Overview and Categorization of European Biogas Technologies

- Biogas Storage -

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DiBiCoo – Digital Global Biogas Cooperation
Grant Agreement N°857804

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Executive Summary of D 2.2

The following document gives an overview of existing European biogas technologies.

The structure following the introduction section about Anaerobic Digestions (AD) follows the biogas processing logic: from feedstock storage on site and necessary pre-treatment to the various digester technologies. Special chapters on important elements of any biogas plant are elaborated in detail (e.g. on measurement, control and regulation technologies).

Upgrading biogas to biomethane quality as well as various application of Biogas are introduced (e.g. its GHG mitigation potential, as Combined Heat & Power (CHP) plants).

Due to the huge amount of existing information and knowledge on this topic it may occur that not everything is included or considered extensively. We propose this deliverable as a solid starting point getting to know about anaerobic digestion. This doesn´t replace special training courses and at least professional planning. In order to incorporate more relevant technologies and Biogas applications, some sections already outlined in this technology overview (e.g. on various pumps, pipes and valve types; or safety equipment) will be presented in an updated version later in October 2020.

The detailed descriptions of certain technologies are not implying any preference to a technology, service provider or device. Similarly, pictures including company names shall not be seen as a preference to any specific company or technology. It is done for visualization purposes only.

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Summary of the DiBiCoo Project

The **Digital Global Biogas Cooperation (DiBiCoo)** project is part of the EU’s Horizon 2020 Societal Challenge ‘Secure, clean and efficient energy’, under the call ‘Market Uptake Support’.

The target importing emerging and developing countries are Argentina, Ethiopia, Ghana, South Africa and Indonesia. Additionally, the project involves partners from Germany, Austria, Belgium and Latvia. The project started in October 2019 with a 33 months-timeline and a budget of 3 Million Euros. It is implemented by the consortium and coordinated by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

The overall objective of the project is to prepare markets in developing and emerging countries for the import of sustainable biogas/biomethane technologies from Europe. DiBiCoo aims to mutually benefit importing and exporting countries through facilitating dialogue between European biogas industries and biogas stakeholders or developers from emerging and developing markets. The consortium works to advance knowledge transfer and experience sharing to improve local policies that allow increased market uptake by target countries. This will be facilitated through a digital matchmaking platform and classical capacity development mechanisms for improved networking, information sharing, and technical/financial competences. Furthermore, DiBiCoo will identify five demo cases up to investment stages in the 5 importing countries. Thus, the project will help mitigate GHG emissions and increase the share of global renewable energy generation. The project also contributes to the UN Sustainable Development Goals (SDG 7) for ‘Affordable and clean energy”, among others.

Further information can be found on the DiBiCoo website: www.dibicoo.org.

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Content

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List of Abbreviations

AD	Anaerobic digestion
CHP	Combined Heat & Power
EU	European Union
MCR	Measurement, control and regulation technique

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1 Biogas Storage

Thanks to the scientific and technical developments during the last decades, professionally operated biogas plants often run very constantly at full load capacity. This is mainly when feedstock can be stored or will be delivered constantly and therefore can be fed to exact times when needed. Such biogas plants can reach full-load-hours above 8,000 h a^{-1}. When organic residues from households, caterers or other seasonally accruing feedstock are the main feedstock, then biogas production will vary according to the delivered feedstock. This is because the amount of organic waste from households differs between seasons and carbon rich effluent from sugar plants or biofuel plants occur only seasonally etc. Furthermore, biogas application might also follow consumer needs and might also be interrupted due to maintenance reasons etc. Additionally, at times when the gas consuming application is not working, e.g. in times of maintenance, the produced biogas must be stored. This partially occurring imbalance between biogas production and biogas application is usually balanced through special gas storage systems.

The size of the gas storage system differs significantly. For plants which can use the produced biogas without restrictions, the size of the biogas storage system covers often 3 up to 10-fold of hourly produced biogas[1].

As biogas is a very reliable and flexible energy source, the focus of attention shifted also to the application of biogas balancing the electricity grid. The idea arose that biogas could also help balancing the electricity grid by producing peak load electricity or control energy or by being applied over a specific time period. Although there has been some scientific work done in changing the biogas production within the digester corresponding to the consumer demand, in the end it became clear that it is better to run the digester constantly and to store the biogas in the periods where the electricity is not requested.

These systems usually have biogas storage systems that can store the produced biogas for one day or even longer. An important consequence is that the CHP then often has the double or even 3-fold electric capacity as it would have when operated constantly. In Germany for example, there are several thousand biogas plants offering flexible operation in which the CHP can be turned on (to produce electricity) or off (to store biogas) to balance power consumption with electricity generation at a level of some GW_{el}.

The most common biogas storage devices are different kinds of membranes (EPDM, PVC, etc.). Almost all of them are low-pressure systems running with few millibar overpressure (depending on manufacturer and system up to 50 mbar). These types of gas storage systems can be differentiated into:

- Low pressure systems (membranes)
  - Single membrane
    - As roof of the digester
      - Self-supporting through biogas pressure (with or without outer net to shape the maximum size)

[1] For example, a biogas plant with a size of 500 kW_e has a biogas production rate of about 250 m^3 per hour. If the biogas production of 6 hours shall be stored, e.g. during maintenance of the CHP, the capacity of the gas storage should be 1,500 m^3.

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- Suspended from a middle pile
- Incorporated in the roof of the digester and suspended it
- Separately in-house systems
- Double membrane
  - As roof of the digester
    - Inner membranes as gas membrane
    - Outer membrane as weatherproof cape
      - Suspended from a middle pile
      - Shaped with air by an external blower
  - Stand-alone systems
    - Inner membranes as gas membrane
    - Outer membrane as weatherproof cape (shaped with air by an external blower)

There are very different kinds of biogas membrane storage systems on the market. Each manufacturer has its special system. It must be considered that compared to steel or tight-concrete systems, membrane storage systems are not completely gas-tight. Therefore, technical guidelines set requirements on permeability, tearing strength, stability to weather and especially ultraviolet radiation and aging in order to limit gas emissions and to avoid leakage.

Table 1: Technical requirements for biogas storage membranes; © BMWFW, 2017.

Property	Requirement
Tearing strength	Min. 3 000 N $5cm^{-1}$ (if a membrane cannot fulfill this requirement itself it must be shaped by a net)
Permeability	Max. 1 000 ml m^{-2} $d^{-1}bar^{-1}$
Ultraviolet radiation stability	Declaration from the manufacturer on secure holding period

Picture 1: left: cross section of a model with single membrane; right: digester with single EPDM membrane

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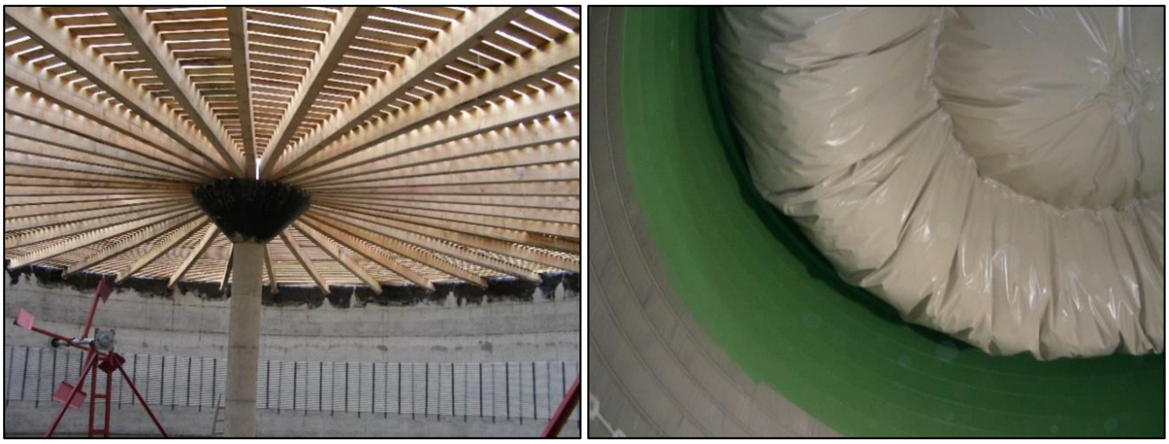

Picture 2: A view from the inside of a digester to the top, left: wooden roof under the gas membrane; right: gas membrane from the inside.

Picture 3: Single membrane gas storage in external housing.

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Picture 4: Left: double membrane with middle pole, right: digester with inner single membrane suspended from roof on the left and digester with double membrane shaped by air blower on the right.

Especially for double membrane storage systems, where the outer membrane is shaped through an air blower, the height of the outer membrane can be varied according to consumer needs. The stability against wind, weather and snow is done by the pressure of the air blower.

Picture 5: Stand-alone double membrane biogas storage systems shaped with air blower.

Each gas storage system also includes several safety devices in order to avoid over pressure, damage through lightning, damage through cars etc. These devices are already described in the chapter on MCR.

A special case that was commonly used in the past and is to some extent still used today is the wet gasometer. This technique was commonly used in European cities to store city gas. It is a tube filled with water in which another tube is put upside down. The gas circulates through a pipe from the bottom into the water filled tube and ends above water level. The pressure is given by the upper tube which raises during filling and lowers at demand.

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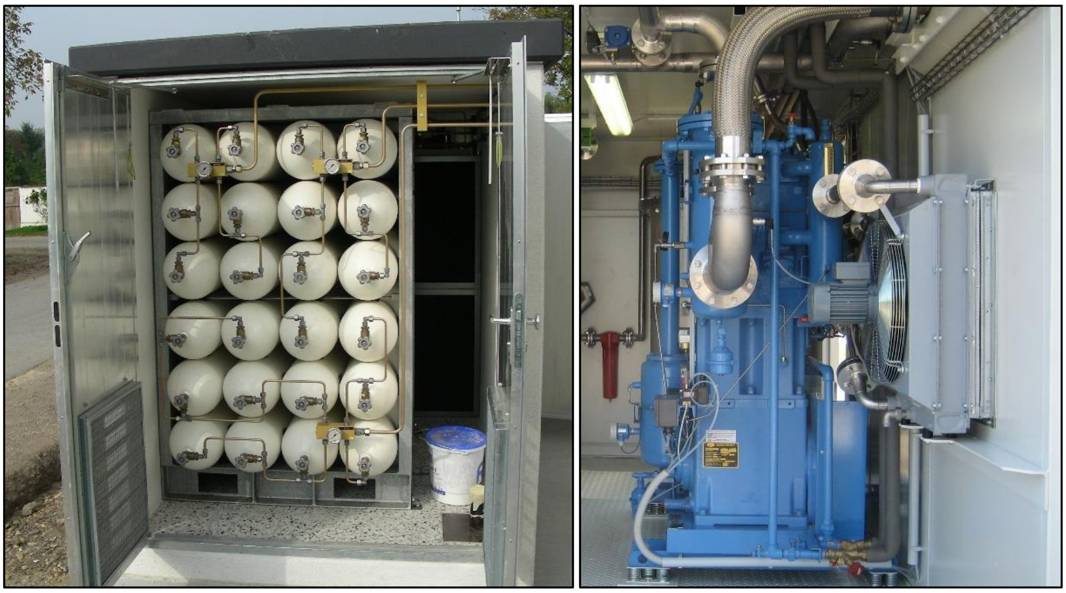
Picture 6: Wet gasometer directly included in the digestate storage tank.

- High pressure systems (steel tanks)

Although biogas is usually stored in low pressure systems, high-pressure systems are also available. These systems are usually installed when higher pressure is needed in the subsequent application. E.g. for the use as transport fuel where pressure above 200 bars is required. Usually these storage tanks are made from steel. It is necessary to at least dehumidify and desulfurize the biogas as otherwise it would cause corrosion. Typically, the biogas is upgraded to biomethane quality to fill highly concentrated biomethane (without CO_2) into the gas cylinder.



Picture 7: High pressure biogas storage systems with piston compressor.

Currently not very recognized is the option to use former natural gas caverns as seasonal storage systems. In the future, these seasonal storage capacities used after biogas has been upgraded to biomethane and after the gas has been injected into the grid will become more important within the EU.

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Digital global Biogas Cooperation

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