Federal Ministry
for Economic Affairs
and Climate Action

中德能源与能效合作
Energiepartnerschaft
DEUTSCHLAND - CHINA

Biomethane trading systems in Europe and Germany

Experiences for China

Sino-German Energy Partnership

giz Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

Imprint

The report "Biomethane trading systems in Europe and Germany – Experiences for China" is published in the framework of the Sino-German Energy Partnership between the German Federal Ministry for Economic Affairs and Climate Action (BMWK) and the National Energy Administration of the People's Republic of China (NEA). BMWK has commissioned the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH to implement the German side's contribution on its behalf. This report introduces European and German biomethane trading systems and discusses their relevance for the development of corresponding biomethane markets in China. The later part was developed jointly with the China Biomass Energy Industry Promotion Association (BEIPA).

As a German federal enterprise, GIZ supports the German government in the achievement of its goals in international cooperation for sustainable development.

Published by

Sino-German Energy Partnership
commissioned by the German Federal Ministry for Economic Affairs and Climate Action (BMWK)
Tayuan Diplomatic Office Building 1-15, 14 Liangmahe South Street, Chaoyang District
100600 Beijing, P. R. China

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BSR / p.17

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Harmonised and transparent renewable gas certificates are fundamental for biomethane trade in Europe. They create trust in the market and ensure product quality. In the following sections, the basic mechanisms of European biomethane certification and trading systems will be introduced. The systems in place in the UK and Netherlands will be highlighted. The main focus, however, will be placed on Germany as one of the countries, which has played a larger role in establishing an international system.

The general benefits and requirements of biomethane certificate schemes are explained in the first chapter. The underlying principles of certificate trading and the national approaches are presented. Therefore, the individual certificate trading schemes are examined in more detail in sections 2 to 4. The focus will be laid on core structure and important key data of the national trading systems. Concluding with three German case studies, reflections on market conditions in China will be elaborated in the final section.

1. Introduction to European biogas certificate trading systems

European biomethane trading structures can provide favourable conditions that encourage investments in biomethane production. To ensure the necessary quality for the various sectors in which biomethane is being used, experts need to create a system for the respective renewable gas sector. The quality should be tracked by a biomethane registry, and the product should be guaranteed to be market-ready for the respective path of use. As a neutral and dependable platform for biomethane/renewable gas certificates, the registry has obligations to market participants. These include setting up a uniform platform for the registry's settlement process and handling requirements like the registration process.

Biomethane is a flexible energy carrier that can be marketed as a renewable gas for heating and cooling, transportation fuel, renewable electricity, and more. As mentioned above, various marketing paths require different characteristics for the respective biomethane product. The biomethane certificates should reflect these requirements, for example for grid injection. In addition to the various end uses, the register system should consider different forms of renewable gases (biomethane, bio-syngas, and green hydrogen), which will all be a part of an integrated renewable gas market.

The most logical choice for a European country is to select or establish one central clearing agent and one central registry. These should have the ability to cover all types of renewable gases and applications in order to develop a competitive renewable gas market that addresses the challenges of climate change and offers a solution to the administrative issues of a national and European certification scheme. A centralized system – first nationally and then on European level – will simplify operating procedures and ensure the highest level of trust and transparency for all market players. It will also eliminate any potential for double counting and claiming. The registry system must be able to give comprehensive and adaptable attribute lists[1] in order to offer the necessary details for each type of renewable gas and its marketing channel.

The European Union issued a directive in 2009 in order to regulate renewable energy use and set targets for greenhouse gas reduction. The directive was later referred to as the Renewable Energy Directive or RED. In 2018 the directive was updated (RED II). A further revision – RED III – was approved by the EU parliament on September 14th, 2022. One of the key provisions for creating market transparency in the RED is a system for confirming the origin of biomethane. According to Article 15 paragraph 6 of the Renewable Energy Directive (RED), the Guarantees of Origin[2] (GoO) must specify at least:

[1] (Edel, et al., 2019)

[2] Guarantees of Origin, also known in other terminology, such as biomethane certificates, Certificate of Origin (CoO), Renewable Gas Guarantees of Origin (RGGO)

- The energy source (interpretation for biomethane: the biogas substrates)
- Start and end of production (interpretation for biomethane: start and end of injection)
- Identity, location, type and capacity of the producing facility
- Investment support provided to the producing facility
- Financial benefit provided for the unit of energy (support scheme such as feed-in-tariff, a feed-in-premium, investment subsidy, tax advantage, etc.)
- Date, country of issue
- Unique ID

1.1 Principle of green gas certificates

The trading of green gas certificates can be based on two different approaches: Book and claim, and mass balancing. In the following, the basics of the two principles are explained. In both approaches, the volumes of biomethane fed into the natural gas grid are measured by calibrated and gauged equipment.

1.1.1 Book and Claim

In this scheme, it is possible to decouple the physical production of green gas from its use by issuing green gas certificates for a certain amount or all of the injected biomethane. The certificates can be used for granting subsidies.

A biogas producer, for example an agricultural company, sells the green gas it produces to a company that trades in gas. In addition, the trader receives the certificates. Gas users can purchase gas, and green gas certificates, via their regular connection to the distribution network. In this way they buy green gas as it were, with which they can achieve their own sustainable energy objectives. There are therefore two markets: a physical gas market (trade in gas) and a virtual certificate market (trade in certificates). A certificate is issued at the time of green gas production, after which the gas is traded as normal fossil gas and transported to users. At that time, the green gas is no longer recognisable as green gas because it mixes with natural gas in the transport pipeline. The green attribute has been converted into a certificate that can be traded separately from the physical gas flow, and linked again to the physical gas flow if an end user consumes the green gas. As a result, anyone can buy green gas without being physically connected to a producer of green gas, and in this way, can still make their energy consumption more sustainable.[3]

1.1.2 Mass Balancing

In this approach, biomethane is traded along with the biogas certificate throughout the value chain from production (injection point into the gas grid) to final use (e.g. connection point at the gas grid of a final user who operates a combined heat and power (CHP) unit). Hence, the traceability of each kWh of biomethane from production to extraction from the natural gas grid is ensured by mass balancing. The amount of gas that the gas trader or consumer can use is limited by the amount of biogas that was added during the reporting period. Therefore, the purchaser or consumer must install a measurement system to withdraw the corresponding registered amount in the certificate[4].

For mass balancing, it is necessary that a theoretical pipeline connection between the purchaser and the producer exists.

1.1.3 General Key Data

According to the prevailing practice in some European countries, feed-in-tariffs or feed-in-premiums are paid to the producer of biomethane upon injection into the domestic natural gas grid under the assumption that the product will be consumed in the same country. In some other countries, there are incentives like tax reductions for the final consumers of biomethane, which allow sufficient payment of biomethane production costs to the producers.

Generally, the feed-in-tariffs or feed-in-premiums are paid by government agencies or by bodies mandated by the government. As a consequence, the rights of use of the product are transferred from the producer to the designated government body or government agency. This means that – after having injected the biomethane into the national natural gas system – the producer will have no

[3] (Vertogas, 2022b)

[4] (dena biogasregister, 2019)

rights of use of the product and will not be entitled to a GoO representing the volume covered by the feed-in tariff or feed-in-premium.

Presently, no European government, excluding Denmark, is offering feed-in-tariffs or feed-in-premiums for exported biomethane consignments. This means that the producer of biomethane must decide:

- Whether he/she wishes to take advantage of the domestic financial support (provided to the unit of energy – biomethane) and correspondingly does not export the product
- or his/her biomethane consignment is designated for export and (as such) does not receive financial support at home.

1.2 How biogas certificates create value

With the exception of the current gas crisis in Europe 2022, biomethane production costs typically exceeded prices for natural gas in Europe – at least at locations, where a natural gas grid existed and a physical connection to the gas grid was possible. Typical natural gas prices were in the range of 15 – 25 €/MWh for industrial customers compared to 60 – 80 €/MWh production cost for biomethane. The added value of biomethane is mainly its green nature (renewable; low CO_2 intensity) and its contribution to reducing the import dependency for natural gas.

In the member states of the European Union different models were developed in order to give the added value of biomethane a corresponding financial value. Some countries opted for governmentally guaranteed feed-in-tariffs, which compensate for at least the production cost of biomethane (France, UK, Italy, Luxembourg, Denmark).

Sweden guarantees tax exemptions for the use of biomethane, which also compensate for the high production costs.

Germany – in parallel to a certificate model – defined high feed-in-tariffs for electricity production from biomethane. In this case, the high price for electricity covers the cost for biomethane as fuel for CHP units.

Additionally, in many countries, limited amounts of biomethane are sold to consumers at a higher price, which covers the production and trading costs. This is, however, voluntary and only works with consumers who are willing to accept the higher cost for a low-emission product. In many cases, they are motivated by the market (e.g. that selling their products requires proof of low CO_2-emission impact) or forced by governmental regulations (e.g. that they must certify low CO_2-emissions for heating their buildings).

Some countries use models where biogas certificates do play a major role in financing the cost difference between natural gas and biomethane (Germany, The Netherlands, UK). Typically, there are two price components for biomethane:

Price component 1: Biomethane is physically sold for the price of natural gas – this price component is bound to the natural gas price level and in the past covered around 20-40% of the biomethane cost.

Price component 2: When biomethane is used, it substitutes a fossil fuel. With this substitution, greenhouse gas emissions (GHG) are saved. Biomethane can be used for fuelling vehicles, heating, industrial use (chemical industry) or in CHP units for electricity and heat production. The certificates are issued for this greenhouse gas reduction, which has a corresponding real greenhouse gas emission reduction value or a standardised general value. In countries where biogas certification systems have been established, governmental obligations for GHG reduction in the heating sector (UK) or vehicle fuels sector (UK, NL, D) are in place. If the obligations are not fulfilled, market participants must pay a fine to the respective governmental body. Market participants who do not manage to achieve a GHG reduction by internal measures (e.g., use of biomethane or other renewable energies) have to prove to the government that they have reduced GHG reduction outside of their own activities. To do that, they can purchase GHG reduction certificates (such as biogas certificates) from other market participants that have exceeded their own obligations or only intended to produce certificates.

Based on the detailed definition of the national system, the practical applicability and financial incentives resulting from the system depend on the following:

- Politically set targets: Which measures can be applied and what are the hurdles to achieving these targets? It is expected that the achievement of targets through biogas certificates will lead to a higher demand for certificates on the market. As long as there is no surplus of certificates on the market, the price of the certificate will rise. Therefore, increasing targets year by year is a good prerequisite for a real market and interesting pricing. The targets must be set far in advance (> 5 years) so that a reliable basis for investments in new biomethane facilities is given.
- Definition of certificate trading procedures: Mechanisms must be transparent for all market participants and must not change by time. Clear calculation of the GHG value and the market value of the certificates must be possible. There should be as few as possible exemptions for groups of market participants.
- A defined, transparent and practically working control mechanism must be established – a governmental body or certification bodies with governmental allowance should be responsible for issuing certificates. A doublecheck mechanism should be established with a second review body to avoid misuse. One central body should have the knowledge and overview of all issued and sold certificates to avoid double counting of certificates.

To avoid double counting or other infringements to the regulations, fines and penalties must be defined in case the governmental targets are not fulfilled. The cost of penalty must assure that buying certificates is financially more attractive than the payment of penalty.

Prior to introducing several national schemes and registries, we provide a short overview of one European solution for biomethane certificate trading, the European Renewable Gas Registry (ERGaR) in the following.

ERGaR was founded with the aim of establishing a European market and trading place for biomethane and green gas certificates. ERGaR is developing an independent and transparent documentation scheme for the mass balancing of biomethane and other green gases. This will allow a secure cross-border transfer of sustainable certificates (Certificates of Origin, CoO). The following national registries are approved as system participants:

- Vertogas
- Green Gas Certification Scheme by the Renewable Energy Assurance Limited
- Biomethane Register
- dena Biogas Register.

Presenting some statistics of the ERGaR Scheme, it is noteable that the transferred amount in the first (433 GWh) and second quarter of 2022 (148.857 GWh) is much higher than in the fourth quarter of 2021 (30 GWh)[5] due to gas shortage in Europe.

Higher demand for green gas and certificates requires a platform with harmonised European standards.

2. Biomethane certificate trading system in the United Kingdom

In the United Kingdom (UK), gas providers who can prove that at least 95% of the gas they provide is biomethane using green gas certificates from a recognized certification programme are exempt from the Green Gas Levy (GGL). The green gas levy is a quarterly tax which is imposed on fossil fuel gas suppliers. Suppliers are required to pay according to the number of meters they provide for. With effect from 30 November 2021, the following biomethane certification programmes are authorised for use with the Green Gas Levy exemption mechanism[6]:

- **The Green Gas Certification Scheme (GGCS)**, run by Renewable Energy Assurance Ltd.
- **The Biomethane Certification Scheme (BMCS)**, run by Green Gas Trading Ltd.

Each company provides its own registry, whereby GGCS issues the Renewable Gas Guarantees of Origin(RGGOs)[7] for around 80% of all the biomethane that is injected into the UK gas grid.

[5] (ERGaR, 2022)

[6] (gov.uk, 2021)

[7] (Renewable Energy Assurance Limited, 2022)

To avoid double counting, there is a 'Memorandum of Understanding' between the two registries that was put in place in February 2020 to prevent plants that produce on both schemes from double counting their produced green gas units. One scheme may interact with the other scheme on a monthly, quarterly, or yearly basis regarding plants which are registered on both schemes.

2.1. Green Gas Certification Scheme (GGCS)

Renewable Gas Guarantees of Origin (RGGOs) are unique identifiers, issued, transferred, and retired by the GGCS within this registry. RGGOs are issued to green gas producers for each unit of kWh of green gas injected into the gas grid, which displace units of fossil gas. The GGCS ensures the issuance of one RGGO per injected unit, secure transfer, and the allocation to one final consumer. The GGCS is run by the private company Renewable Energy Assurance Ltd., which carries out a range of certification and consumer protection activities, all of which promote renewable energy and a circular economy.

Government support is available to biomethane producers for injecting biomethane in the form of a feed-in-tariff known as the Renewable Heat Incentive (RHI). The Office for Gas and Electricity Markets (Ofgem) administers the RHI, which is funded by general taxes. For the benefit of the scheme and its members, the GGCS incorporates its procedures into the RHI's compliance procedures.

For every kWh of biomethane that a producer injects and registers, the GGCS issues a RGGO. Each kWh is given a special identification number that contains details on the technology used, the feedstock type, the production location, and the injection time.

Producers are required to show that the biomethane injected complies with the scheme's definition of green gas, which is to:

a) be a gas produced from a renewable source, the production and consumption of which have lower GHG emissions than an equivalent fossil fuel product; and

b) have complied with the quality standards of the distribution network into which the gas was injected. These standards, which include details on gas contents and characteristics, are outlined in the Gas Safety (Management) Regulations 1996 for injection into Gas Distribution Network (GDN) and National Transmission System (NTS).

The RGGOs can be transferred into trading accounts within the GGCS registry. From there, RGGOs can be distributed to gas customers or retired from the system and transferred between trading accounts.

The Greenhouse Gas Protocol's Quality Criteria for contractual instruments have been demonstrated to be met by RGGOs issued by the GGCS, making them a trustworthy data source when employing the market-based method for emission reporting.

2.2. Biomethane Certification Scheme (BMCS)[8]

The Green Gas Trading Limited (GGT), a private limited corporation, operates the Biomethane Certification Scheme (BMCS), which is an independent certification scheme (ICS). Green Gas Trading was founded to offer a reliable certification procedure for biomethane as well as a platform for trading certificates. The core idea is to provide a platform to certify, track trade and consume the "green" value of the biomethane. The BMCS certifies grid injected biomethane, but also liquefied or compressed gas for use as a transport fuel. l.

2.2.1 Main objectives

The BMCS was designed in compliance with the European Energy Certification Scheme (EECS) standard, which is administered by the Association of Issuing Bodies (AIB). The certificates also align with the requirements outlined in Article 19 (7) of the revised RED II directive. The BMCS certifies all data that is required for this standard, and its registry is provided by the largest provider of EECS certificates in Europe, Grexel.

[8] (Green Gas Trading, 2021)

The GGT's rationale and the basis for creating the system is that the biomethane producer should receive additional "green" value for its particularly low-carbon output. In monetising the green value of its gas, GGT also believes that the biomethane producer should not be forced to become a price taker. By separating the feedstock product (methane) from the certificate, the producer can move from being a price taker to a price maker. If buyers are only interested in the "green" value, the separation may result in a higher profit for the producer compared to the GGCS scheme. Thus, whether the producer in the GGCS scheme is a price taker depends on the demand for the energy value and/or the green value of the biomethane. This is due to the connection of the RGGO to the injected and traded amount of green gas (GGCS). The system also aims to offer all participants who can acquire shares the opportunity to become owners of the programme, a user-friendly platform with affordable prices.

The Biomethane Certificates (BMC) can be traded separately from the physical commodity gas. This allows the certificate owner to transact with the physical commodity on the market at the price for that product while seeking the highest economic value for their BMC.

2.2.2 Certification[9]

Since there is a greater focus on the biomethane certificates at BMCS, the point of certification is explained in more detail here than for the GGCS scheme. A certificate is created at each point in the process of the certificate lifecycle, which has three phases:

a) Allocation (issue),
b) Transfer, and
c) Notification (cancellation/ retirement).

The allocation certificates are automatically generated by Grexel and represent the point of production. Grexel also automatically generates a certificate for each and every transfer so that the path of the green gas can be followed. The final certificate is generated when the green gas reaches its end user and is cancelled or retired.

For the purposes of certifying specific quantities of biomethane under the scheme and verifying the output of the relevant production device, companies rely on production data. The production data is comprised of:

- Production Volume Data:
  The volume and calorific value (CV[5]) of the injected biomethane is recorded. If the CV of the produced biomethane is more than 2% lower (Regulation: DVGW G685) than the CV of the gas in the receiving gas grid, a technique has to be installed to even track the CV in the grid (software or measurement system) or add propane to raise the CV of the biomethane. The added propane is also recorded in the production volume data.
- Incentive Feedstock Data:
  Consists of the types and proportions of the used feedstock and its GHG emissions.
- Average GHG Figure:
  Represents the weighted average GHG emission for a period of production, based on the contribution of each feedstock to the overall energy generated.

a) Issuance

To generate RGGOs, producers (who must also be a scheme member) must submit a claim to the scheme operator containing valid and complete production data and a certified copy of the relevant incentive return, unless stated otherwise by the scheme.

Upon receipt of valid and complete production data and a certified copy of the relevant incentive mechanism return, Green Gas Trading calculates the amount of RGGOs that are to be allocated and issues them accordingly. This act of first allocation of RGGOs requires the producer to pay the certification fee to the scheme operator.

Biomethane that has not made a declaration or submission for payment under a government incentive can still be eligible for RGGOs. To be considered in these circumstances, it is required to supply all or part of the required information that Green Gas Trading requests.

[9] (Green Gas Trading, 2021b)

b) Transfer

The producer can select for the RGGOs to be allocated directly to the account of another scheme member, to a third party who is not a scheme member, or to its own account. The transfer of certificates allows them to be passed to intermediaries before being sold to the final customer and end user.

The RGGOs can only be held and be transferred by the scheme member. However, scheme members may act on behalf of third-party beneficial owners. Any scheme member who issues a transfer request is liable for transfer fees, if applicable.

c) Notification: Retiring/Cancellation

By submitting a notification request, any scheme member may request that an end user certificate is issued to any end user (including itself). Green Gas Trading then will issue the End User Certificate to the beneficial owner. The relevant scheme member is liable for the end user certificate fee.

3. Biogas certificate trading systems in The Netherlands

Certification and trade of green gas in the Netherlands is based on the basic ideas explained in chapter 1 of this report and can be attached to the book and claim method. Vertogas is the most relevant platform for trade in green gas in the Netherlands. It is an independent institute mandated by the Dutch Ministry of Economic Affairs and Climate. The most relevant information is explained in the following.

Vertogas[10]

Vertogas facilitates green gas trading with its certificate system. It guarantees the origin of the gas for every certificate issued. Therefore, a solid basis for a biomethane market and investment in production is available.

The execution of GoOs for electricity from renewable energy sources has been governed by a ministerial rule ("MR GvO"). Gas used in MR GvO is biomethane and bio-hydrogen gas, both of which are sources of renewable energy.

Producers

In order to be eligible for green gas certificates, biogas producers must be registered as a producer with Vertogas. The facility must also be approved by the network operator. A registered producer can then register one or more production facilities that have to meet certain requirements.

Issuance of the Guarantee of Origin (GoO)

The GoO displays confirmed information about the precise origin of the green gas, such as:

- The amount of energy injected per type of biomass utilized
- Information about the producer, location, installation, production month, and biomass mix
- Information on the sustainability of the biomass used and the reduction of CO_2 emissions

Transferring and cancelling GoOs :

In the Vertogas system, the trader has to be registered and own an account. Parallel to a sales contract, GoOs must be electronically transferred from the producer to the buyer. The system allows the transfer of GoOs between GoO account holders. Traders can agree with producers that the production will be allocated to the trader's account. The conditions of this agreement are a matter of the two involved parties. Vertogas holds the respective accounts, but has no influence over this process.

In the last step, a trader orders the delivery of a quantity of gas to the end user. Specifying the purpose of the use of the number of certificates, the certificates are cancelled and debited from the trader's account. The cancellation of GoOs serves as evidence of the delivery of the green gas.

[10] (Vertogas, 2022)

4. Biogas certificate trading systems in Germany

In Germany, multiple biogas registers are used to track the streams of renewable and certified biomethane apart from the streams of fossil natural gas. Their primary responsibility is to monitor biomethane levels (using the mass balancing approach), which enables a nearly independent conveyance in the gas grid and prevents the sale of biomethane at two different times. The German Biogas Registry (Biogasregister), run by the German Energy Agency (dena), is the most significant registry for biomethane (www.biogasregister.de) and biomethane certification. The usage of the Nabisy registry, operated by the Federal Office for Agriculture and Food (BLE), is mandatory for the certification of sustainable biofuels (transport fuel obligation).

In Germany, both biomethane certificate trading principles, mass-balancing and book and claim, are being applied (compare chapter 1.1).

For mass balancing, it is necessary that a theoretical pipeline connection between the purchaser and the producer exists. Due to the nationwide installed gas network, the mass-balancing approach is the most commonly applied method. It represents an even more sophisticated method of verifying green properties.

In general, there are no stipulations that a specific mass balancing system or book and claim system must be used. The producer and the purchaser of the gas have to agree to use a system which fulfils the governmental requirements or to use their own system. Requirements for such systems are clearly defined and vary depending on the markets:

- heat based on the GEG (Gebäude-Energie-Gesetz - Building Energy Law) - mass balancing required, no requirements regarding substrates and technologies;
- electricity based on the EEG (Erneuerbare-Energien-Gesetz – Renewable Energy Act) – mass balancing and production within Germany required, very detailed requirements regarding substrates and technologies;
- vehicle fuel based on laws for GHG reduction in the vehicle fuel sector - mass balancing and production within Germany required, very detailed requirements regarding substrates but not related to technologies;
- market for customers who voluntarily use biomethane – requirements depend on individual customer expectations.

The most common used mass balancing system in Germany is the Biogasregister. There are alternative private registers but they have little significance on the market. The Biogasregister is used for biomethane in the heat, electricity and voluntary market. Only when biomethane is intended to be used as vehicle fuel, there is an obligation to use the Nabisy system.

4.1 Biogasregister

In 2009, dena and the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety worked together to establish the biogas register in Germany. It started operations in 2010. The concept behind the register was developed in discussion with traders and political and economic specialists. 14 leading biogas and energy corporations have been supporting the register from the beginning. The Biogasregister Germany is a platform for standardised and simple documentation of evidence of biogas quantities and qualities in the natural gas grid. The Biogas Register Germany documents evidence of the use of biogas, in particular for the following:

- Electricity and heat production (regulated in the EEG)
- Heat production (regulated in the GEG)

4.1.1 Functionality

The gas grid operator tracks the biomethane that is supplied to the natural gas grid. The quantity, property profile, and origin of the biomethane included in the register are verified by an environmental auditor or expert who visits the plant and production on site on a yearly basis (see table 1 for detailed information)[11].

[11] (dena biogasregister, 2022)

Figure 1. Overview of biogas register work (Source: biogasregister)

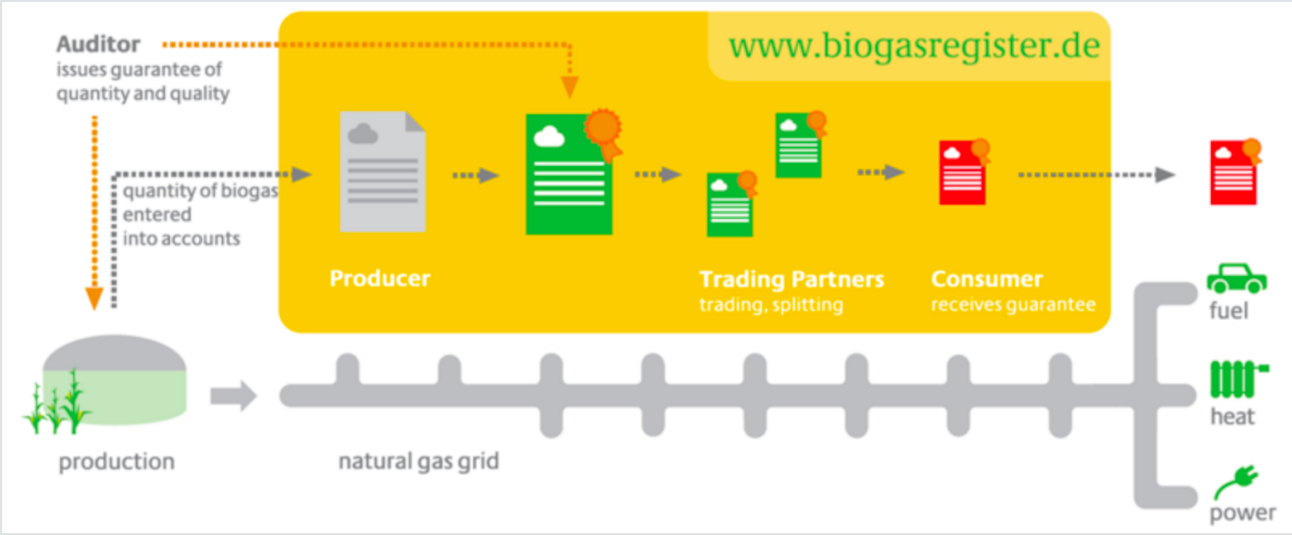

Table 1. Data to be confirmed by the registered auditor

Proof of origin	Proof of quantity	Proof of properties
- Plant names/address - Injection point - Meter number - Year of commissioning - Company ownership - Time from which the audit is valid	- Production facility - Audit client -Production period for each batch confirmed in the audit report - Injection point und meter number - Injected quantity of each batch confirmed in the audit report	- Satisfaction of the verification criteria based on their definition in the criteria catalogue and the statutory bases defined therein

The biogas register cannot be used until an environmental expert has completed a plant audit. This helps achieve a biomethane supply that is compliant with the standards based on various parameters. If all conditions have been satisfied, the biomethane producer can start entering biomethane volumes into the biogas registry.

To check the quantity and quality of the biomethane, another audit is conducted, usually covering the annual biomethane quantities produced by the facility. The report is uploaded to the biogas register and checked by the dena register administration for consistency against the data entered by the biomethane producers. By entering the consumer's information in the biogas register and generating the register extract, the biomethane can be used after receiving dena clearance. This provides the final user with trustworthy and verifiable proof of the received biomethane.

According to the supply chain, producers and intermediaries transfer the purchased amounts of biomethane to the accounts of other registry participants. The user, either alone or with the assistance of his supplier, extracts the biomethane from the natural gas grid and reports the relevant amount from the register. The transfer is completed with confirmation from the buyer and the corresponding identification code in the registry. The customer receives a certificate from the registry when the biomethane is withdrawn, indicating the quantity consumed along with its origin, property profile, and feed-in and withdrawal details. The certificate describes the volume and attributes of the injected biomethane.

A certificate must first be cancelled[12] in the biomethane registry before it can be used for the end user. The same certificate cannot be traded again after cancellation. In the effort to build trust and integrity in the market, this process is crucial.

The registry administrator states that the facility operator is free to market the biomethane separately from the physical quantity or together with the certificate. The price for the actual gas quantity is left up to the participants to decide, the administrator has no authority in the matter. The price is also neither recorded nor displayed in the registry. Biomethane producers can earn their money through making a deal with gas traders, through energy suppliers or directly with the consumer.

4.1.2 Statements issued by the German Biogas Registry

Two categories of biogas registry statements (origin and purpose) are issued by the German biogas register:

- Biogas registry statement on the biogas delivery (mass balancing)
- Biogas registry statement on the biogas Guarantee of Origin (without mass balancing)

In the first case, the amount of biogas will be supplied from the plant to the consumer, together with any documentation of rights transfers within the natural gas network. As a result, the German design for mass balance is met. In the second case, the gas property is transported separately from the other biogenic qualities. Upon arrival at the consumer, the properties are reconnected. The mass balancing terms are no longer satisfied in this situation.

Content of biogas registry statements

The registry statement includes a summary of all relevant details, particularly the following information:

Part 1: Production and injection information. The first section reproduces the documented facility and injection data, which includes the following information:

- The location of the biogas production facility, including commissioning.
- The time of injection and injection point.

These statistics come from facility and operation audits. The biogas quantity is the amount used, not the amount created.

Part 2: The documented criteria from the criteria catalogue (biomethane quality) which follows a listing of the criteria from the German biogas registry. These standards indicate the quality of the biomethane. The criteria catalogue specifically sets out expectations by the German legal system.

Part 3: This section documents how the company uses biomethane, particularly who the recipient of the gas and the relevant GoO certificates is.

Biomethane producer

The biomethane plant operator/producer typically sends operational data to the register. The registry, where certificates are issued in accordance with the physical injection of biomethane into the natural gas grid, comprises accounts for each plant operator.

Through the account system of the registry, the produced biomethane volume can be separated into more than one certificate to be passed along (1 certificate ≥ 1 MWh in size).

One or more plants may be operated by a biomethane producer; hence it must be feasible to register each plant independently and attach it to an account. Certificates are produced on the producer account's credit side.

[12] The final use of biomethane/renewable gas requires a confirmation to the end consumer that the amount biomethane/renewable has been explicitly used for that end consumer and that no double counting (multiple usage) occurred. Therefore, the biomethane/renewable gas owner must cancel the certificate in the biomethane registry.

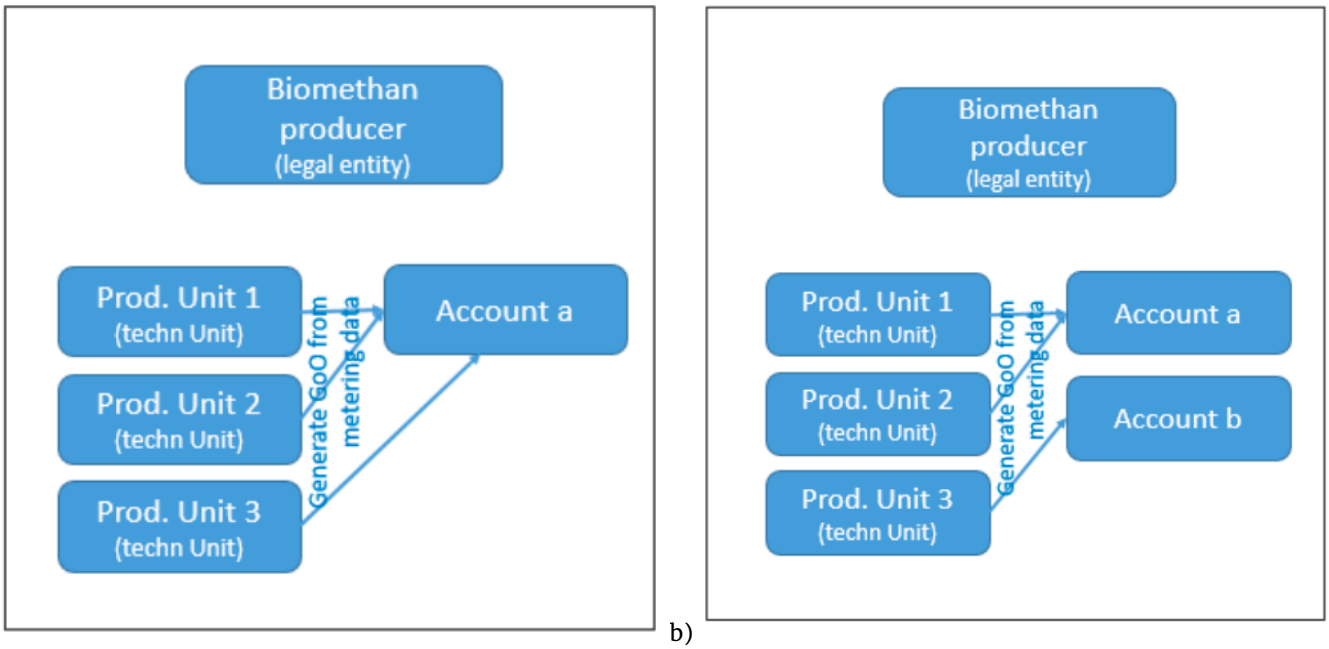

Figure 2. Three biomethane production plants are linked into a) one account and b) separate accounts

Figure 2a illustrates one account and three production facilities. In this instance, the plant operator chose this configuration because he wanted all injections to be recorded on one account. The amount of biomethane that each plant injects into the grid determines the amount of certificates being produced. Each certificate contains information about its production facility as well as an authorised auditor expert statement. As shown in Figure 2b, the plant operator can choose which production plants will be assigned to which one of the two accounts as it is essential to give plant operators options and liberties on how to arrange their certificates in the registry.

4.2 Nabisy[13]

Nabisy, the governmental sustainable biomass system web application (Nachhaltige Biomasse System), operated by the Federal Office for Agriculture and Food (BLE), serves to prove the sustainability of bioliquids and/or liquid or gaseous fuels from biomass, in line with the EU Directive 2009/28/EC. According to the Nabisy registry liquid or gaseous fuel from waste, residues, cellulosic non-food-material and lignocellulosic material have priority according to RED I and II, which received additional subvention in the form of multiple counting of the GHG savings for the respective incentive system. Nabisy records the multiple counting.[14]

The Nabisy system is obligatory when biomethane is intended to be used as biofuel in Germany. The system itself works similar to the Biogasregister regarding the registration of produced biomethane amounts, transferring them to a trader or final consumer, and the certification process. The main difference is that in addition to the biomethane quality and production numbers, the GHG emissions connected with the production of biomethane must be registered and certified. Therefore, producers can work with standardised figures for GHG emissions from biomethane production, or they can provide an individual GHG calculation for the entire biogas plant. The latter typically results in better GHG values for the biomethane than using the standard values.

[13] (BLE: Nabisy, 2022)

[14] (ETIP Bioenergy, 2022)

5. Financial basis for the German biomethane trading systems

There are several support schemes to incentivise the production and utilization of biomethane in Germany. All of them are indirect, as there is no direct subsidy in place. The following chapter introduces these indirect instruments.

5.1 Heating market and voluntary market

If the biomethane is sold into the heating market or voluntary market, the end user pays directly for the specific consumed amount of energy/biomethane. The price is determined by the market and depends on the willingness of the consumer to pay a (usually) higher price for biomethane compared to natural gas. This price used to be higher than the price of fossil natural gas, although this has changed recently due to the gas crisis in Europe.

In the building sector, the building energy act (GEG) creates an indirect incentive for the consumption of biomethane: The GEG obliges heat network operators to produce heat more sustainable and lower their primary energy factor of the distributed heat. Producing heat using biomethane is one way to lower the primary energy factor. This law hence indirectly supports the development of the biomethane market, without additional subsidy payments.

5.2 Biomethane in the electricity sector enforced by the Renewable Energy Act (EEG)

In the year 2000 the EEG came into force and since ensures a 20-year granted feed-in tariff/premium for electricity produced from renewable energy sources (biomass, solar power, hydro power, geothermal power or wind energy).

The general support mechanism works according to the following principle: Based on the measured kWh injected into the electricity grid, a feed-in premium is granted to the operator of the plant. The direct payments to the plant operators are made by the grid operators themselves. These payments are shared equally among all electricity consumers. In the past, the relatively high premium payments for biomethane-based electricity allowed for a viable business model for biomethane production (s. figure 3).

In the case of the EEG, the strong growth in renewable energy plants has caused this levy to rise and thus to become a substantial part of the energy bill. Hence, to reduce the burden on electricity consumers, the legislator has since repeatedly adjusted the premium payments downward. While the EEG was a considerable driver for the strong growth of biomethane production in the past, today's plant owners need to find more complex business models to ensure profitable plant operation (s. examples given in chapter 6).

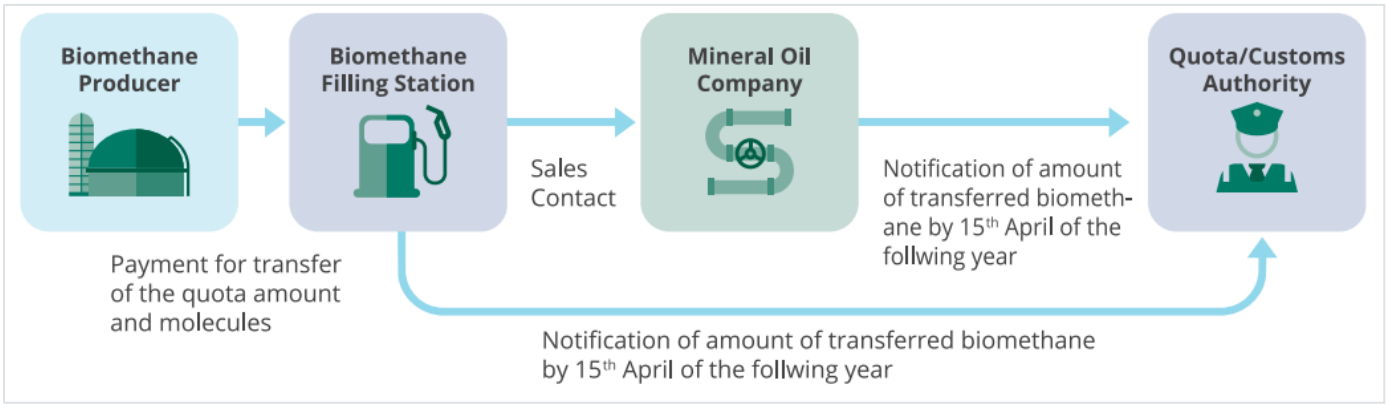

Figure 3: Biomethane and money flow within the EEG market (Source: Fachverband Biogas)

5.3 Transportation sector

The German biofuels quota (as regulated in the Federal Immission Control Act, BImSchG) requires all companies selling engine fuels to reduce GHG emissions. This is mainly done by including renewable fuels such as biodiesel, bioethanol and biomethane on the market. The regulation transposes European legislation into German law and allows recognition of biomethane as fuel for compressed natural gas (CNG) vehicles. The quota system is designed in a market-based approach: Companies producing renewable fuels receive a quota credit for each volume of fuel produced. Mineral oil companies selling engine fuel need to obtain quota credits in the defined quota of their fuel sales. The market for quota credit works as described in Figure 4 and 5.

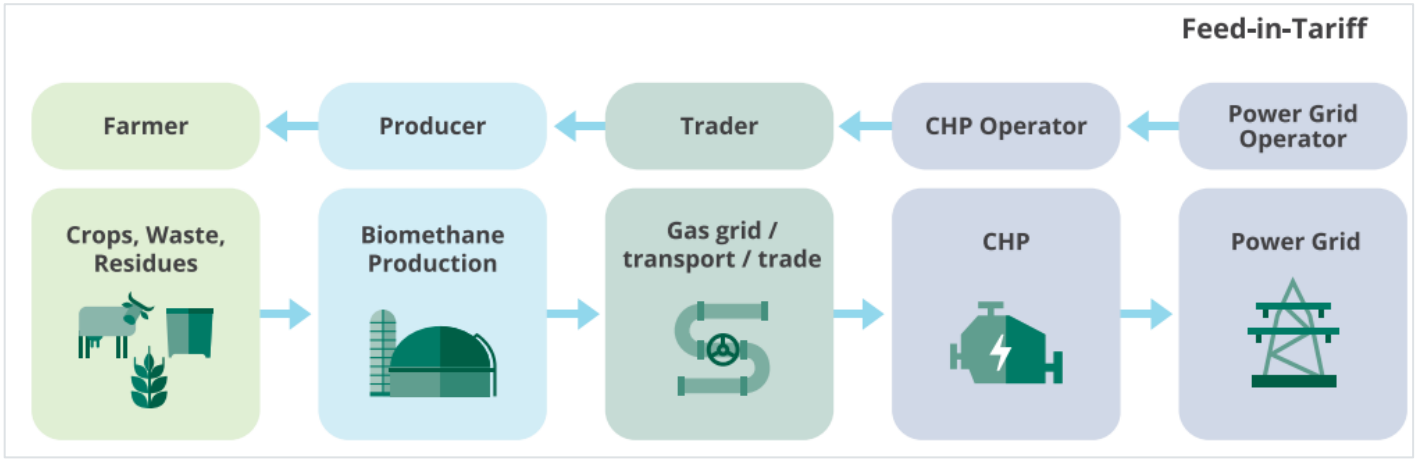

Figure 4: Biomethane and money flow within the transportation sector (Source: Fachverband Biogas)

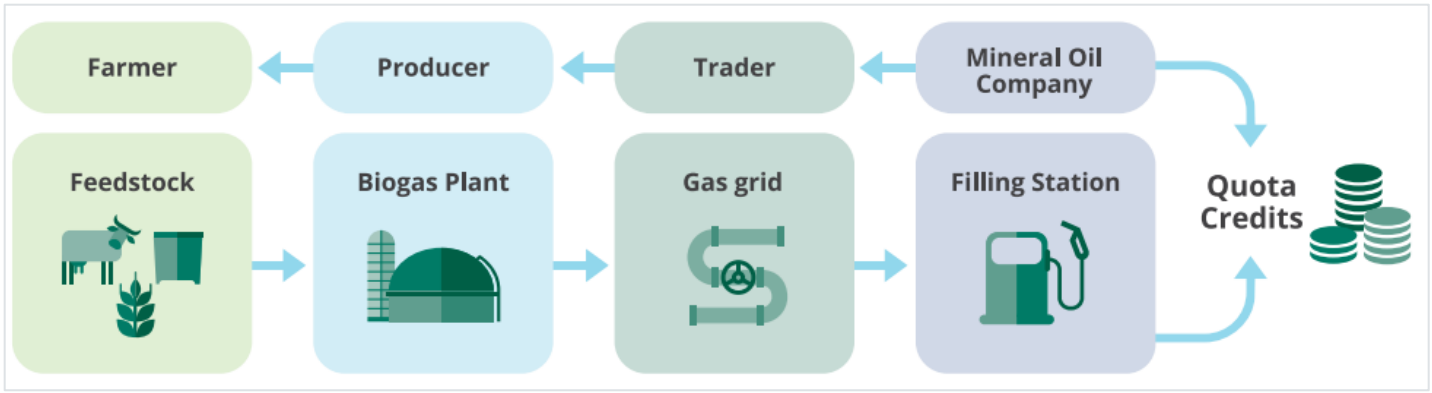

Figure 5: Overview quota system (Source: Fachverband Biogas)

Operators of filling stations certify their sold amounts of biofuels (e.g. biomethane) to the customs authority and receive quota credits for the GHG savings associated with it. Then they can transfer/sell their credits to mineral oil companies who must present these credits to the same authority in their annual reporting obligation. They are obliged to show a minimum amount of GHG quota. In relation to the sold fuel, they must show a GHG reduction of 6 %, which will increase to 25 % by 2030. If a company fails to achieve the minimum GHG reduction, they have to pay a fine of 600 € for each ton of CO_2 not reduced. This value determines the market price for GHG quota credits, which is currently at a level of 500 €/t CO_2 reduced – mainly due to a lack of biofuels on the market.

The German regulations include a calculation of the amount of quota credits granted. The quota credits are granted in relation to the GHG savings, which means that a fuel with higher GHG savings achieves a higher quota and therefore a higher price on the market. The calculation of GHG emissions savings (in relation to fossil fuel) is determined by a life cycle analysis of the production path. In addition to the general biofuel quota, a "sub-quota" for advanced biofuels with special provisions needs to be fulfilled. Biomethane from waste and residue materials (e.g., wet and dry manure or straw) are eligible as an advanced biofuel and thus achieve increased accounting (multiple accounting as mentioned above) of quota credits.

Figure 6 shows average GHG savings per biofuel type as reported by the German registry for sustainable biomass and the threshold values based on the date production in a plant started (green dotted lines). Threshold values mark the minimum GHG savings which must be achieved with the fuel produced from a biofuel production plant compared to the standard emission value for fossil fuels given by law in the Renewable Energy Directive (RED). Rising threshold values (50%-65% GHG reduction) show how GHG savings from biofuel production need to be further reduced in the future. Biofuels below this threshold are not eligible as biofuels. In comparison with other biofuels, biomethane has a high GHG reduction rate. This advantage may increase the demand for biomethane in the transport sector in the future.

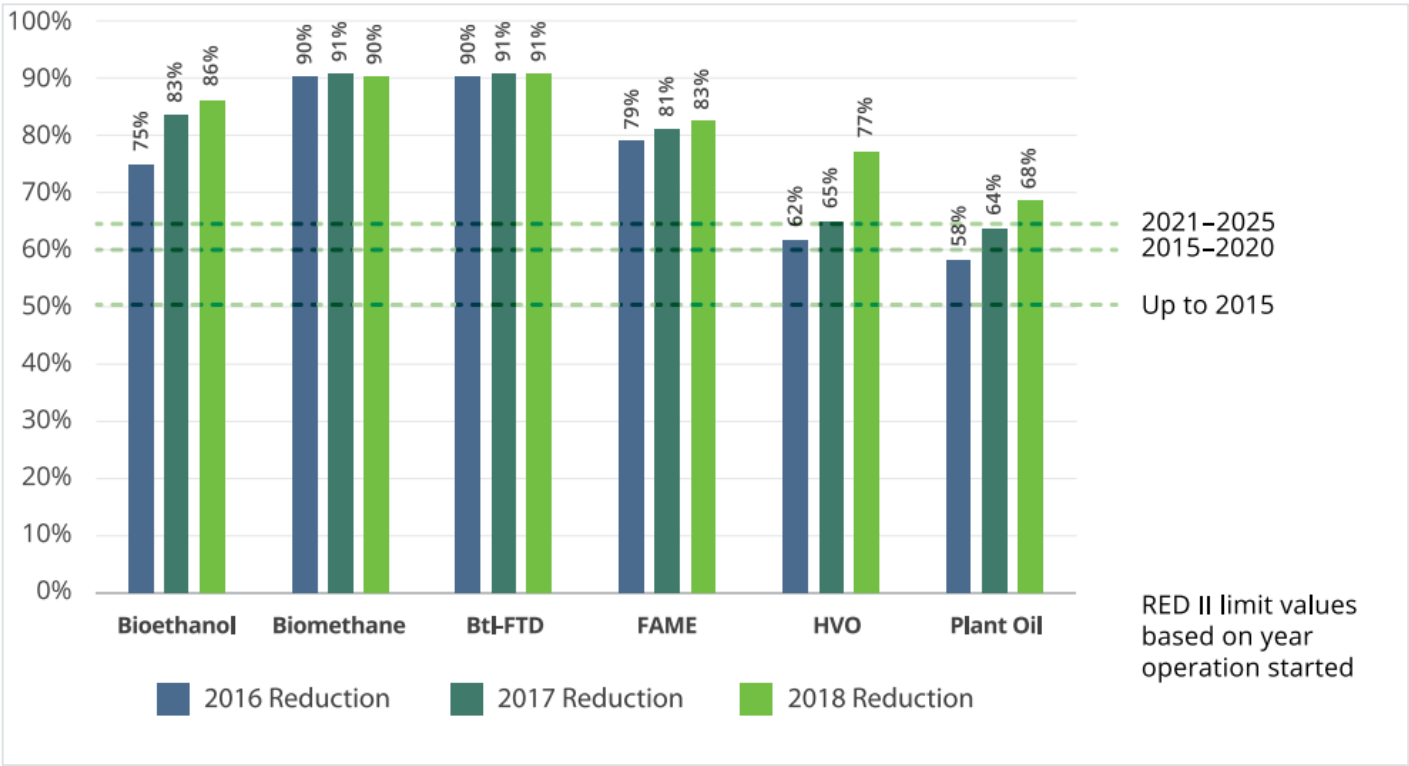

Figure 6: Emission reduction of biofuels according to fuel type (Source: BLE, 2019)

6. German case studies

In this chapter, three business cases are presented demonstrating three typical models for biomethane production and use in Germany. The first case is a plant that is operated by a municipal waste disposal company, whereas the second and third cases are agricultural plants operated by an agricultural cooperative and an investment company, respectively.

Waste plants – both for municipal household waste and wastewater – usually receive gate fees for the treated waste and are not solely dependent on the income from the gas production.

6.1 Biomethane plant of a municipal waste authority

Typically, organic waste is sourced and separated in households and collected in a separate organic waste bin in Germany. Hence, this waste can be recycled as organic fertiliser. There are around 150 organic waste digestion plants installed in Germany, one of which is shown here.

The municipal waste treatment company, which is 100% owned by the municipality, uses the biomethane produced from a part of the city's organic waste to fuel 150 of the city's waste collection vehicles. In practice, all of the biomethane is injected into the public gas grid at the biomethane plant and taken out at CNG filling stations, which are operated at the waste trucks' parking sites. Surpluses of biomethane are sold on the free market.

Table 2: Overview: Biomethane plant of a municipal waste authority

Year of commissioning	2012
Feed-in capacity (biomethane)	3,600,000 m³/a
Input substrates: Municipal organic waste	60,000 t/a
Solid digestate	19,000 t/a
Liquid digestate	30,000 t/a
Total investment	~ 30 Mio €
Advantages	
Readily available substrate Vertically integrated value chain from waste treatment to utilisation as vehicle fuel Strong national policy for GHG emission reduction in transport sector allows for stable income from selling GHG certificates Local gas grid access with guaranteed feed-in capacity	
Challenges	
Very limited space for the construction of plant facilities, resulting in strong limitation of hydraulic retention time Bureaucratic and long decision making due to municipal ownership of the plant Lack of local storage facility and availability of land for local application of digestate results in high transportation costs; therefore no additional biogas yield from digestate storage and extra investments in external storage capacity necessary	

Success criteria
Vertically integrated value chain results in low dependency on governmental fundings or third parties
Constant and secure biomass supply
Highly qualified staff

Figure 7: View of the waste digestion facility with biogas upgrading plant in the upper-left corner (Source: BSR)

The waste management company's business model relies on waste management fees that residents pay for waste collection. These fees cover the overall waste collection, treatment, and final disposal. In cases where gate fees for biowaste in Germany are paid at delivery to the plant, these fees range between 35-90 € per ton of wet waste, which accounts for an essential share of the plant's income.

This plant increases its income by replacing the diesel used in the waste collection trucks with biomethane. Around 2.5 million litres of diesel are substituted annually, resulting in an additional annual income of around 3 million € (as of 2021, the amount has almost doubled in 2022). Additionally, a greenhouse gas emission reduction quota is achieved by using the biomethane as vehicle fuel, which is based on an individual greenhouse gas emission calculation for the plant. The company sells this quota on the market, where the price for 1 ton of greenhouse gas emission reduction is around 350-500 €/t. This results in an additional income of around 3-4 million € per year. All in all, a price of around 15-18 €ct/kWh heating value is achieved compared to a biomethane production cost in the range of 6-7 €ct/kWh.

6.2 Agricultural biogas plant operated by a farming cooperative

The ownership at the biogas and biomethane plant is split between the farmers, who own and operate the biogas plant and CHP unit, and the regional gas utility company, which owns and operates the (biogas to biomethane) upgrading plant.

Substrates for the biogas plant are mainly derived from the farmers' own products as well as chicken manure from a local farmer and other external sources. About 50 % of the biogas produced is used for local electricity production with electricity grid feed, and about 50 % is used for upgrading and gas grid injection. The plant purchases its electricity demand for operation from the free market and receives a feed-in tariff for its electricity generation.

A part of the excess heat from the CHP unit (around 30-50 % depending on the season) is not sold, but rather used on-site for drying digestate, operating an ORC unit (which produces electricity out of heat) and providing the necessary heat to operate the amine scrubber for biogas upgrading.

The produced biogas is sold to a local gas utility company, which operates the upgrading plant located at the biogas plant – the point of transfer being on site. The gas is then injected into the natural gas grid and sold all over Germany.

Table 3: Overview: agricultural biogas plant

Year of commissioning	2010
Feed-in capacity (biomethane)	Approx. 6,000,000 m³/a (more biogas is produced for local CHP operation)
Input substrates:	
Energy crops	45,000 t/a
Pig manure	40,000 t/a
Chicken and cow manure	20,000 t/a
Digestate	Approx. 95,000 t/a
Total investment	~ 25 Mio €
Advantages	
Large farming area in private ownership for energy crops production	
Digestate application and access to residues from animal farming regionally	
Good partnership with operator of biogas upgrading units	
Installation of highly reliable technology with large flexibility for complicated substrates (e.g., straw)	
Large available area for plant construction and local gas grid access with guaranteed feed/in capacity	
Challenges	
Fluctuations in biomethane sales prices in the past	
Technical failures during operation with financial consequences	

Success criteria
Largely secure biomass supply
Guaranteed feed-in tariffs for electricity
Local gas grid access
Highly experienced staff and manager

Figure 8: View of the agricultural biomethane cooperative

Since a huge amount of energy crops is used in this plant, the main expense factor for operational costs is the purchase of energy crops, resulting in costs of around 1.7 – 1.9 million €/a. Additionally, the plant operator must cover the transportation cost of manure. This plants production cost of biomethane is in the range of 5.5-7 €ct/kWh.

This agricultural biogas plant generates revenue by generating electricity from raw biogas (about half of biogas production) for an electricity price of around 20 €ct/kWh. Additionally, biomethane is sold on the market in long-term contracts. Biomethane produced from energy crops is sold to customers who produce heat and electricity and pay around 7-8 €ct/kWh heating value for the gas. Biomethane produced from manure is sold to CNG filling station operators. They can demand high prices for the GHG reduction quota for biomethane used as fuel (biomethane from manure results in highest GHG reduction), with typical prices for biomethane from manure ranging between 18-20 €ct/kWh heating value, making the plant operation economically feasible.

6.3 Biomethane plant operated by an investor

This biomethane plant produces biogas out of energy crops, mainly maize silage, and sugar beet with some sugar beet residues. Locally, waste heat from a used-wood power plant close by provides the necessary heat for the biogas plant and the biogas upgrading. It supplies two CHP units with raw biogas located in the village to supply a swimming hall and a hospital with heat and electricity. Up to 2,000 m³/h raw biogas are upgraded to biomethane and injected into the locally available natural gas grid.

The main factor determining the operational costs is the purchase of energy crops, resulting in costs of around 3 – 3.5 million €/a. The production costs of biomethane for this plant are in the range of 5.5-6.5 €ct/kWh.

This plant generates revenue through electricity generation from raw biogas (about 30 % of biogas production) for an electricity price of around 20 €ct/kWh.

Thus, biomethane is sold to one customer, which operates the CHP units for heat and electricity supply in a 20-year contract. The biomethane produced is sold at a price of around 7-8.5 €ct/kWh heating value, depending on other statistical price factors.

Figure 9: Birds-eye view of the biomethane production plant

Table 4: Overview: biomethane plant operated by an investor

Year of commissioning	2010
Feed-in capacity (biomethane)	Up to 8,000,000 m³/a (more biogas is produced for local CHP operation)
Input substrates Energy crops	 80,000 t/a
Digestate	Approx. 65,000 t/a
Total investment	~ 18 Mio €

Advantages
Cooperation with local energy supplier who takes over all biomethane for own gas grid
Operation of two CHP units with raw biogas
Installation of highly reliable technology
Large digestate storage
Challenges
High dependency on delivery of energy crops
Success criteria
Inexpensive waste heat for upgrading unit (amine scrubber) available from used wood incineration plant
Guaranteed feed-in tariffs for electricity
Highly experienced staff and manager

Relevance of Europe's Experiences in Biomethane Certificates for China

Prior to the Russia-Ukraine conflict in 2022, the cost of biomethane was 2-3 times that of natural gas in Europe. The establishment of biomethane certificate trading systems since in countries such as Germany, the UK and the Netherlands created a win-win situation where they not only boosted the supply of green energy to society and thus facilitated the states' endeavor towards sustainable energy development, but also offered a way for biomethane companies to monetize the green value of biomethane. Experience in these countries can serve as a source of inspiration for the development of the biomethane sector in China.

1. China needs to establish a biomethane certification system in accordance with its national conditions. The UK has two interconnected biomethane certification systems, run by two private enterprises, i.e. Renewable Energy Assurance Ltd. and Green Gas Trading Ltd., respectively. In the Netherlands, the biomethane certificate trading system is an independent institute mandated by the Dutch Ministry of Economic Affairs and Climate. Germany has both biogas certificates and biomethane certificates. The biogas system run by the German Energy Agency (dena) is more sophisticated. Biogas certificates can be traded on the free market and can be used as a basis for producers to receive feed-in tariffs. Biomethane certificates issued by relevant agencies are mostly traded on the voluntary market. China's own biomethane certification system should aim at growing its biomethane industry and achieving targets for greenhouse gas reduction. It is suggested that such a certification platform and relevant systems be led by China's national industry authorities in coordination with third parties or industry associations where the government will act as the supervisor, with the third parties being responsible for the certification, promotion and operation, and broad-based participation from enterprises. The ultimate objective is to put into place a standardized, efficient, open and dynamic system for issuing and trading green biomass certificates.

2. A trustworthy and impartial platform should be developed with technological support that enables online monitoring. In Europe and the United States, green certificates are issued, promoted, run and supervised by a partnership among the government, social organizations and enterprises, and strict issuance processes and regulatory measures are in place to prevent double transactions and use. When promoting the biomethane certificate trading system in China, it is suggested that biogas producers be equipped with smart meters to collect key operational data, including the type and amount of feedstock, the production volume, the methane content and the volume of gas supplied. Data collected in real time will be transmitted to the online monitoring platform for accurate measurement of the amount of biomethane produced by each company. Such a system shall lay a solid foundation for the issuance of green certificates and ensure trustworthiness and fairness of the platform.

3. The value of biomethane certificates should be realized through multiple channels. Firstly, a pilot mandatory quota market mechanism can be explored. Many European countries combined the mandatory quota market and the voluntary market during the initial phase of promoting green certificates. Such experience can be replicated in China in the early stage of promoting green certificates. The initial quota can then be gradually increased until, after passing a certain threshold, the market is completely transformed into a voluntary market if conditions allow. Secondly, clear policies should be set to allow green certificates to offset fossil energy in calculating total energy consumption. At present, local governments are strictly bound by total energy consumption and energy intensity indicators in relation to economic development. Allowing green certificates to offset part of the total fossil energy consumption will serve as a strong incentive for the adoption of green certificates. Thirdly, green certificates should be allowed to offset carbon quotas. As a carbon-free energy source, biomethane enables convenient carbon reductions calculation. Interaction with the carbon emission trading system should be allowed so that biomethane certificates can be used for offsetting carbon quotas of enterprises, or in the voluntary carbon market (the China Certified Emission Reduction scheme, CCER)

to achieve carbon neutrality in the production and operation activities of enterprises or households. These measures will help realize the green value of biomethane and promote the sustainable growth of the industry.

4. Financial institutions should be guided to incorporate green certificates in their credit policies and ratings of enterprises. The economic value of green certificates will become more evident once they participate in carbon trade and total energy consumption substitution. Therefore, incentive policies should be formulated to stimulate development of diversified green financial products, rating systems, green certificate credit loans, investment and financing services, and financial derivatives. The use of green certificates for multi-channel financing will boost the development of the biomethane industry.

5. Organic waste-based biomethane should be prioritized when fostering supportive policies. Many European countries favor waste-based biogas and liquid fuels because of their greater potential and value for emission reduction. When promoting biomethane, China may draw on this experience, differentiating the feedstock by means of online monitoring and labelling the gas products accordingly. Biomethane produced from waste can be made eligible for double counting in fossil energy substitution, carbon reduction targets, quotas, etc. so as to drive differentiated waste utilization.

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