BIOGAS WORLD

Biomethane Report

Market Intelligence

January 2023

Europe

biogasworld.com

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About BiogasWorld

BiogasWorld is a business generation network and project support platform, connecting the suppliers of products and services with project developers. We accelerate the biogas and biomethane industry worldwide.

With the experience of working with hundreds of suppliers and collaborating to over 50 biogas and biomethane (RNG) projects in North America, BiogasWorld offers to project developers a wide range of services to help them reduce the cost and duration of their project implementation.

For more details, feel free to contact us at info@biogasworld.com.

Project Leads

Access public and private opportunities for your business; find funding and grant opportunities for your projects.

Market Intelligence

Support your business development efforts and grow your business by getting access to market intelligence and tools.

Online Promotion

Promote your business in biogas and biomethane industry and generate business opportunities through our online platform.

Notice to Readers

Terminology: Biomethane Vs. RNG

There are two terms widely used to describe upgraded biogas: biomethane (used in Europe) and Renewable Natural Gas or RNG (used in North America). To make the reading of the report easier, we opted to use the term "biomethane", however, some direct references to existing legislation and programs in the US will use "RNG" to make it easier for readers to make additional research.

Energy Conversion

The report uses a number of energy units to present the information due to the fact that different sources of information may use various units of energy. When reading the report, you will find helpful the following table containing approximate energy conversions for biomethane as reference.

Table 1. Energy Conversion

Unit of Energy	Conversion
1 PJ	1 000 000 GJ
	0,9478 TBTU
	947 817 MMBTU
	277 780 TWh
	26 518 000 m3 Biomethane (RNG)
	0,9478 Bcf

Abbreviations

PJ Petajoule
GJ Gigajoule
TBTU Trillion British Thermal Units
MMBTU Metric Million British Thermal Unit
TWh Terra Watt hours
Bcf Billion cubic feet

Europe

Market Overview

Europe - Current Market Overview

France has the highest number of biomethane upgrading facilities at 506. Other notable European markets are the UK (102 plants), Sweden (89 plants) and the Netherlands (84 plants).

The gas crisis in Europe has prompted the most significant investments in renewable energy in the Union's history, laying the foundation for a revolution in renewable energy production.

In the spring of 2022, the EU announced the REPowerEU plan which includes over 200 billion EUR in investments for green energy, increasing efficiency, R&D, industry, and transport fuel conversion. 37 billion EUR has been allocated for developing Europe's biomethane sector with the EC targeting 35 bcm of domestic output by 2030, a tenfold increase over the EU's current 3 bcm output. The EBA has further postulated that 95 bcm in 2050 (covering 30-40% of total gas demand) is possible.

At the EBA's conference in October 2022, the details of the Biomethane Industrial Partnership were announced. The BIP supports the 2030 and 2050 goals of REPowerEU and promotes new public-private partnerships which promote the development of the industry.

Recent data shows that the EU has met its 2020 target of 10% renewables (including biomethane) in its fuels mix.

Europe - Current Market Overview

Projects in Development

According to the EBA, 184 new biomethane production facilities are expected to become operational by the end of 2022, marking a 20% increase over the previous year.

There are at approximately 150 biomethane plants scheduled to start in 2023-2024, with many more in the pipeline.

The major markets in development are France, UK and Italy, and notable emerging markets in Europe include Ireland and Spain.

International Trade

The inter-country biomethane trade has traditionally grown from Swiss market demand that is met by certificates from Denmark, the UK and Germany. However, as biomethane requirements within NG networks continues to ratchet up, demand is likely to increase from countries such as Italy and France. The trade of GO credits has been hindered by the lack of standardization within the system.

There is currently a regulatory push for a more efficient integration of the ETS, GOs, and other credits. Regulatory inconsistencies have resulted in price fluctuations between countries and led to certain countries becoming more lucrative export markets than others.

According to OLYX, approximately 58% of unsubsidized biomethane is traded on the compliance market.

Biomethane Potential

A recent Gas for Climate Report estimating the biomethane potential in Europe estimates 41.8 bcm by 2030 is theoretically feasible, increasing to 98 bcm in 2050. The report also analyses the potential of thermal gasification, assuming the technology becomes deployable in the next decade. The 2030 potential of thermal gasification is estimated at 3.3 bcm, and increases to 67.1 bcm in 2050.

Accounting for both anaerobic digestion and thermal gasification, there is estimated to be a potential of 45.1 bcm in 2030, and 165.1 bcm in 2050.

Europe - Market Drivers

- **REPowerEU**
  - Announced in the spring of 2022 following the Russian invasion of Ukraine and the ensuing gas crisis, REPowerEU seeks to fundamentally overhaul European power generation and promote self-sufficiency of energy
  - REPowerEU has set the target of 35 bcm by 2030, increasing to 95 bcm by 2050
  - The plan has 3 goals:
    - Diversify energy
    - Promote circularity of the economy and combat the climate crisis and
    - Promote energy security

- **Biomethane Industrial Partnership (BIP)**
  - Formally launched in October 2022, the BIP promotes new public-private partnerships to further develop biomethane in Europe and meet REPowerEU's 2030 and 2050 targets
  - The BIP is comprised of 5 task forces:
    - National biomethane targets, strategies, & policies
      - Creating solutions and sharing best practices
      - Knowledge sharing between member states
    - Accelerate biomethane project development
      - Value-chain coming together
    - Sustainable potentials for innovative biomass sources
      - Unlock new feedstock potentials
      - Biofertilizer and the development of the circular economy
      - Assess data and collect more where needed
    - Cost efficiency of biomethane production and grid connection
      - How can biomethane be more cost-effective and be competitive in the transition
      - CO2 recovery
    - R&D and new end-use applications
      - Increase autonomy in green technology
      - Reduce CH4 leak
  - BIP goals and task force outcomes are non-binding, industry must come together to achieve goals

Europe - Market Drivers (Continued)

- **Renewable Energy Directive (RED II)**
  - As of May 2022, REPowerEU has been incorporated into the provisions of RED II
  - Utilizes the updated EU Taxonomy, outlining what is and is not considered environmentally sustainable economic activities
    - The Taxonomy will greatly influence activities in the 2021-2027 period removing incineration supports and adding biogas from bio-waste supports
    - Increases strictness of rules on collection, separation and management of waste, raising recycling targets to 65% by 2035
    - Critical to the new Waste Management strategy is that the municipalities which generate the waste carry the responsibility to manage the disposal of it, therefore landfill gas collection and new commercial AD recycling facilities are expected to attract significant public funding during the decade
    - Member states can request detailed Guarantees of Origin on any waste
  - Member states will need to reach 38-40% of RES on final energy consumption by 2030 (instead of previous 32%) per the recommendation of the Climate Target Plan
    - Members must also submit to the European Commission by the end of 2019 a 10-year integrated national energy and climate plan (NECP), which went into effect at the beginning of 2021
  - Target to raise the share of RES supplied for heating and cooling by 1.1% annually
  - In transport sector, fuel suppliers should target 14% share of final fuel consumption
  - Support schemes included within REDII:
    - States can grant exemptions from competitive bidding and direct marketing on small-scale projects
    - Waste mitigation and recycling takes priority action over increasing supply of biomass to meet AD demand
    - Facilitating of cross-border supports for renewable development without interfering in national support schemes
  - Major issues with RED II:
    - The tailpipe approach to measuring carbon fails to recognize biomethane's carbon neutrality as a fuel source
    - The potential within the maritime sector goes unrecognized
    - Stricter regulations are implemented for RNGs use as heating
  - Preparations and preliminary discussions for REDIII are currently underway

Europe - Major Drivers (Continued)

- The Fit for 55 package remains the EU's long-term strategy, however, REPowerEU has hastened the rollout of renewable energy packages and doubled biomethane targets
  - The long-term aim remains to reduce EU emissions by 55% by 2030 compared to 1990 levels

- There are calls for EU regulators to push for a universal gas standard which would allow biomethane to more easily be traded over borders

- In 2024, EU member states are obliged to introduce separate collection for bio-waste (green waste and household kitchen waste)

Austria

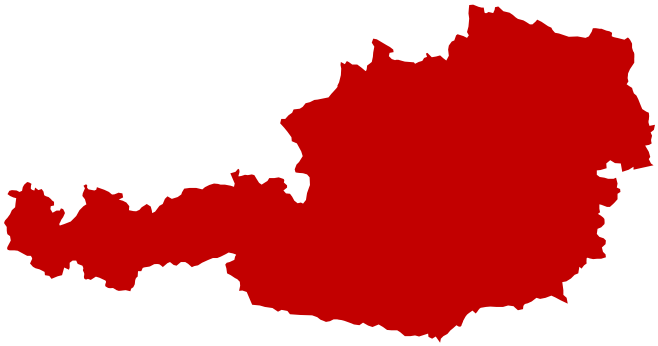
Market Overview

Austria - Current Market Overview

Per AGCS Biomethan Register Austria, there are 16 registered biomethane facilities. Overall, the biomethane upgrading capacity is around 4,200 m³/hour, or 4% of total biogas output. As of the end of October just over 0.115 TWh were injected into the Austrian gas grid. Municipal waste and sewage sludge are the main feedstock used to produce biogas in these facilities, however, there exists significant potential within the agricultural industry, utilizing energy crops and agricultural waste.

The Renewable Energy Expansion Act (EAG) (2021), reignited biomethane development in Austria, providing new support schemes for an otherwise stagnating industry. In conjunction with the European Green Deal and REPowerEU, biomethane is favoured for its capability as a gaseous energy character.

The EAG implements new financial measures to convert biogas-CHP sites to biomethane production and support direct injection into the grid.



Austria - Current Market Overview

Biomethane Injection

Biomethane producers use AGCS Biomethane Register Austria to connect to the grid.

In 2021, 136.41 GWh of biomethane was injected into the grid, and 81.95 GWh have been injected as of July 2022.

At 0.136 TWh injected, biomethane accounts for approximately 0.14% of Austria's total gas consumption.

The Austrian Government has set a goal of 5 TWh of nationally produced biomethane by 2030.

Market Potential

The association Kompost & Biogas Verband estimates that Austria could increases its current injection levels to 1 TWh over the next year and a half through the conversion of existing facilities.

It is estimated that Austria has the capability to produce approximately 0.5 bcm by 2030, increasing significantly with the addition of crops deemed insufficient for consumption (diseased or drought damaged) and with the thermal gasification of biomass.

Market Incentives

The EAG was implemented in early 2022, adding new funding for biomethane facilities and incentives for existing CHP facilities to convert to biomethane production.

The EAG includes a market premium, which compensates for the difference between production cost and electricity cost.

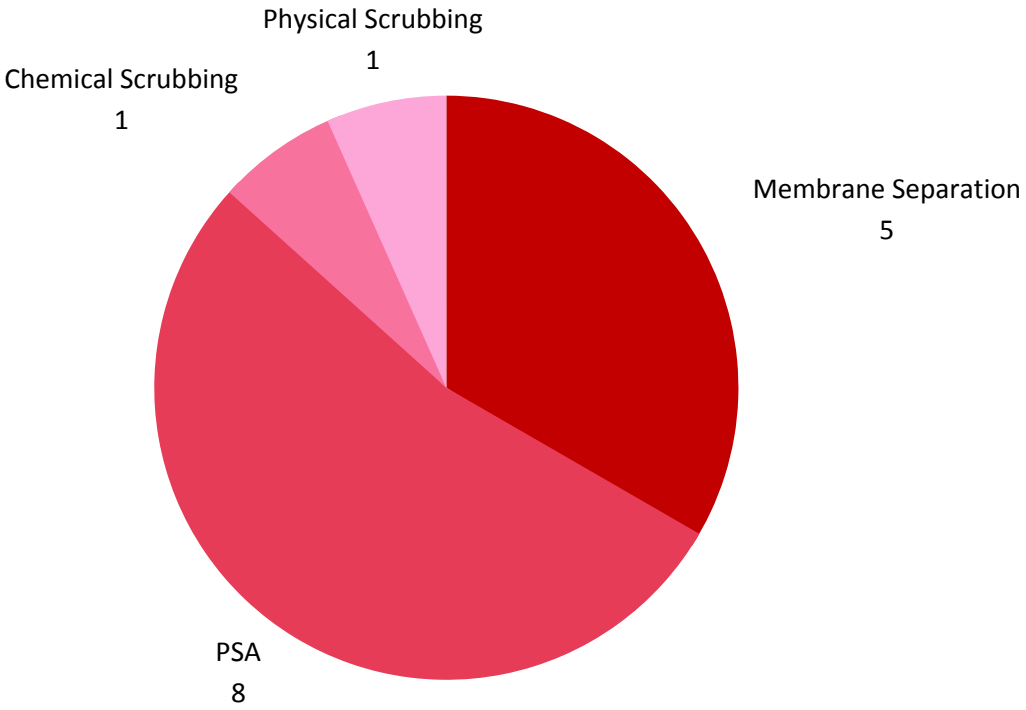
klimaaktiv mobil scheme includes incentives for the development and implementation of biomethane in transport fuel, including tax credits.

Austria - Upgrading Snapshot

Per AGCS, there are 16 facilities upgrading to biomethane in Austria. The most used upgrading technology in operating biomethane facilities (based on the unit count) is PSA, followed closely by membrane separation.

Companies that have their systems installed in Austria are Air Liquide, Axiom, Carbotech and Xebec.

Figure 1. Biogas Upgrading in Austria, Number of Plants



Austria - Market Drivers

- The Renewables Expansion Act was enacted in July of 2021 and implemented earlier this year. The act adds several new supports for biomethane projects
  - Includes an investment subsidy for converting electricity to gas feed-in
    - Up to 45% of costs
  - Investment schemes for new facilities that inject biomethane into the grid
    - Up to 30% of costs
    - Grid owners are responsible for covering costs of extending the grid (10km for existing facilities and 3km for new ones)
  - A capped upper limit on the use of energy crops, tightened on year-by-year basis
  - Follow up premiums for a period of 24 months for existing facilities which relied on the previous FiT
    - Only for facilities with a capacity of 250 kWel and >10km from a grid injection station
    - All other facilities will continue to receive subsidies up until their 30th year of operation
  - Investment grants for conversion of electricity into hydrogen or synthetic gas
  - Article 19 of REDII enacted into law, providing Guarantees of Origin on gas, in addition to 'Green Gas Certificates' and the 'Green Gas Seal'
    - Exploring the further integration of a Green Gas Quota for gas suppliers, through which they would have to obtain a "Green Gas Seal" to confirm the gas' sustainability
    - In October of 2022, the Austrian government announced a new market premium component to the EAG, which intends to compensate for the difference between production and electricity costs for biogas
- Under the updated Natural Gas Tax Act, favorable treatment is awarded to biogas and hydrogen, including tax exemption for biogases and hydrogen upon meeting certain sustainability criteria.

- The Austrian Gas Grid Management authority (AGGM) is developing a map of current biogas facility locations, and where potential exists for the development of new facilities which facilitates their connection to the gas grid
  - The AGGM is also collaborating with the Austrian Power Grid AG to develop a 'Power to Gas' (P2G) map which facilitates the development of Austria's new National Hydrogen Strategy

- Facilities required to recompress gas for reaching higher levels of biomethane in the gas network are currently constructed at the expense of the biomethane producer, however, if the facility becomes considered part of the network infrastructure in maintenance duties, costs for recompression can also be borne by network operators, writing off expenses over the long-term

Austria - Market Drivers (Continued)

- #mission2030's Flagship Project 7- "Greening the Gas Initiative", Austria aims to replace a significant share of current natural gas use with biomethane and hydrogen, converting current biogas CHP units to upgrading and grid injection facilities
  - This iniative has been integrated into the EAG

- In August of 2022, the EU approved a funding package for Austria worth €136 million under the Just Transition Fund (JTF). The JTF is intended to support regions currently dependent on high emission sectors transition towards carbon neutrality

- Impediments to industry development persist through preexisting regulations which restrict hydrogen injection to a maximum of 4% and prevent biomethane from being injected into underground storage facilities

Denmark

Market Overview

Denmark - Current Market Overview

At the end of 2021, there were approximately 190 biogas facilities in Denmark producing approximately 5.8TWh. There are 72 facilities upgrading biogas to biomethane.

Approximately 30% of biogas produced in Denmark is upgraded to biomethane, 96% of which is injected into the gas grid. As of September 2022, biomethane represented 40% of total methane delivered through the grid and 29.7% of total gas consumption.

A new regulation on energy crop use was implemented in 2022, ratcheting the previous 12% before 2022 down to 4% by 2025. To maximize biogas potential, Denmark has the highest rate of sustainable removal of agricultural residues in Europe.

Danish best practices have led to some of the highest rates of public acceptance of biogas and biomethane in Europe.

Similar to other parts of the EU, it is likely that through the REPowerEU program, many existing biogas plants will shift from electricity production to biogas upgrading to offset Europe's reliance on foreign energy, and through changes to the green support scheme, it is likely all new facilities will be planned for upgrading biogas to biomethane.

Denmark - Current Market Overview

Certificates & Exports

Danish GOs can be traded in the EUETS as a carbon offset.

4.2 million green gas certificates, or 84%, produced in Denmark were sold across Europe (44% to Sweden and 28% to Germany) in 2021 (Energinet).

The Danish Energy Agency is promoting a common framework for green gas standards and elimination of trade barriers, which would allow for the trade of gas more freely across borders.

The Danish government is also promoting the integration of green hydrogen regulations to promote its trade across the EU.

A new type of GO is being developed which will allow the tracking of additional information including mass balances and overall sustainability.

Carbon Capture

The Danish Energy Agency expects a growth in the demand of biogenic CO2 for methanization in PtX processes from 2023 onwards.

Currently carbon capture at biogas facilities accounts for a sizeable share or CO2 demand in the food and beverage sector.

Research agencies are also developing new mineralization methods for converting biogenic CO2 into more valuable resources.

Market Targets

Denmark has set the goal to be fossil free by 2050, which includes a gas grid comprised of 100% green gas.

The Danish Bio-energy Cluster estimates that based on raw material availability, biogas production could be increased to 94 PJ (equivalent to over 26,000 GWh) in 2040. This availability is in line to surpass the quantity required to meet Energinet prediction that it can achieve 100% biomethane within its grid by 2034.

The Danish Energy Agency has targeted 51PJ by 2030, 40PJ of which will be upgraded and the remaining 12PJ for process heat and electricity.

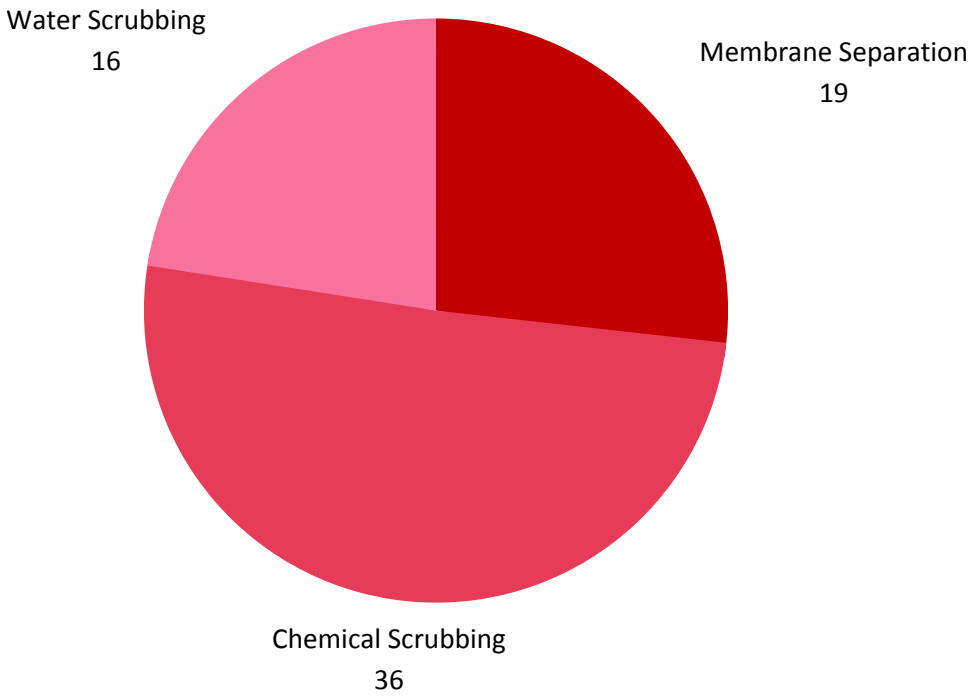
Denmark - Upgrading Snapshot

According to BiogasWorld's data there are 72 biomethane facilities in Denmark.

Amine scrubbing is the most popular upgrading technology in Denmark and is used at 36 facilities.

Actively working in Danish market are Ammongas, DMT, Envitec, Greenlane, Malmberg, Pentair and Wärtsilä.

Figure 2. Biogas Upgrading in Denmark, Number of Plants



Denmark - Market Drivers

- In 2022, the Danish government launched the green gas support scheme, a tender-based system which aims to increase the production of green gas by 10 PJ over the 2024 to 2030 period. The program will receive approximately €90 million.

- A change to the maximum allowed quantity of energy crops was implemented in 2022, ratcheting down each year to 2025
  - Prior to 2022, 12% energy crops were allowed, but this has been reformed to only 6% in 2023, and 4% in 2024
  - In 2025, maize use will be banned.

- Plants commissioned after 2020 will be subject to a tendering limit on the installed capacity to a maximum of €32 million /year.
  - 20-year FiTs will be awarded through a tender process and include a ceiling price
  - Plants commissioned in or before 2020 will continue to receive their guaranteed supports

- The Feed-in-Premium support scheme ended in 2020 and is to be replaced by an auction-based system.
  - Since the beginning of 2020, governmental supports on new biogas facilities producing fuels for transport, industrial processes and heating are no longer awarded
  - The new green gas support will only provide financial assistance to projects which upgrade and inject biomethane into the gas grid, and for e-methanol projects

- The Auction-Based support system framework for biogas and other green gases include:
  - Support for biomethane which is upgraded and injected into the gas grid
  - Bids must be quoted as a fixed-premium price for each GJ of green gas supplied to the grid, subjected to a maximum amount
    - Financial support is also capped at DKK 120/GJ
  - An upper limit on the number of bids submitted
  - 20-year support period
  - A green gas quota with penalties for non-compliance
  - Between 2024 and 2030, the total budget is approximately €1.8 billion (€87 million /year for 20 years)
  - No aid for biogas used for heating

- From 2020, a fixed share of fuel used in the transportation sector must originate from waste (5.75-10%) and biogas is the least expensive way to meet these requirements. Fines will be distributed against companies which fail to comply

- A national initiative between three gas distribution companies HMN Naturgas, Dansk Gas Distribution and NGF Nature Energy to assist in transition for the green gas with an investment of over EUR 7 billion on the gas network.

Denmark - Market Drivers (Continued)

- Biomethane has a certificate value from the sustainability certificates (mostly REDcert and ISCC). These schemes are primarily utilized in the transportation sector
  - Certificates equal 1 MWh of green gas in the grid
  - GOs registered on Energinet can be sold to the markets in Austria, Germany, and the UK, and can be used in the emissions trading system
  - Certificates are cancelled on Energinet when used in Denmark, sold through Sweden or Germany, or transferred to the German certificate system, to ensure sale only occurs once
  - In 2021, almost 6 million certificates were issued by Energinet, and by March of 2022, approximately 2.5 million certificates were issued

- At the start of 2023, all municipalities will be required to separate waste into ten fractions, one of which is food waste (to be processed via AD) and the resulting digestate to be processed for fertilizer use

- Denmark has the shortest permitting time in Europe, averaging between 18 and 24 months

- Tax regulation mechanism: Renewable energy sources are exempt from the taxes that are levied on the production, processing, possession, receipt and dispatch of fossil fuels for heating purposes, for example the energy tax on mineral oil products, taxes on coal, lignite and coke or the carbon dioxide tax on certain energy products.
  - Biomethane supplied through the gas grid is subject to standard natural gas taxes, including CO2 tax

- New Climate and Energy Agreement includes a new Power to X (PtX) tender
  - Denmark contributing 1.25 billion DKK (EUR 168 million) to produce between 4 and 6 GW of electrolysis capacity by 2030
  - The tender includes the construction of 2 artificial islands for the production of green energy, the islands in the Baltic and North Seas are planned to produce 3 GW and 12 GW (respectively)
  - Hydrogen produced through electrolysis can potentially replace heavy transport fuels for aviation or transoceanic shipping

- Results from Rambøll for the voluntary scheme measuring methane leakages at biogas production plants was released in August of 2021. The report found methane leakage to be extremely high at production facilities and recommends additional regulation be enacted. The results show an average methane loss of approximately 2.5%. The report points to inefficient pressure/vacuum valves, in addition to uncovered storage tanks/sludge storage.
  - Communal biogas production facilities had the lowest averages
  - Small-scale plants experienced the highest methane losses

Finland

Market Overview

Finland - Current Market Overview

Per 2022 data, there are 22 installations that upgrade biogas to biomethane, mostly using municipal waste and WWTP sludge as feedstock.

Overall, 25% of all biogas units in Finland upgrade the biogas, with biomethane accounting for a growing percentage of vehicle fuel. This is a result of support schemes which promote its uptake in the transportation sector through subsidies and fuel tax exemptions. Biomethane accounts for 10% of Gasum's production (Finland and Sweden's largest gas company). With the assistance of Gasum, Finland has begun converting several ferry lines and Sweden-Finland cargo lines to bio-LNG.

Finland's 2022 budget promotes biogas as a means of meeting the country's overall goal of carbon neutrality. The budget continues to promote the use of biogas as transport fuel and emphasizes the proper storage and use of digestate to prevent detrimental effects on waterways.

In December of 2021, the European Commission approved two major investment packages for the development of advanced biofuels and biogas for road transport in Finland. The projects comply with REDII sustainability criteria

Finland - Current Market Overview

Transport Application

Biomethane for truck use is estimated to be 2.5 TWh by 2030.

Biofuels quotas target 19.5% in 2020 and 30% in 2029. In response to the energy crisis, Finland slashed this quota to 12% for 2022 and 2023.

Finland is aiming to halve its transport sector emissions and have of 50,000 private NGVs by 2030.

The 2022 budget discusses the possibility of requiring 100% biogas in road transport by 2030 through methods such as a Green Deal procedure.

Market Potential

The EBA estimates that Finland has an output potential of around 1 bcm from AD and approximately 6.5 bcm from thermal gasification.

2021-2022 experienced significant growth the in biowaste and sewage sludge sectors, and 2023-2025 is slated to experience significant growth in the agricultural waste and residues sector.

The Finnish government has set a goal of reaching 4 TWh /year by 2030, up from the current 1 TWh /year.

Gasum predicts it will produce 4 TWh of biogas across the Nordics by 2025

Market Particularities

The natural gas network is available only in the southern part of Finland, where the population is concentrated. Thus, the production of off-grid biogas is crucial.

Natural gas accounts for only approximately 3% of energy use in Finland, therefore, biomethane is viewed primarily for its industrial potential.

16 of Finland's 22 upgrading sites do not inject biomethane into the gas grid.

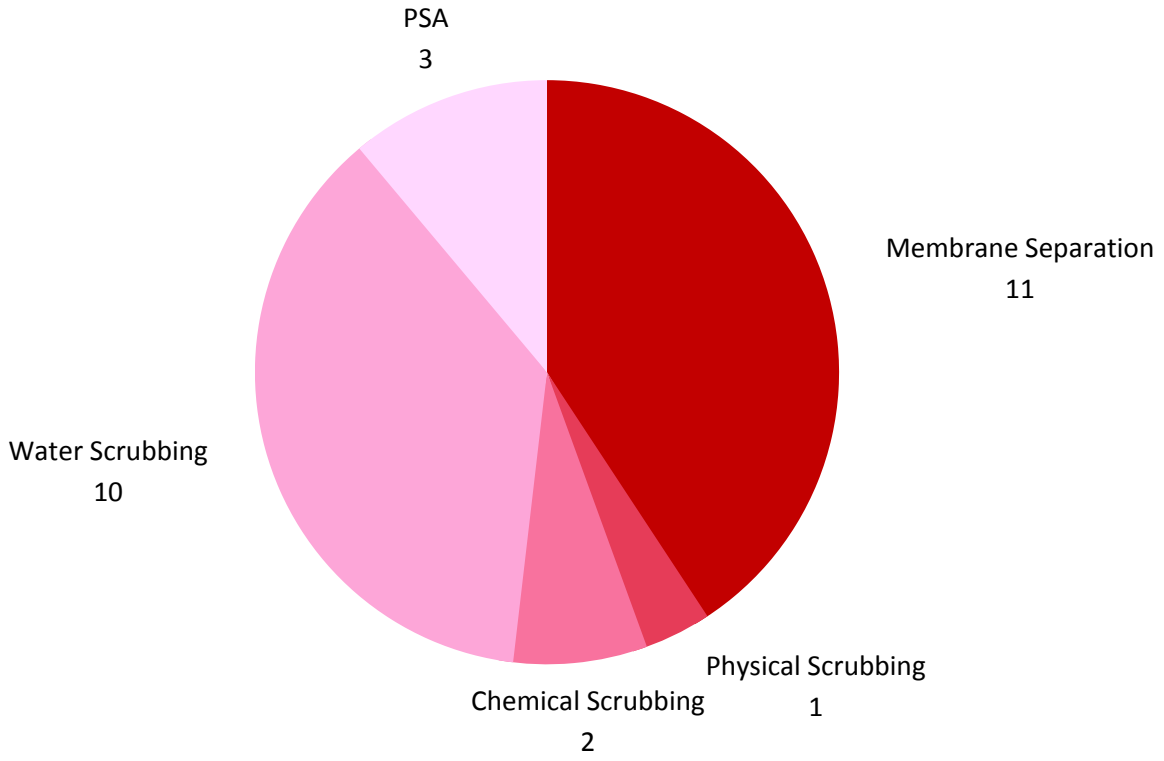
Per NGVA Europe, there are 64 biomethane filling stations.

Finland - Upgrading Snapshot

Out of 24 biomethane plants with available upgrading information, most use membrane separation or water scrubbing. A small number of facilities us PSA, chemical scrubbing, and physical scrubbing.

Upgrading companies that are present in the Finnish market are Ammongas, Bright Biomethane, Greenlane, Malmberg and Wärtsilä.

Figure 3. Biogas Upgrading in Finland, Number of Plants



Finland - Market Drivers

- The GO system has been extended to biogas and streamlining the permitting process

- Existing subsidy packages provide up to 30% of overall project costs, increasing to 40% if the facility plans to use new technologies

- Two separate subsidy schemes exist for biogas facility development:
  - Agricultural: administered through the Ministry of Agriculture and Forestry and is subdivided further into two types of farm AD:
    - Farm-scale digesters which use the electricity they produce and do not sell excess gas to the utility company are eligible to receive up to 40% of investment costs
    - Large-scale digesters which sell electricity or biomethane to either the utility or transport fuel company is eligible to receive up to 30% of investment costs. In addition, a separate company must be contracted to conduct this work
  - Industrial: administered through the Ministry of Employment and Economy:
    - A maximum subsidy of up to 30% of investment costs

- To promote the development and upgrading of biogas, and encourage its use as transport fuel, biomethane as traffic fuel has been exempted from fuel taxes
  - Heavy vehicles running on 100% alternative fuels (including biomethane) are classified as 'clean vehicles'

- National biogas action plan (published in January 2020)
  - Defines the measures for the sector until 2024
  - Target for the number of gas vehicles: 50 000 passenger cars by 2030

- In July of 2022, the Finish government submitted to parliament a proposal which would reduce the blending obligation for renewable fuels by 7.5% for 2022

- 2021 introduced the third phase of the liquid biofuel mandate (which includes natural gas), eliminating double-counting mechanisms and raising targets above REDII mandate levels

- Renewable fuel for transport
  - As of the beginning of 2022, biomethane has been included in the biofuel quota, improving the profitability of biogas projects. Also improves eligibility for financing.
    - Quota obligation of 19.5% in 2020 and 30% by 2029
    - When biofuel is produced from waste, its energy content is counted as double (in calculations of the final amount of biofuels)
  - Excise duty on liquid fuel
    - Excise duty on liquid fuels is collected on all types of fuels, including biofuels.

France

Market Overview

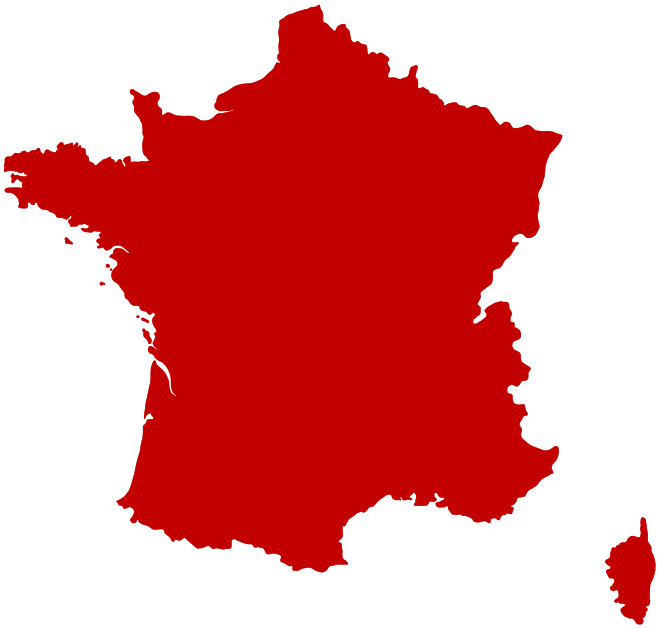
France - Current Market Overview

As of January 3, 2023, France had 515 biomethane installations injecting gas into its network (9.1 TWh) (430 of which inject gas into the GRDF grid). Last year, France overtook Germany in the number of biomethane plants.

Production is up 18% over 2021 and biomethane represents 2% of gas consumption volume. The French government has targeted 10% of gas consumption to be covered by green gas in 2030. The French government has made clear the role of biomass and biogas to achieving their net-zero by 2050 ambitions and continue to decrease barriers to industry development.

In December 2022, the GRDF chief stated France was already on track to surpass its 2023 biomethane targets.

French biomethane production is mainly concentrated in the North and East of France, with around 30% of national production coming from Hauts-de-France and Grand Est regions. Other regions active in biomethane production include Bretagne, Nouvelle-Aquitaine, Pays de la Loire, Normandie, and Ile-de-France. Almost 80% of biomethane producers are farmers.



France - Current Market Overview

Projects in Development

As of October 2022, there were around 920 biomethane projects queuing to be potentially operational within 2-5 years. There is approximately 18 TWh of projects at various development stages in France. This is estimated to cover approximately 4% of annual gas consumption in France.

Nearly 3 new facilities are commissioned each week, with 149 facilities going online over 2022.

Market Targets

2020 PPE (Multi-year Energy Program) targets biomethane consumption at between 7 and 10% of total gas consumed in 2030.

The 3.1 bcm (approx. 30.29 TWh) target for 2030 is a 30-fold increase from the 108 mcm (1.86 TWh) produced in 2019. The interim plan within the PPE ambitiously targets 1.2 bcm (11.72 TWh) by 2023.

By 2028, France plans to have a capacity of between 14 and 22 TWh.

ADEME has set the target to reach nearly 100% renewable gas utilization by 2050 by using the mix of RNG/biomethane, hydrogen, pyro-gasification and power-to-gas, the French Gas Association (AFG) is confident this goal will be met.

France must continue to develop its reverse-flow infrastructure to continue to meet its ambitious goals.

Biomethane Potential

The EBA predicts that when accounting for both AD and thermal gasification, biomethane in France could reach just under 7 bcm/year by 2030 , and approximately 23 bcm/year by 2050.

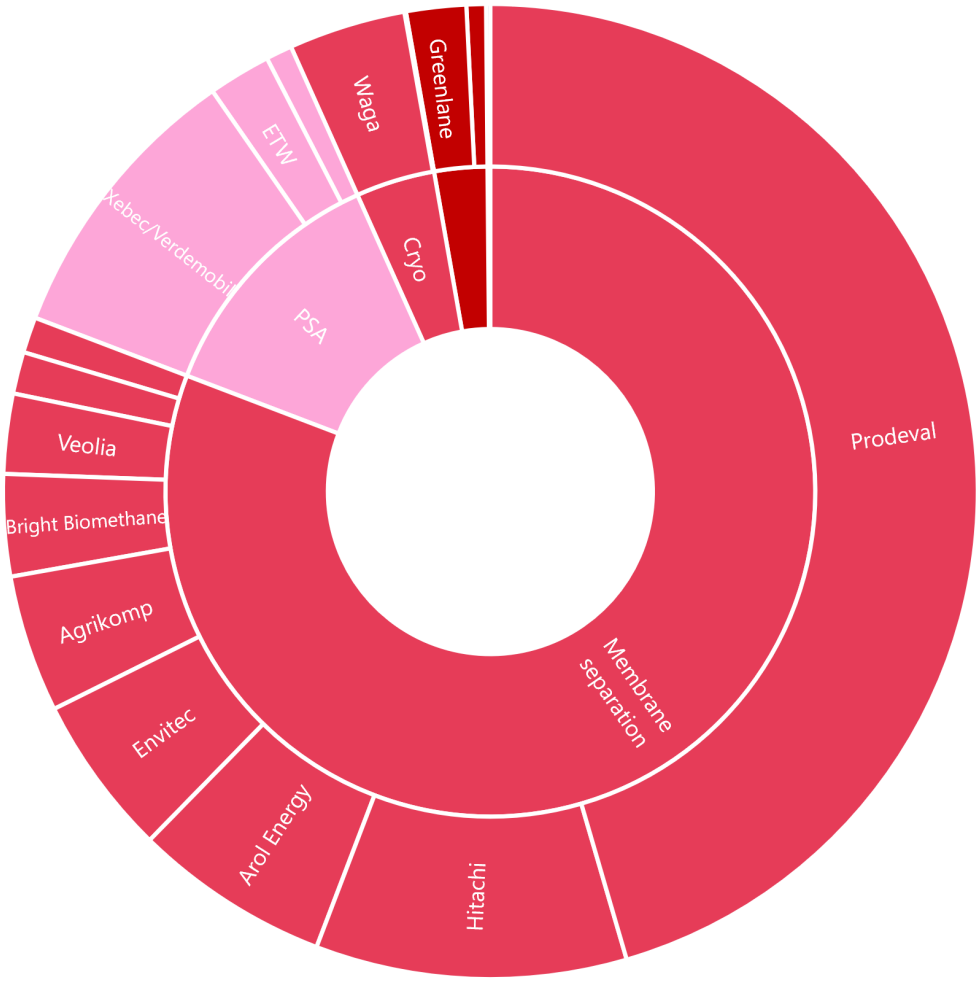
The French Association of Natural Gas Vehicles (AFGNV) has announced that the registration rate of new NGVs increased by 30% in 2021. 49.3% of buses registered were CNG. 95 fuelling stations opened in 2021, putting the number of fuelling stations in France to 255. AFGNV plans to reach 350 by the end of 2022.

Biomethane is currently being considered as an option to reduce the GHG emissions of its train network.

France - Upgrading Snapshot

Based on the installed capacity, the most popular upgrading system in France is membrane separation, followed by the PSA. The details are presented in the following Figure.

Figure 4. Upgrading Suppliers in France, Installed Capacity, m3/hr*,



* This graph utilizes the data BiogasWorld has received from upgrading suppliers operating in France.

France - Market Drivers

- French Resilience Plan
  - Biomethane is aimed to account for 10% of French gas consumption by 2030

- PPE (Multiannual Energy Program)
  - The PPE established a 10-year growth plan for the development of France's renewable energy sector, including feed-in tariffs to support growth: included in the definition of renewable energies are biomethane and bio-hydrogen, produced from biogas.
  - Targets of 7%, or 21 TWh, of biomethane in natural gas grid by 2030 (if decrease in production costs can reach 75 EUR per MWh in 2023 and 60 EUR per MWh in 2028. If the cost reductions are more, the target is up to 10% by 2030. Per Sia Partners, the current production costs are between 80 and 100 Euro per MWh.
  - The PPE has been adjusted, and now targets 7 TWh in 2023, and has placed the 2028 target on a range, from a low of 12 TWh to a potential high of 18 TWh.

- Biogas Production Certificates were announced, setting a minimum incorporation rate for all natural gas suppliers, allowing the continued growth of the industry without the continued use of public monies

- Modification to crop use regulations Decree No. 2022-1120 (August 2022)
  - Clarifies what is considered "main crops" for the purpose of adhering to the 15% limit of main crop gross tonnage for feeding digesters

- Feed-in tariff - Biomethane
  - All facilities that signed the contact before November 2020 benefit from the FiT ranging from 46 up to 139 Euro per MWh
  - For facilities with the capacity of 300 Nm3/h that signed the contract after November 2020 and facilities with annual capacity of 25GWh/year that signed after December 2021:
    - The FiT is offered for 15 years and consists of two elements:
      - Reference tariff between 55 Euro and 99 Euro per MWh for landfills and reference tariff between 86 and 122 Euro per MWh for all other plants
      - Premium tariff that varies between 0 and 20 Euro per MWh
      - Other conditions apply (e.g., premium between 1 and 3 Euro per MWh if biomethane is injected into the distribution grid with less than 100,000 clients, etc.)
  - In September of 2022, France announced a revision to biogas supports and plans to reduce the current approval time for renewable energy projects in half
    - Tariffs will be adjusted for inflation, increasing the supports by an estimated 10-11%
    - Construction deadlines to qualify for FiTs will also be extended, providing an additional 18 months to complete projects
  - Capacity limit will be used to distinguish between plants that will use old renumeration system and new auction system

France - Market Drivers (Continued)

- As of March 2, 2022, the costs for grid interconnection paid by GRD and GRT have increased from 40% to 60%
  - These operators have developed a zoning approach, and created a map with the most favourable areas to connect a biomethane plant to the French gas network and is available publicly and provides developers ease for preliminary feasibility checks
  - ADEME (French Environment and Energy Management Agency) recommends biomethane injection into the distribution grid whenever possible.
  - Direct subsidies and grants are offered by ADEME (French Environment and Energy Management Agency) EU funds and regional councils.

- Guarantee of origin (GO) system
  - As of November 2021, the over-the-counter system has ended and GOs are now auctioned off by the state
  - GOs are traded by the retailer
  - Registry is mandated and is managed by GRDF
  - The GO price went from 0,42 Euro per MWh in 2021 to 3,19 Euro per MWh in August 2022

- Value-added tax reduction
  - Reduced VAT of 5.5% is used for supply of electricity, natural gas and heat produced with at least 50% of renewable energy.

- The 2019 Mobility Strategy and Mobility Law introduced measures to boost the role of alternative fuels (including biomethane and hydrogen), and required all passenger vehicle sales to be low-emission by 2040
  - Use of biomethane as bus fuel and within the train network is discussed

- In August 2021, the French Parliament adopted the Climate and Resilience Law ("2021 Climate Law")
  - The law focuses primarily on the manufacture and advertisement of consumer goods and services, however, it is worth noting:
    - The impact and use of water must be recorded over the entire lifecycle, and more stringent laws are in place for greenwashing
    - How companies use the words "carbon-neutral" and "carbon negative" in their advertisements is more strictly regulated

France - Market Drivers (Continued)

- In 2020 a national strategy to develop decarbonized hydrogen for use in as transport fuel was announced, the plan includes a mechanism which ensures a decarbonized guarantee of origin.
  - The plan allocates 2 billion EUR for “renewable and low-carbon hydrogen”
  - ADEME has also launched a call for tenders “Ecosystèmes territoriaux hydrogène” which facilitates investment in hydrogen production and distribution infrastructures between 2021 and 2023.

- Some financial options are available including Bpifrance that provides loans, guarantees and equity to French micro-businesses, SMEs and mid-caps within the state, or its territories, to assist in the financing, development, and construction of new projects- including biogas

Germany

Market Overview

Germany - Current Market Overview

Per latest information, there are 242 biomethane facilities producing approximately 11 TWh per year. The capacity of newly installed biogas facilities is projected to be at around 65 MW in 2022, or as many as 120 new facilities. While most plants still utilise energy crops as their main feedstock, this is rapidly changing with the implementation of REDII and its regulations preventing indirect land use change (ILUC) and ratcheting down of acceptable limits.

Germany is estimated to have the highest biomethane potential from anaerobic digestion by 2030, at over 7.5 bcm, increasing to almost 14.5 bcm by 2050, placing it second only to France. Including Germany's 2050 estimates of 8.5 bcm from thermal gasification by 2050, Germany has the highest biomethane potential in Europe.

Germany intends to increase its biogas production to substitute its Russian imports, and BDEW, a German Utility association, has stated with the removal of barriers, a whole new potential has been unlocked for Germany. The group estimates that Germany could produce 100TWh by 2030, or one fifth of its current imports from Russia.

As one of the first and largest biogas producers, Germany is the largest exporter of biogas engineering and technologies.

Additionally, Germany imports, and exports biomethane. In recent years export amounts fluctuated between 150 and 200 GWh, and imports have come principally from Denmark (with Denmark exporting 28% of their biomethane to the German market).

Germany - Current Market Overview

Market Targets

In response to the gas crisis, Germany has pledged significant increases in its biomethane output targets, in line with goals put forward in the REPowerEU plan. Renewable energy consumption targets remain; however, new targets have been laid out for the increase in domestic biogas/biomethane production.

The Bundestag updated its Renewable Energy Sources Act (2021), raising the consumption targets of renewable energy to 65% by 2030. To achieve this, Germany plans on tendering 56.7 GW of renewable capacity between 2021 and 2028. Of the 56.7 GW, 4 GW is designated for expanding biomass capacity (2.8 GW for solid biomass and 1.2 GW for biomethane-fired technologies).

Upcoming Changes

A new amendment to the Energy Security Act would reduce the regulatory hurdles associated with developing biogas and biomethane projects.

Most facilities in Germany remain in the power generation sector, with only 2% of facilities currently upgrading to biomethane. This is likely to change as demand soars for biomethane and new incentives are introduced to convert CHP facilities to biomethane.

Hydrogen demand in Germany is projected to increase from 191 TWh in 2022/23 to 342 TWh in 2040, requiring significant expansions to the gas network, and increasing demand for ‘green’ blue hydrogen.

Biomethane as Fuel

There are over 900 CNG and LNG filling stations in Germany with an output just over 1 TWh. Nearly all these stations have now transitioned to biomethane.

While demand for NGV is increasing, the gas crisis is pulling demand from the transportation market towards the German industrial sector.

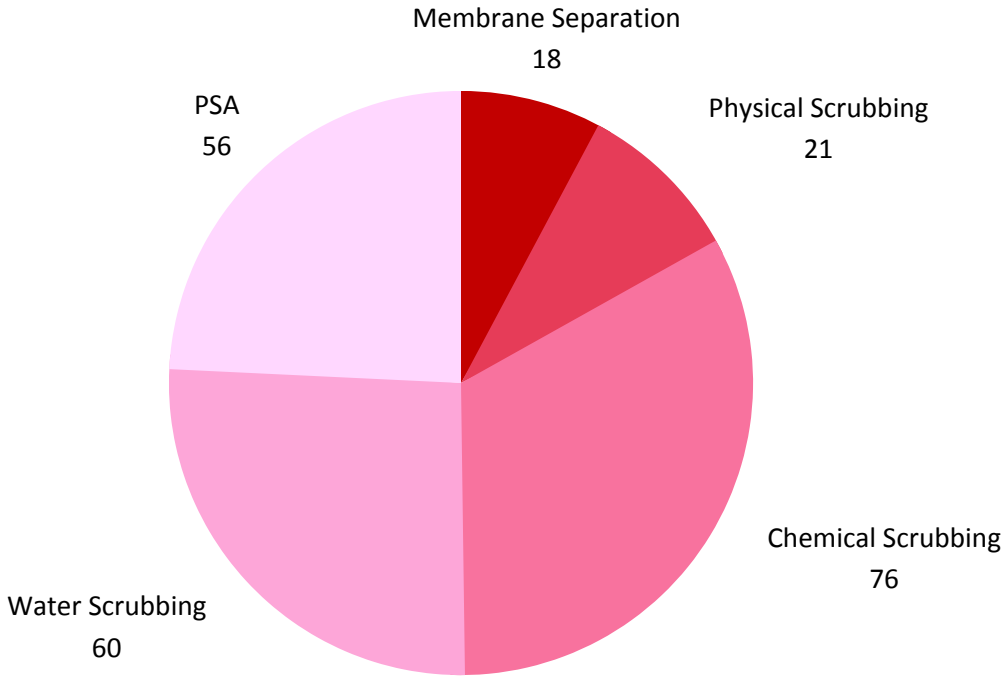
Fuel requirements are established by standard DIN EN 16723-2:2017.

Germany - Upgrading Snapshot

As in the last year the most used upgrading technologies are chemical and water scrubbing, followed closed by PSA technology.

Companies that work in the German market include Greenlane, Greenmac, Envitec, Carbotech, ETW, Hitachi, Malmberg, Schwelm, Wartsila and Weltec Biopower.

Figure 5. Biogas Upgrading in Germany, Number of Plants



Germany - Market Drivers

- To increase the rate at which new facilities are commissioned, the German government has implemented an amendment to the Energy Security Act to remove regulatory hurdles and increase domestic biogas production

- For projects to benefit from support schemes, they must both inject into the gas grid and be registered into the Guarantee of Origin system provided by the German Energy Agency

- In May of 2021, REDII's direct was passed into law in the German parliament
  - REDII includes clear criteria restricting ILUC, when food or feed crops are diverted to AD and biogas production
  - Targets were set at 14% for all road and rail transport to be carbon-free by 2030, however, the new law has been criticised for its emphasis on electric mobility (being counted 4x), while leaving biomass and waste-derived fuels at the 2020 level- 6%. It is argued that this will push conventional biofuels out of the personal transport market by 2024

- The 2 key drivers in Germany have been the Renewable Energy Sources Act (EEG) and the Gas Network Ordinance (GasNZV), which together drove Germany to be a dominant developer of biomethane.

- Changes to EEG in 2014 and 2017 brought cutbacks in available subsidies, particularly where energy crops are used. Former subsidies expired in 2021, however, the 2021 changes add the category "subsidized plants" for systems under 100kW which went into operation before January 1, 2021, offering a feed-in tariff until the end of 2027.

- December of 2020 modifications were made to the EEG that came into effect January 1, 2021, targeting 65% energy from clean sources by 2030. The increase in renewables is paired with a decrease in the renewable tax levied on German energy bills.

- The 2021 EEG modifications introduces a 'Southern Quota' on December 1, 2022, tendering 150MW of highly flexible biomethane for CHP annually in Southern Germany.
  - A flexibility bonus exists for CHP plants using biomethane, set to EUR 65 kWel

Germany - Market Drivers (Continued)

- Tender model introduced in 2017: producer can apply for a supplement and subsidy, especially attractive for larger facilities. As part of the 2021 EEG modifications, the annual tender volume was increased to 600MW, and the maximum bid values were increased to 16.4 ct/kWel for new systems and 18.4 ct/kWel for existing systems.
  - Although the new EEG strengthens small-scale digesters, they remain less economical compared to their larger counterparts.

- As a whole, biomethane industry is not directly supported by grants or other support mechanisms, but some support schemes are available:
  - Tax exemption and biofuel quota trade for vehicular fuel application of biomethane.
  - Biomethane qualifies under the Renewable Energies Heat Act.
  - There is no statutory eligibility for the FIT of RNG into the gas network – producers of RNG need to market it themselves. But use of RNG in electricity generation is eligible for FIT.

- Transmission System Operators (TSOs)/Distribution System Operators (DSOs) must cover 75% of the costs of grid connection, and a cap has been set on how much of the grid connection cost can go to plant owners

Ireland

Market Overview

Ireland - Current Market Overview

Ireland presently has 2 biomethane units, injecting a total of 3,900Nm3/h, both constructed in the last 3 years.

Ireland is preparing to invest up to €1.8 billion in its biomethane industry by 2030.

Ireland has a significant biogas potential from agricultural and commercial food production sources.

AD development in Ireland is viewed as a method to diversify and support the development of a circular bioeconomy, boost bio-fertiliser production, support the transition to a more sustainable food and beverage industry, and create approximately 3,000 jobs in rural Ireland. Biogenic CO2 is viewed as an extremely valuable co-product of the process, as the country currently imports all its CO2.

Ireland - Current Market Overview

In Development

There is at least one large-scale AD/biomethane site currently under development in Ireland.

Market Size

When accounting for both AD and thermal gasification, the EBA estimates that Ireland has the potential to produce ~0.75 bcm of biomethane by 2030, and ~1.5 bcm of biomethane by 2050.

The 40by30 report by Renewable Energy Ireland asses Ireland to have a 2030 potential of 10 TWh. The report further states that 39% of Ireland's heat demand could be met by biogas and other biofuels.

Market Targets

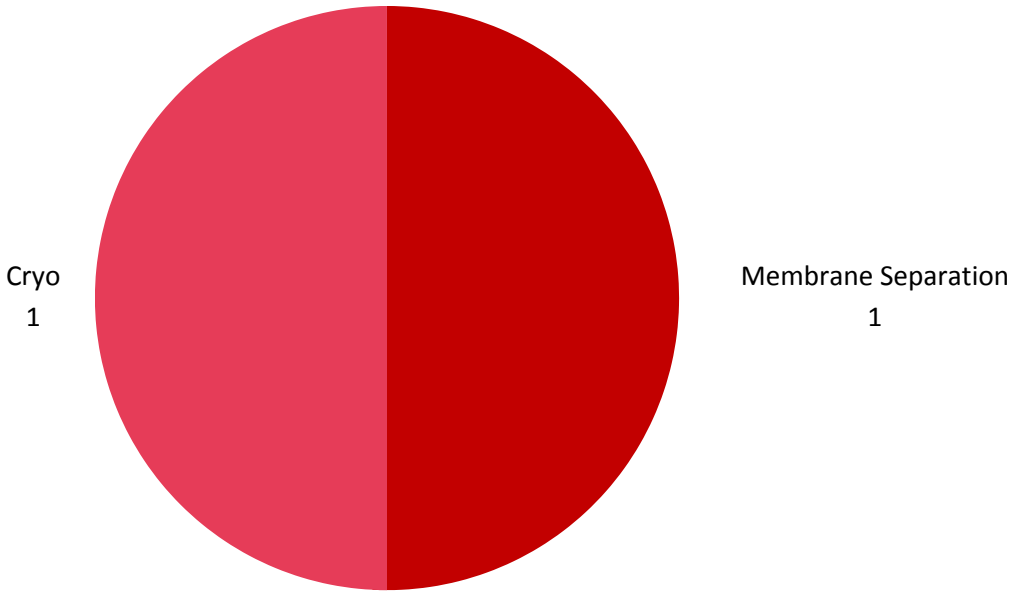
Ireland has targeted 5.7 TWh of biomethane production by 2030, a goal estimated to require between 150 and 200 AD facilities. This would cover 10% of Irelands current gas demand. This is a substantial increase from the Climate Action Plan's (2021) target of 1.6 TWh by 2030.

Ireland - Upgrading Snapshot

Ireland has one cryo, and one membrane upgrading sites.

Active in the market are CryoPur and Bright Biomethane.

Figure 6. Biogas Upgrading in Ireland, Number of Plants



Ireland - Market Drivers

- The Renewable Heat Obligation (RHO) is scheduled to be implemented by 2024
  - Requires energy suppliers to ensure a certain proportion of renewable energy used for heating
  - Renewable energy supported through the Support Scheme for Renewable Heat (SSRH) does not count towards the RHO
  - Only renewable energy which meets RED criteria will qualify (biogas/biomethane, bioliquid, biomass, and green hydrogen)
  - Biomethane has been deemed the renewable energy source with the lowest overall cost for the consumer (between 8c/kWh to 12c/kWh)
  - Supports for biogas boilers or biogas HE CHP heating systems
  - Costs are distributed across all non-renewable fuel types
  - The Irish government has declined funding through the REPowerEU iniative in favour of its RHO and NRRP programs

- The Support Scheme for Renewable Heat (SSRH) provides operational support for biomass boilers and anaerobic digestion heating systems

- In July of 2022, Ireland committed itself to reaching a biomethane target of 5.7 TWh (~0.58 bcm) by 2030

- The Ireland Strategic Investment Fund (ISIF) has announced plans to invest EUR 200 million over the next decade to support the countries biomethane production targets

- Project Clover, an initiative launched by dairy product manufactures, promotes the full integration of the biomethane supply chain, where dairy manure directly fuels the dairy product manufacturing process

- Both the National Development Plan and the Climate Action Plan (2021) includes increasing the role of AD for decarbonization

- Gas Networks Ireland (GNI) is preparing a roadmap to be released in 2023 for a strategy on biomethane development in Ireland, which will include projects and targets

Italy

Market Overview

Italy - Current Market Overview

As of 2022, there was 35 biomethane plants in Italy (producing approximately 44 thousand Nm3/h, or 1.2 TWh).

Italy is third in terms of the number of biogas facilities. Biomethane support schemes have led to a rapid growth in the Italian NGV sector, which is largely comprised of light-duty vehicles. The EBA predicts Italy to become a European leader within the Bio-LNG market.

In response to the European energy crisis, the Italian government announced in 2022 that Italy would look to further expand it biomethane capabilities, and in August of 2022, the EU approved an additional EUR 4.5 billion package to increase Italian biomethane capabilities. The government is targeting 3.5 bcm by 2030, 1.1 bcm of which will be designated for the transport sector. The government is aiming for biomethane to cover 5% of gas consumption by 2026.

The main feedstock used in biomethane plants is organic fraction municipal solid waste (OFMSW) (76%), followed by agricultural wastes/energy crops (23%). Roughly half of facilities currently generate biomethane for the transportation sector.

For several years, Italy has employed the Biogasdoneright system, which aims to increase biomass availability for digesters, without effecting food or feed output. The process has allowed Italian farmers to further improve food output and more effectively valorize digestate to reduce chemical fertilizer use and increase soil fertility

Italy - Current Market Overview

In Development

There are at least 3 projects under construction and scheduled to be operational by the end of 2023.

With electricity generation supports for facilities commissioned after 2012 not set to be renewed, many of these facilities are likely to be upgraded for biomethane production.

Through the CIC scheme, Italy is expected to produce between 0.6 to 0.7 bcm by the end of 2022.

Market Size

Through the PNRR, and recent budgetary announcements, the government aims to reach 4 bcm by 2026.

It is estimated that by 2030, the Italian biomethane sector could reach 6.5 bcm from agricultural and agro-industrial biomass. The further development of OFMSW, WWTP, and landfills is estimated to add 1.5 bcm.

Biomethane as Fuel

Italy currently has the largest CNG fleet in Europe, and biomethane for transportation remains the most significant driver of the industry in Italy.

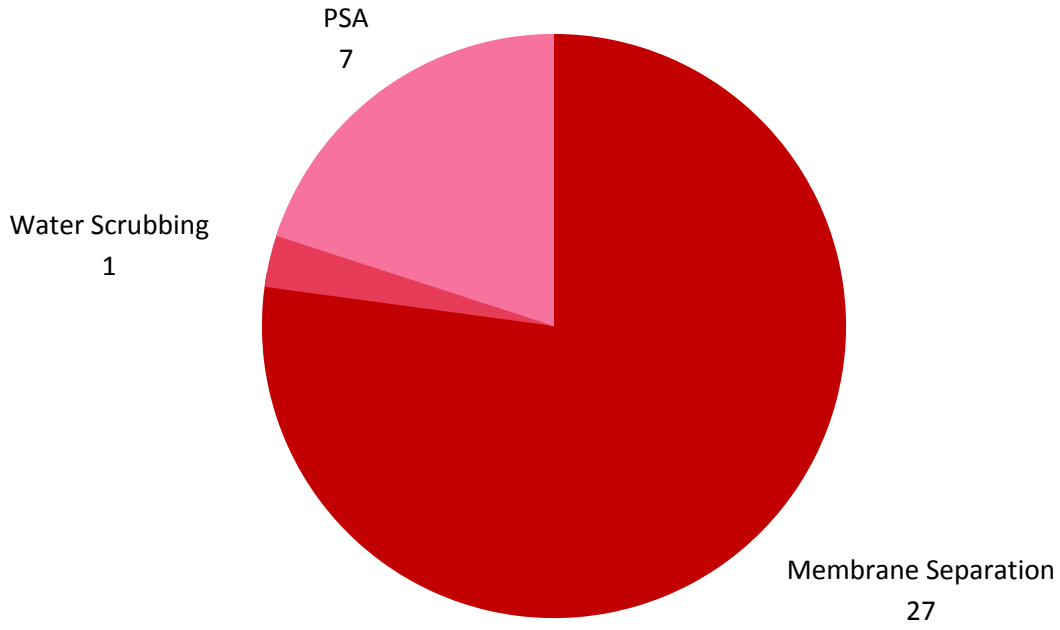
There are currently 1,538 CNG and 126 LNG filling stations in Italy, and over 1 million CNG and LNG vehicles on the road (approx. 750 vehicles/refuelling point). Currently, biomethane accounts for 19% of NGV fuel.

Italy - Upgrading Snapshot

Membrane separation is the most used upgrading technology in Italy, being used in 27 plants out of 35 facilities.

Companies that work in the Italian market are Air Liquide, Bright, ETW, Malmberg, Pentair, Prodeval and Xebec.

Figure 7. Biogas Upgrading in Italy, Number of Plants



Italy - Market Drivers

- In August of 2022, the EU approved a EUR 4.5 billion package to increase Italian biomethane output, the funds were made available through the Recovery and Resilience Facility (RRF)
    - EUR 1.7 billion is available in the form of an investment grant which covers 40% of eligible investment costs and;
    - EUR 2.8 billion for an incentive tariff (€/MWh) paid during a 15 year operational phase
  - o The scheme aims to support sustainable biomethane for injection into the grid and used in transport and heating sectors
  - The new scheme is planned to run until June 30, 2026
  - To qualify, projects must comply with requirements set out in EU RED II
  - Funds are additionally available to the conversion of biogas to biomethane facilities

- Italy National Energy Strategy sets up the target of 28% of RES in total energy consumption by 2030
  - This would require 224 TWh of renewable energy capacity to be operational, 22TWh of which has been designated for bioenergy: 12 for biogas/biomethane

- The National Recovery and Resilience Plan (NRRP) was implemented in December of 2021, as an economic recovery package following the pandemic. Of the total package, 1.92 billion EUR has been designated for developing the biogas and biomethane sectors in Italy.
  - Other areas of the Plan include improving the climate resiliency of infrastructure, increasing the production and distribution of hydrogen, increasing the availability of sustainable transportation
  - The plan aims to increase the efficiency of biogas plants in the agricultural sector, support the development of new upgrading facilities (through investments totalling 40% of the cost), expand existing biogas facilities with upgrading capabilities, promote sustainable practices within its biomethane industry, promote the replacement of obsolete or low-efficiency vehicles with biomethane fuelled vehicles, and improve the efficiency of heat recovery.
  - The government has announced plans for a reform package which would accelerate and simplify procedures

- On October 27, 2022, the Biomethane Decree went into force
  - Funding administered through the NRRP
  - An all-inclusive tariff for facilities with a production capacity equal to or lower than 250 scm/h, and a premium tariff for facilities with a production capacity of over 250 Scm/h

Italy - Market Drivers (Continued)

- The Decreto Semplificazioni bis, enacted in the fall of 2021allows biogas and biomethane facilities under 300 kW access to past incentives set out in the Ministerial Decree of the 23 of June 2016

- The Integrated National Plan for Energy and Climate for 2030 targets 22% renewable energy in transport fuel by 2030, as set by the REDII directive.
  - The plan further outlines the contribution of biomethane to account for 75% on final energy consumption in the transport sector (0.08 Mtoe or 1.1 billion cubic meters) by 2030

- Biomethane promotion scheme
  - Scheme is based on the certificates of release for consumption ("Certificati di Immissione in Consumo di biocarburanti", better known as "CIC")
  - A company that releases non-renewable fuels for consumption has to hold CIC enough to cover its obligation. Obligations were updated in January of 2021. And now require for 2021 are 10% for biofuels and 1.5% for advanced biofuels. From 2022, the obligation for advanced biofuels changes to 2.5%, and then to 3.0% in 2023
  - As a basic rule, one CIC is assigned every 10 GCal of biomethane. Some exclusions apply, double counting mechanism is into force.
  - Support scheme gives preference to small-scale digester projects
  - Advanced biomethane is produced from specific feedstock, including organic fraction of municipal waste, manure, crop waste, etc.
  - During the first 10 years of advanced biomethane production, the plant can request a special scheme where each certificate is valued at 375 Euro
    - The GSE will withdraw the advanced biomethane which is produced for a maximum share equal to 75 % of the obligation, minus any shares of “obliged subjects” that do not intend to join the arrangement. The withdrawal of the biomethane will take place at a price equal to that of the MPGAS (Spot Market for Gas) reduced by 5 % and the GSE will recognize the value of the corresponding CIC, assigning each certificate a value of 375 Euro

- Biomethane as a transportation fuel is included as a pathway to meet the fuel CO2 reduction quotas, with a 2% biomethane blend requirement in the transportation sector for 2022
  - The purchase of CICs is required to meet targets
  - Advanced biomethane receives double a CICs value, with a bonus 20% available if biomethane is compressed or liquified
  - If a producer does not already receive a CIC, they can opt for GOs, which can be sold to obliged parties
  - In 2018, changes to FiTs removed supports from biomethane used to produce electricity to only support biomethane used as transport fuel

Italy - Market Drivers (Continued)

- Italy's plan for developing agricultural biomethane use involves converting tractors to biomethane and increasing self-sufficiency of farms
- Electricity generation support is coming to an end for facilities built before the end of 2012, and the Italian government intends to shift these facilities to biomethane production
- Ministerial Decree introduced in October 2018 allowing biomethane produced by the agricultural sector to be used as bio-fuel (agricultural tax incentives)
- Digestate is being promoted within the circular economy as a bio-fertilizer capable of replacing agricultural dependence on synthetic fertilizers
- The requirements for natural gas quality and European technical regulations for additional biomethane elements presented in Technical Regulation UNI/TR 11537:2016 Injection of biomethane in natural gas transport and distribution networks, was replaced by UNI/TS 11537:2019
- 110% Superbonus Tax Deduction available for all energy efficiency retrofits extended to the end of 2022
- A new biomethane support scheme is scheduled to be released in 2022, extending eligible biomethane end-use sectors
  - New eligible end uses will include industrial and residential CNG use
  - Bio-LNG is likely to remain favoured for vehicle transport due to the increase in heavy logistics vehicles running on LNG.
  - The use of biomethane for maritime transport is also being considered
  - It is expected that to benefit from the new subsidy package, facilities will have to participate in a public tender process.
- By the end of 2022, decree FER2 was expected to introduce incentives for small-scale biogas to electricity projects under 300 kWel
  - FER2 was not implemented as of January 2023

Netherlands

Market Overview

Netherlands - Current Market Overview

As of 2022, there are 84 biomethane units in the Netherlands with agricultural waste forming the main feedstock. The majority of biomethane is injected into the gas grid (approximately 200 million Nm3 or 7 PJ). Additionally, Netherlands has its own national renewable gas registry, operated by Vertogas.

The Netherlands is targeting 2 bcm of biomethane by 2030, which would result in a 3.6 Mton GHG reduction. This is a 10x increase from the countries current 0.2 bcm output.

Biomethane development is framed in the country as an investment in energy security and a method for the decarbonization of hard-to-abate sectors.

As part of its 2030 Climate Agreement, the Netherlands has set a consumption target of 2 bcm. Additionally, 20% (1.6 bcm) must be blended into the gas grid.

Netherlands - Current Market Overview

In Development

There are at least 5 projects scheduled to be operational by the end of 2023.

0.4 bcm of CHP is targeted to be converted to RNG by 2030.

Market Size

It is estimated that if the Netherlands utilized all agricultural manure, it could double its biomethane output.

Gas for Climate estimates that the Netherlands has a biomethane potential of almost 1.5 bcm by 2030, increasing to 2.5 bcm by 2050. When also accounting for thermal gasification, its potential increases to approximately 3 bcm.

Biomethane use is prioritised for the built environment within the Netherlands.

Transport Sector

At gas stations, biomethane becomes bio-CNF (it should be at least 82% methane). There are over 200 CNG and LNG fuelling stations in the Netherlands.

Blending obligations are in place for fuel stations, and 90% of the NG in the transport sector is comprised of biomethane. There are at least 170 filling stations (CNG and biomethane) and in more than half, 100% biomethane is available.

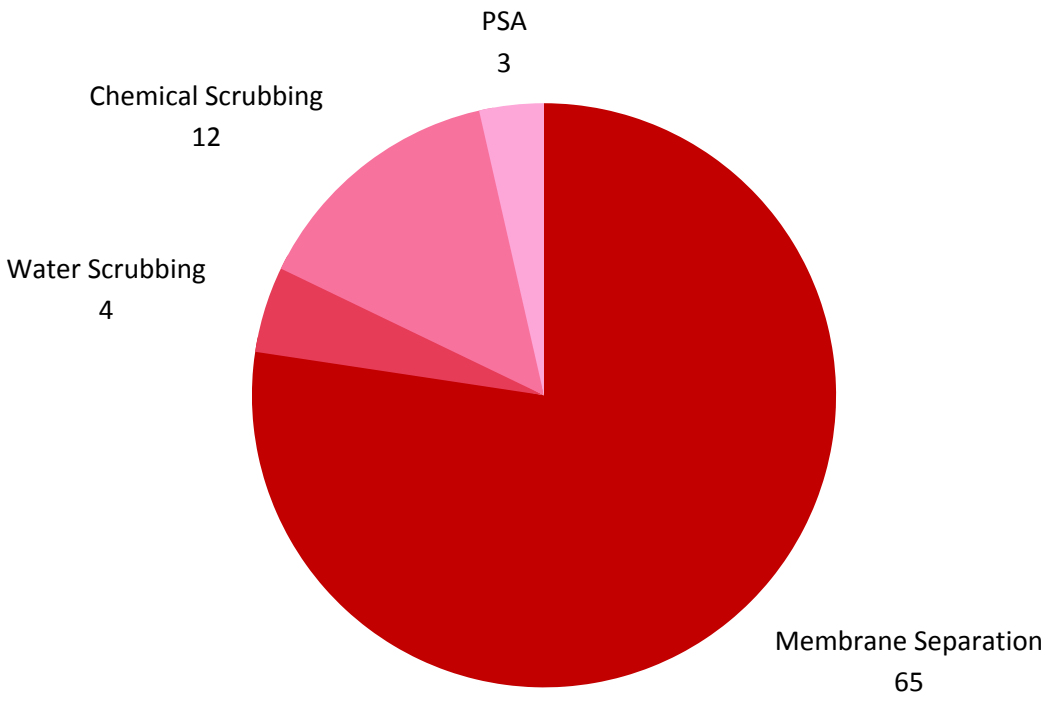
Netherlands - Upgrading Snapshot

Figure 8 has been updated with BiogasWorld's latest figures provided by upgraders operating in the Netherlands.

Membrane separation is the most used upgrading technology in Netherlands, being used in 65 plants. Chemical scrubbing is used in 12 units.

Companies that work in this market are Bright Biomethane, Carbotech, DMT, and Pentair.

Figure 8. Biogas Upgrading in the Netherlands, Number of Plants



Netherlands - Market Drivers

- FiT (SDE++ [Stimulering duurzame energieproductie en klimaattransitie])
  - Has now taken over and added to the SDE+ regulation, which was active between 2013 and 2020
  - Sustainable Energy Transition Incentive Scheme (SDE ++) will stimulate the roll-out of renewable energy and CO2-reducing technologies by compensating the unprofitable top of these technologies. This is done through an operational support
  - The scheme is based on tenders
    - Bidders are required to submit zero-subsidy bids as part of award criteria
  - Main difference with SDE+ is that now it is possible to apply for a subsidy for other technologies that reduce CO_2 or other greenhouse gases and the competition is allowed on the basis of avoided tons of CO2 equivalent, instead of cost price for renewable energy
    - In 2020, the premium was between €30.0/MWh (WWTP) and €79.0/MWh (biomass gasification)
  - Blending quota to 2030 set at 1.6 bcm, with blending obligations beginning in 2025
    - Recommendations for how the quota should be ramped up will be submitted to parliament in Q1 2023
  - Biogas and biomethane projects fall into the following categories:
    - Renewable heat: geothermal, aqua thermal, biomass and solar thermal
    - Renewable gas: fermentation and gasification
    - Other CO2 reducing technologies: electric boiler, large-scale heat pump, industrial waste heat, hydrogen through electrolysis and carbon capture and storage (CCS)
  - The second round budget is beginning of SDE++, awarding 11 billion EUR of projects and public support of up to 8 billion EUR. The intake of bids will begin again in the fall or 2022.
  - The SDE++ subsidy cannot be combined with EU investment supports

- Supplier obligations exist for small-scale consumers, set at 0.15 bcm for 2025, further details are expected to be released by the end of Q1 2023

- The Renewable Fuel Units (HBE) trading system (where 1 unit = 1GJ)
  - The HBE forces fuel producers to increase the share of renewable fuels within their systems from 17.9% in 2022 to 28% by 2030.
  - Plant owners can choose to benefit from either the HBE or the SDE++

- As of January 1, 2022, GOs from biogas can be used within the EU ETS, however the benefits are taken into account before SDE++ supports

- The Dutch government is currently developing a regulatory framework to streamline the permitting process while ensuring feedstocks are sourced sustainably
  - One proposed method is through permitting/development zones

Netherlands - Market Drivers (Continued)

- 2023 will introduce Biogas/Syngas 3.0 and promote both hydrogen and biomethane routes for renewable gas, and promote their development at industrial scales

- The ODE (Opslag Duurzame Energie- en Klimaattransitie) is the only relevant tax allowance for renewable energies (including biomass) in the Netherlands.

- The Energy Investment Allowance (EIA scheme) is also available for eligible biogas installations
  - A fund of 150 million EUR has been allocated to support the development of small-capacity units
  - Earmarks funds for hydrogen production, including hydrogen from biogas

Spain

Market Overview

Spain - Current Market Overview

There are approximately 300 biogas facilities in Spain, 6 of which are upgrading biogas to biomethane (5,000 m3/h).

In March of 2022, the Spanish Council of Ministers approved a new biogas roadmap for the country which aims to multiply the current output of Spain by 3.8x by 2030 (over 10.4 TWh). Of that total, 5.7 TWh/y has been designated for upgrading and grid injection. The roadmap focuses on waste recovery and promotes the use of electricity and heat for industrial purposes, and as transportation fuel. The biogas roadmap was announced alongside several other energy roadmaps, signalling the beginning of a wider planned transformation of the Spanish energy system (which biogas and biomethane's role has been recognized).

Further potential within Spain lies in its integration of REDII and demand within the agricultural sector for biofertilizers.

Spain - Current Market Overview

In Development

According to GASNAM, before the end of 2022 there will be 12 biomethane facilities in operation within Spain and another 30 under development. The further forecast that by 2024 there will be at least 64 biomethane facilities in operation in Spain (generating a total of 2,077 GWh/y).

Market Size

A recent report by the European Commission estimates that Spain has a biomethane potential of 122 TWh, however, it is estimated that new waste recovery technologies increase this potential.

While biogas is the main renewable gas within the Spanish energy system, it accounts for just 1.4% of Europe's total biogas supply.

Spain has enormous feedstock potential generating annually 49 million tons of livestock waste, 7 million tons of food waste, and 9 million tons of agricultural waste.

Transport Sector

In 2019, bioenergy accounted for just over 5% (approx. 1.5 Mtoe) of energy used within the transport sector.

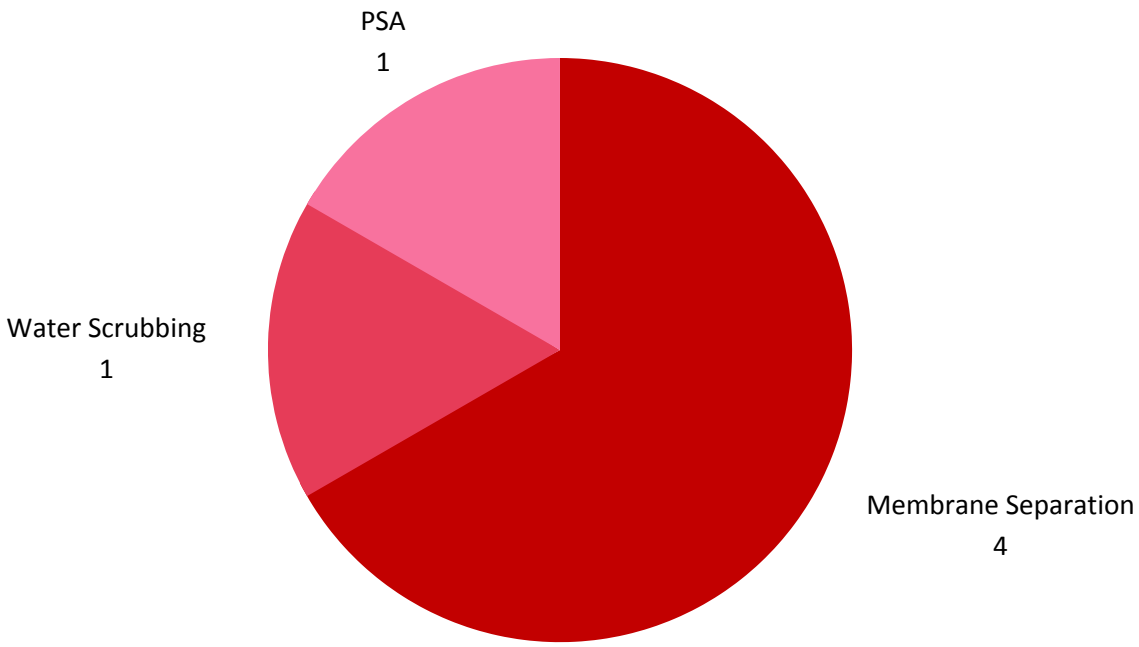
The 2021-2030 Integrated National Energy and Climate Plan (PNIEC) targets 28% total renewable energy in transport, in addition to the requirements set out in REDII (0.2% in 2022, 1% by 2025, and 3.5% by 2030).

Spain - Upgrading Snapshot

There are currently 6 facilities upgrading to biomethane, with membrane being the most used technology.

Companies active within the market include Greenlane, Bright Biomethane, Prodeval, DMT, and Sysadvance.

Figure 9. Biogas Upgrading in Spain, Number of Plants



Spain - Market Drivers

- El Gobierno aprueba la Hoja de Ruta del Biogás (Biogas Roadmap)
  - Approved in March of 2022, the Biogas Roadmap announced the states intention to multiply the current Spanish biomethane output by 3.8x its current levels until 2030
  - The roadmap announced an upcoming guarantee of origin program for renewable gases with an additional possibility for setting objectives and supply or utilizing quotas to develop its market
  - The roadmap promotes the recycling of waste materials such as agricultural residues, agri-food industries and municipal sewage sludge
  - A ministerial order is currently being processed to accompany the roadmap with €150 million in support (paid by the Recovery, Transformation and Resilience Plan (PRTR)
  - Includes guarantees of Origin and Consumption objectives
  - Priority of use will be given to local demand sources
  - Sets goal of 1% of total natural gas demand to be filled by biomethane by 2030

- In 2020, €300 million in ERDF funds were allocated as grants for developing renewable electricity and heat within Spain
  - 34% of the funding has been allocated to biomass projects, and 20% to biogas and other renewable gases

Sweden

Market Overview

Sweden - Current Market Overview

There are 70 biogas upgrading plants in Sweden (about 65% of biogas is upgraded) producing approximately 2.2 TWh of biomethane. 23% of plants inject biomethane into the gas grid. About 87% of produced digestate was utilized as fertiliser.

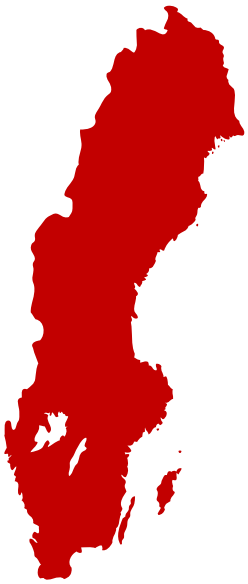
The 2022 Budget Bill set aside SEK 500 million to increase biogas production and the competitiveness of producers. SEK 700 million has been proposed for the 2023 and 2024 budgets.

The primary feedstock used in Sweden is sewage sludge, as the treatment of urban and industrial organic waste is a high priority.

A study by Westlund et. al. found that the average cost of producing biomethane in Sweden was €90/MWh. The authors go on to recommend a premium of between 20 and 45 €/MWh to make biomethane competitive against natural gas.

The use of biogas for transportation has been prioritized as a method for decarbonizing road transport, and regulatory frameworks have shifted to incentivize use as vehicle fuel. Liquid and compressed biomethane now accounts for approximately 95% of Swedish NGV fuel.

About half of its biomethane (~2 TWh) is imported from Denmark where it is subsidized, combined with Swedish tax exemptions, Danish biomethane has become more competitive with natural gas, and a more attractive market for Danish producers.



Sweden - Current Market Overview

Market Goals

There is currently no official strategy or goal for biomethane or other energy gases in Sweden, however, the industry association Energigas has announced an investment commitment to achieve 10 TWh of biogas production by 2030, 7 TWh of which will be produced via traditional AD, and the other 3 TWh from other techniques.

Sweden's newly elected government has announced that aspirations for renewable energy leadership will be tempered in coming years.

Market Size

A recent report from Gas for Climate estimates Sweden to have a biomethane potential of approximately 10 bcm/y (when accounting for both AD and thermal gasification).

The Swedish government has highlighted biogas and biomethane utilization as a key method for reducing methane emissions in its agriculture and waste sectors.

The long-term potential of the Swedish market is estimated to be over 30 TWh/y.

Transport Sector

Almost two-thirds of biomethane produced in Sweden is fed into the vehicle fuel market.

With no grid connecting the north of the country, LNG has been the favoured end-use for biomethane.
The bio-LNG and bio-CNG fuel markets have experienced enormous year-over-year growth in Sweden in recent years, and in 2021 accounted for 65% and 95% of all LNG and CNG (respectively) in the transportation market.

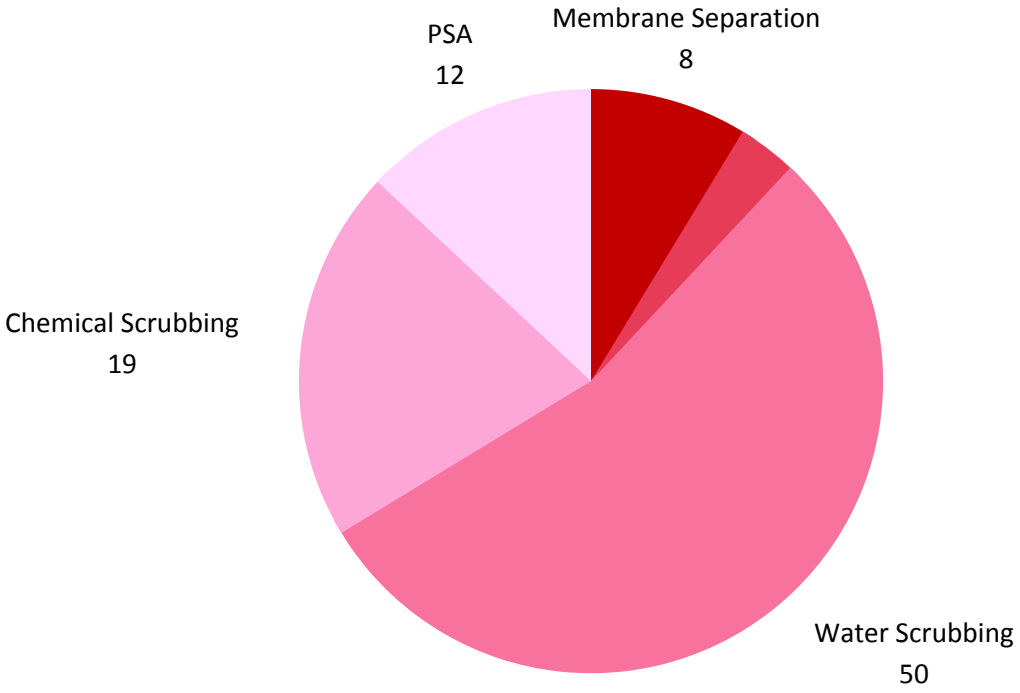
There are 209 filling stations for CNG in Sweden, and 26 LNG filling stations.

Sweden - Upgrading Snapshot

Water scrubbing is the most used upgrading technology in Sweden, being used in 50 plants. Chemical scrubbing is used in 19 units.

Air Liquide, Bright Biomethane, Carbotech, DMT, Econet, Greenlane, Hitachi, Malmberg, Puregas and Wartsila are present in the market.

Figure 10. Biogas Upgrading in Sweden, Number of Plants



Major Drivers - Sweden

- The 2022 Budget Bill sets aside SEK 500 million (€47.9 million) to increase biogas production and boost the competitiveness of producers. SEK 700 million (€67 million) has earmarked for the 2023 and 2024 budgets (the 2021 Klimatklivet proposed SEK 700 million each year for the 2022 – 2040 period)
  - The new regulation provides a subsidy of up to 30 ore (€0.02)/kWh if biogas is upgraded, with an additional 15 ore (€0.01)/kWh to eligible liquification sites

- A national Guarantee of Origin system for biogas and biomethane is being prepared by the Swedish Energy Agency

- Energy and CO2-Tax
  - Biofuels are eligible for tax exemption (energy and carbon dioxide taxes are levied on the supply, import and production of fossil fuels)- approved until the end of 2030
  - For biogas sold or used as a motor fuel the maximum deduction amounts to 100% from energy tax and 100% of CO2-tax
  - The CO2-tax rate 2022 was SEK 1,200 /tonne CO2 (~23 EUR /MWh).
  - Exemptions from CO2 and energy tax for biogas or biomethane for heating (including industrial uses) is approved by the Commission until the end of 2030.

- With the implementation of REDII, all suppliers of biofuels (including biomethane used in transport), that are eligible for taxation, must apply through the Swedish Energy Agency for tax exemptions or other support systems.
  - To receive a valid Sustainability Decision, a supplier must prove a control system that covers all aspects of production and distribution (parts of the supply chain) meets sustainability requirements.

- As of January 1, 2020, cities can enforce polluting zones which restrict noise and emissions from vehicles to 3 different restriction levels. Only NGVs, hydrogen vehicles, and electric vehicles are allowed in all three zones.

- Production support/premium
  - Production support for biogas and biomethane from manure 0.20 SEK /kWh (or ~20 EUR /MWh) until 2023.
  - Since 2021, the premium has supported 10 – 40 €/MWh to biogas producers for up to 10 years

- Local climate investment program (Klimatklivet 2015-2026):
  - Investment support (up to approx. 45 %) for all types of GHG reduction measures, including support to biomethane plants and filling stations.

- Climate Leap Programme: provides investment support for biogas facilities, including biogas for electricity generation

United Kingdom

Market Overview

UK - Current Market Overview

There are currently 96 biomethane plants in the UK with the total installed capacity of just over 80,000Nm3/hr (or 4.5 TWh).

Biomethane is mainly injected into the National Grid from certified Renewable Heat Incentive (RHI) installations, however, the RHI has been replaced by the Green Gas Support Scheme (GGSS) since November of 2021.

70% of plants use mainly agricultural feedstocks (energy crops and manure), The rest treat organic and industrial wastes; only 1% of sewage sludge in the UK is digested. As a result of the Environmental Bill (2021), the UK is mandating all municipalities implement food waste collection programs and promote the AD and nutrient recycling of these wastes (only 15% is currently digested).

The largest gas distributor in the UK, Cadent, operates 36 biomethane facilities, with another 20 either under construction or in late phases of development. Cadent alone is estimated to add another 4 TWh of biomethane per year into their network, and through the GGSS, an additional 2.4 TWh is predicted over the 2025 to 2046 period.

In 2023, councils across England will be required to provide organics collection on a weekly basis, bringing the country in-line with the other members of the UK. A landfill organics ban is being explored for 2028.

UK - Current Market Overview

Market Demand

Demand for biomethane comes from several venues:

- Back-up power generation (RNG to be stored and delivered via gas grid)
- Use of RNG as vehicle fuel for public transport and trucks
- The Renewable Transport Fuel Obligation (RTFO) requires fuel suppliers to incorporate renewable fuels into their networks (including biomethane)
- There used to be demand for renewable heat under the RHI, but it was closed to new applicants in early 2021

ADBA estimates that the full potential of the UK biomethane sector could reduce approximately 6% of the UK's total emissions. 10 of the UK's biomethane facilities use a CO2 collection system, storing and selling it to the food industry rather than venting it.

Market Size

The CCC estimates 20 TWh per year of biomethane to be feasible by 2050, however, their recent Sixth Carbon Budget report suggests upward revisions. Separate food waste collection systems are coming into force across England and are expected to significantly increase the number of anaerobic digestors in coming years. Yearly food waste is estimated at 1 Mt, emitting 4% of all GHGs in the UK.

A 2022 report by Zemo Partnership estimates that Scotland could easily double its current output without resource conflict if it more fully utilized whisky production, brewery wastes, and agricultural feedstocks.

The 2022 Green Gas Report by Ecotricity estimates that through Green Gas Mills, the UK has the potential to produce 236.5 TWh.

Transport Sector

In July of 2022, the Renewable Transport Fuel Obligation Order 2007 was amended to increase the supply of renewable transport fuels within the UK. Among its amendments, it encourages the increase in biomethane volume in transport fuels.

The report by Zemo Partnership found that Scotland has the capability to be self-sufficient in biomethane for transport given their projected supply and demand-side projections.

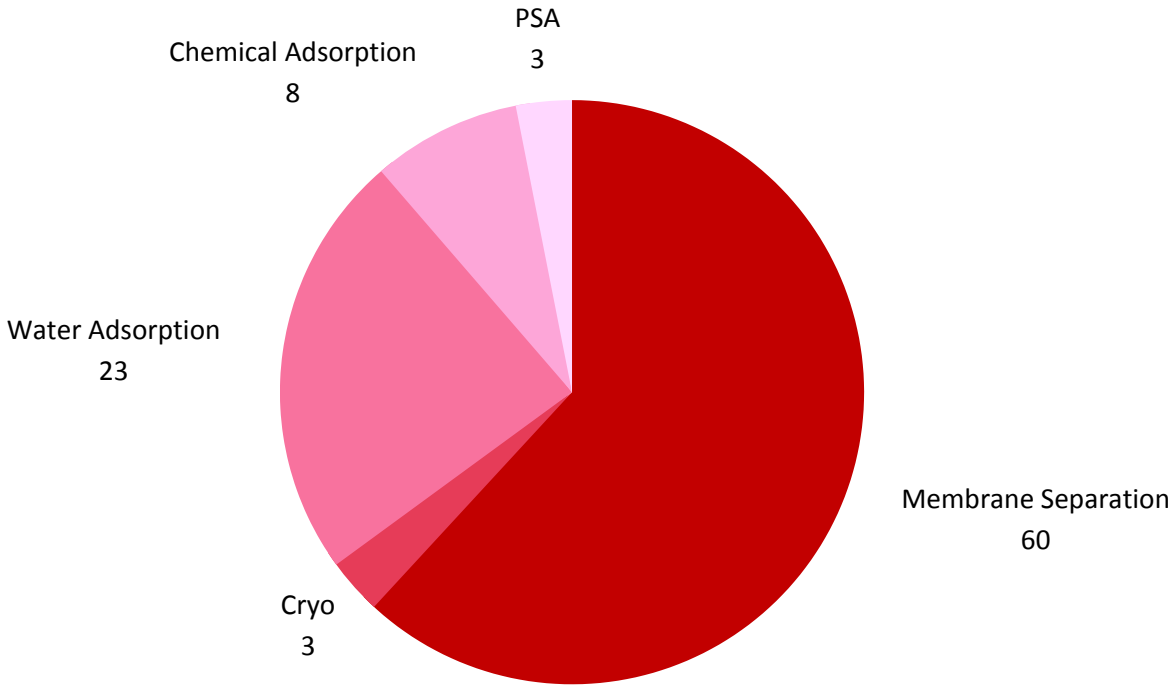
Of the total 186 million litres equivalent of renewable fuels, biomethane made up under 10%.
There are currently 14 CNG and 14 LNG refuelling stations in the UK.

UK - Upgrading Snapshot

Membrane separation is the most used upgrading technology in the UK, being used in 60 plants.

The upgrading suppliers present in this market are Bright Biomethane, Carbotech, CryoPur, DMT, Envitec, Gasrec, Greenlane, Hitachi, Malmberg, Pentair, Prodeval, Wartsila and Weltec Biopower.

Figure 11. Biogas Upgrading in the United Kingdom, Number of Plants



UK - Market Drivers

- At the beginning of November, 2021, the new Environment Bill (2021) was passed into law, included in the Bill is:
  - The expansion of food waste collection services with the goal of preventing these forms of wastes from ending up in landfills
  - Increasing resource efficiency and waste reduction, with an emphasis on improving the environment in addition to soil health and quality, and air quality

- From 2023/2024, the British government is planning on releasing £290m to fund food waste collection programs for all councils
  - By 2023, all councils must provide weekly food waste collection programs
    - A goal of 65% recycling of municipal waste by 2035 has been set
  - By 2023/2024, all businesses and non-domestic premises (school, universities, hospitals, nursing homes) will also be included
  - A landfill organics ban is being explored for implementation by 2028

- At the beginning of 2022, the buy-out ceiling for RTFCs was raised from 30p/litre to 50p/litre

- In July of 2022, the Renewable Transport Fuel Obligation Order 2007 was amended to increase the supply of renewable transport fuels, the increase of biomethane volumes for NGVs was amongst the amendments

- The Green Gas Certification Scheme (GGCS) provides valuable Certificates of Origin to grid-injected biomethane

- In July of 2022, the British government released SR2021 No 6: a Statutory guidance for AD facilities and the resultant biogas

- There are currently proposed changes to the UK Emissions Trading System (UK ETS) to extend to biomass (gaseous & solid) and AD when it is combusted as fuel by energy intensive industries or for power generation
  - Currently, through meeting certain sustainability criteria biomass and AD can only qualify for a zero rating
  - Does not extend to biofuels used for transport

UK - Market Drivers (Continued)

- Green Gas Support Scheme (GGSS)
  - Removes incentives for CHP production, supporting only biomethane produced from anaerobic digestion (AD) of biomass feedstocks and injected into the gas grid
  - Opened November 2021, and replaced the Non-Domestic Renewable Heat Incentive (RHI), the program will be open to new applications for 4 years.
  - The scheme has two associated caps:
    - The Applications Budget Cap (ABC), where applications are checked against the budget to ensure funds are available
    - The Overall Scheme Expenditure Budget Cap (OSEB), which is set above the ABC and relates directly to the levy collection
  - The tariff is tiered to reflect the cost of producing biomethane at different scales. The opening tariffs are:
    - Tier 1: First 60,000 MWh of eligible biomethane – tariff amount: 5.51 p/kWh
    - Tier 2: Next 40,000 MWh of eligible biomethane – tariff amount: 3.53 p/kWh
    - Tier 3: Remaining (above 100,000MWh) eligible biomethane – tariff amount: 1.56 p/kWh
    - Tariff payments will be available to participants for 15 years
  - The GGSS is financed by the Green Gas Levy, a levy on fossil fuel gas suppliers, which was introduced in April of 2022

- Following COP26, the UK government published its Net Zero Strategy: Build Back Greener, a part of its wider Ten Point Plan for a Green Industrial Revolution. The strategy includes:
  - A commitment to delivering 5GW of hydrogen production capacity by 2030, and has set up the Industrial Decarbonization and Hydrogen Revenue Support (IDHRS) scheme, which will fund hydrogen production and carbon capture projects
  - Investments in low-carbon farming and agricultural innovations (via the Farming Investment Fund and the Farming Innovation Programme) for equipment, technology, and infrastructures

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Questions? Contact us!

www.biogasworld.com
info@biogasworld.com
+1 (418) 780-4001

2828 Blv. Laurier, Suite 700
Quebec (QC) G1V 0B9
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