological concerns of the people. It can be seen that initiatives for the use of renewable energies have been slowed down in the last 10 years by changes in the political framework. This is due on the one hand to the influence of the large energy companies fearing for their market shares and on the other hand to ecological concerns (for example, too much maize cultivation for biogas production).

Climate protection through volunteering is the idea behind KlikKS. In this way, even smaller municipalities and city districts can implement climate protection projects directly on site with



the help of voluntary climate protection patrons. KlikKS is a joint project of state associations, energy and climate protection agencies and is the successor project to the project "KlikK aktiv - Klimaschutz in kleinen Kommunen durch ehrenamtliche Klimaschutzpaten" (KlikK active - climate protection in small municipalities through voluntary climate protection mentors) initiated by the Energy Agency in Rhineland-Palatinate, which was awarded the "Climate Star" of the European Cities Network in 2021. Citizens from a total of eight German states are participating in the project: Baden-Württemberg, Berlin, Mecklenburg-Western Pomerania, Lower Saxony, North Rhine-Westphalia, Rhineland-Palatinate, Saarland and Thuringia. (<https://klimaschutz-ehrenamt.de/ueber-uns/das-projekt>) Courses on the efficient use of fuelwood and the promotion of district heating systems using biofuels are part of the activities.

In recent months, the use of woody biomass energy has come under fire because of fears of a shortage of wood, the destruction of forests and air pollution due to particulate matter.

There is an urgent need to spread knowledge on the real conditions before politicians create strange regulations which unnecessarily interfere with the use of biomass for climate change mitigation. In Germany, citizen participation in the form of investment options is being applied and discussed mainly in the case of wind and photovoltaic projects, but in some cases it could become an approach for biomass plants as well.

AGDW et al. (2022). [Gemeinsames Positionspapier: CO₂-Speichersaldo – unwissenschaftlich und unpassend für Klimabilanzierung](#). AGDW, DeSH, FVH, Familienbetrieb Land und Forst, 12.12.2022.

<https://www.fachverband-holzenergie.de/presse/pressemitteilungen/konzept-eines-co2-speichersaldos-stellt-ipcc-bilanzierungsregeln-infrage>

The German forestry branch explains why the IPCC-rules for CO₂ storage balances for forests are unscientific and inappropriate for climate accounting. Of course, the risk of losing forests as carbon stores completely by storm, bark beetles, drought and fire is not taken into account. Appropriate forest management is necessary to reduce these risks,

EUROACTIV (2022). [Germany to use controversial biomass amid energy crisis](#). 7.4.2022

<https://www.euractiv.com/section/agriculture-food/news/germany-to-use-controversial-biomass-amid-energy-crisis/>

Biomass will be used to meet particularly high energy demands, according to the German government's so-called "Easter Package", which aims to use agricultural raw materials for energy production in response to the war in Ukraine.

Hauptstadtbüro Bioenergie 2022. [Stromerlösabschöpfung: Bundestag nimmt Biogas nahezu vollständig aus, aber gesteht Holzenergie kaum Verbesserungen zu](#). 14.12.2022

<https://www.hauptstadtbuero-bioenergie.de/aktuelles/pressemitteilungen/stromerloesabschoepfung-bundestag-nimmt-biogas-naezu-vollstaendig-aus-aber-gesteht-holzenergie-kaum-verbesserungen-zu>

At the end of an intensive political discussion the biogas branch was able to prevent the skimming of high profits due to the high electricity prices. But funding of wood energy use is still not satisfying.



Morris (2029) Community Energy in Germany - More than just climate change mitigation. RENEWS SPEZIAL No. 89 / Dec. 2019.

https://www.unendlich-viel-energie.de/media/file/3591.89_Renews_Spezial_Community_energie_LECo.pdf

This paper presents the German experience with community energy, however, so it refers mainly to projects for renewable energy and efficiency and less to urban planning aspects. It aims to make German experience – good and bad – available to the international audience. Further details are available in the literature listed and linked to, much of which is in German, however..

Global review for Germany (Focus on Lower Saxony)

Biogas

Biogas production in Germany is of great importance with regard to climate protection and the switch to a renewable energy supply as well as energy supply security. In a renewable energy system, biogas fulfils the important role of a storable and controllable energy source that can reliably compensate for fluctuations in the sun and wind energy supply. The approximately 9,000 biogas and biomethane plants in Germany had an installed capacity of 7.1 GW in 2021, with which they generated 31.3 TWh of electricity in a sustainable, climate-friendly manner and from domestic raw materials. At just under 13 %, they thus made a significant contribution to renewable electricity generation. 2 GW of the installed CHP capacity, which corresponds to the output of two nuclear power plants, is used for the flexible provision of electricity.

In addition, 17.4 TWh of heat as a by-product of electricity generation was provided, sufficient for about 1.5 million households, and almost 1 TWh for the fuel sector. In the same year, the sector avoided nearly 20 million tonnes of carbon dioxide equivalents. The sector also provides around 50,000 jobs, mostly in rural areas.

Currently, there is a growing interest in the expansion of local heating grids to use heat from biogas plants and woody biomass energy instead of fuel oil and natural gas. In principle, the German biogas potential is large and must be further expanded in the future. The German Association of Energy and Water Industries (BDEW) and the German Technical and Scientific Association for Gas and Water (DVGW) estimate the energy potential of biogenic waste - which mainly includes organic waste bins, food waste, animal excrement and crop residues - at 140 terawatt hours (TWh) per year. This could theoretically cover a quarter of Germany's electricity consumption.

Organic waste can only be used if it is collected separately. Studies by the German Nature and Biodiversity Conservation Union show that too many districts and cities in Germany still do without bio bins. Although there has been a legal obligation to collect biowaste separately since 2015, every seventh district and independent city does not comply with this obligation or does so inadequately. To sum up: waste separation still needs to improve.

About 17% of the installed capacity is located in Lower Saxony, which comprises some 15.7% of the agricultural land of Germany. In 2018, 1,662 predominantly agricultural biogas plants with a total rated output of 892 MW_{el} were in operation in Lower Saxony. These plants generate around 18 % of the renewable electricity in Lower Saxony and make a significant

contribution to the provision of renewable energies in the heating market via local heating networks.

Woody biomass energy

Currently about half of the German annual timber harvest is being used for energy; half of this volume directly as fuelwood from the forest and the other half as wood waste and residues from the industry and households.

In 2021, there were 1,213,173 log firing systems in operation in Lower Saxony in the output range below 1 MW. 33,258 pellet boilers and 3,057 wood chip boilers were in operation. In the output range above 1 MW, 40 heating plants and 20 CHP plants were in operation. The latter produced nearly 1 million MWh of electricity and more than 2 million MWh of heat.

In 2021, 2.18 million m³ of logs, 170,000 t of pellets and 1.22 million srm of wood chips were used. In plants above 1 MW, 1.46 million t of biogenic solid fuels were used. In the total of all plants. This corresponds to 3.7 million t of fuel or 12.5 MWh of final energy.

The use of wood as an energy source in plants below 1 MW results in Lower Saxony in a saving of 7.1 million MWh of fossil primary energy. The generation of electricity and heat in plants above 1 MW avoid the consumption of 4.3 million MWh of fossil fuels. The total of all wood-fired plants in Lower Saxony reduced carbon dioxide emissions by 2.52 million tonnes by 2.52 million t.

Energy wood consumption in 2021 amounted to 13.1 mio. MWh. The energy potential has not yet been exhausted. It has 16.8 million MWh/a and is predominantly formed from untreated wood. 22 % is to be assigned to the category of waste and residual residues. 78 % are by-products of wood harvesting and processing as well as straw and landscape wood.

In 2022, the electricity generation of biogas and combined heat and power plants fueled with wood (38,68 billion kWh) exceeded the electricity generation of the last three nuclear power plants (32.82 billion kWh.) in Germany.