D2.3 Business Missions and B2B meetings Report.

Deliverable n.2.3

GREENMEUP

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Author	Myrsini Christou, Christos Zafiris, Loukas Gavriil / CRES Ronja Wollnik / DBFZ
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Introduction

In order to facilitate knowledge exchange and visits of target countries representatives to advanced ones, two business missions were scheduled to be organized. Candidate destinations for the business missions included Germany and Italy. Experiences and results of the discussions at the business missions would serve as inputs to the policy recommendations. In parallel, dedicated B2B meetings were scheduled to be organized on the occasion of these visits.

Actually, only one business mission was organized, in Germany, the reason being the fact that during the project, the partners had the opportunity to visit 8 plants, jointly organized with the project meetings.

This deliverable aims to report on the business mission organized in Leipzig, Germany, the 26th and 27th March.

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Plant visit 1: PilotSBG at DBFZ

The project PilotSBG focuses on further development of advanced renewable methane as a fuel in Germany. In the first stage, a pilot plant was planned and constructed, and preliminary tests and feasibility analyses have already been carried out.

The innovative approach aims to increase the methane yield from the biogas process. This will be achieved by both increasing the efficiency of the anaerobic digestion process and utilizing biogenic CO2 combined with green hydrogen in order to produce further quantities of green methane. The technological focus of the project is on successfully piloting all involved processes for further optimization of their performance. Conclusions are drawn, which can be used for optimising processes on a commercial scale. The major drivers for optimization are resource efficiency and the closing of material cycles, as well as greenhouse gas abatement costs.

Practical research trials, on the one hand, and the evaluation of results at a conceptual level, on the other, are realized. The pilot plant is utilizing both agricultural resources (straw and cattle manure) and urban resources (organic and green waste). Continuously operated anaerobic fermentation and methanation as the central processes are complemented by hydrothermal processes and a flexible separation cascade to emphasize the modular plant concept.

In addition to the routine operation of the pilot plant, technology- and interface-specific test series are also carried out. Based on modelling and scaling of the results and extending to the entire supply chain, ecological assessments, as well as cost and revenue structures, are considered. Following the Pilot-SBG project, the pilot plant itself will be offered as an R&D technology platform for further research and development projects with partners from industry and science.

1.1 Description of the pilot plant

The description of the pilot plant is based on data given in the plant's technical overview document, which is available on the website of the project (https://www.dbfz.de/en/projects/pilot-sbg/pilot-plant). The pilot plant features a blend of advanced and cutting-edge technologies, including methanation, anaerobic digestion (AD), hydrothermal processing (HTP), and multiple separation units. Located within a 1,000 m² experimental facility at DBFZ in Leipzig, the plant is fully integrated, extensively monitored, and highly automated. Its modular architecture enables flexible operation, allowing processes to be combined seamlessly or run independently. Furthermore, the plant is designed to easily incorporate new technologies, which can function continuously within the complete system or operate separately in individual modules. The system's robust design accommodates a diverse range of feedstocks. Currently, it processes residual and waste materials, including wheat straw, cattle manure, green waste, and biowaste. A schematic diagram of the whole pilot plan is presented in **Figure 2**:

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Figure 1: Introductory banner of the pilot plant

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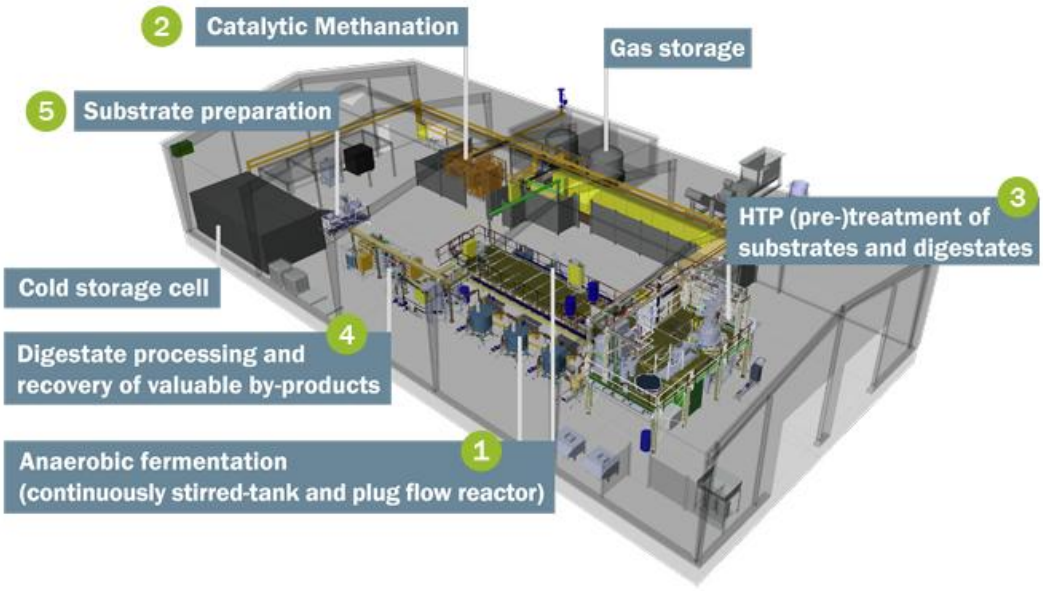

Figure 2: The process units of the SBG Pilot Plant

1. **Anaerobic fermentation:** The heart of the plant is the Anaerobic Fermentation section, where biogas is produced. During fermentation, the processed biomass is decomposed by microorganisms under controlled, oxygen-free conditions at optimal temperatures. This breakdown of organic material within the reactors generates biogas—a mixture primarily composed of methane and carbon dioxide. To facilitate this, the research and demonstration platform is equipped with two distinct reactor lines, each comprising three digesters. These lines differ in their primary digesters, operational modes, and the maximum dry matter content they can handle. This configuration enables direct comparisons between the reactor systems regarding biogas yield and quality at various stages, as well as the impact of hydrothermal pretreatment on the substrates. From both economic and ecological perspectives, assessing methane yields across the process stages provides a foundation for scaling up operations and identifying optimal process parameters. Achieving a balance between substrate utilization and operational costs is key in this evaluation.

   A distinctive feature of the research and demonstration platform is the modular design of the digesters, which enables direct comparisons between various reactor types under identical operating conditions and substrate properties. This flexibility allows for the evaluation of different substrate pretreatment methods, process temperatures, and the use of additives. Additionally, novel organic substrates or combinations thereof can be tested to assess their compatibility with the available reactor systems. The modular arrangement of the two fermentation lines, each consisting of three digesters, supports a wide range of configurations, including sequential or parallel process stages.

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Currently, the platform is equipped with five continuously stirred-tank reactors (CSTRs) and one plug flow reactor (PFR). Each reactor is mounted on an individual frame, allowing the six reactors to be interconnected in various configurations to suit specific research objectives. This setup facilitates the examination of multi-stage processes or the parallel investigation of different scenarios. CSTRs, which are the predominant reactor type in agricultural biogas production, are designed for pumpable substrates with a dry matter (DM) content of up to 15%. In contrast, PFRs can handle substrates with a DM content of up to 45%, making them more suitable for processing organic waste streams. Their lower sensitivity to contaminants also makes PFRs the preferred choice for continuous digestion in organic waste treatment facilities.

Figure 3: Introductory banner of the Anaerobic Fermentation Process section

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Figure 4: The Anaerobic Digesters Lines

2. **Catalytic Methanation:** Biogas extracted from two digesters undergoes purification and catalytic methanation to produce methane (CH_4) that complies with DIN EN 16723-2 fuel standards. Initially, the raw biogas is purified at ambient temperature and atmospheric pressure using adsorbent materials such as activated carbon or metal oxides, which effectively remove harmful substances, particularly hydrogen sulphide (H_2S) and other sulphur compounds.
   Following this, the biogas is compressed to 20 bar, heated to 150°C, and passed through a polishing filter to eliminate any remaining traces of H_2S. In the subsequent methanation stage, hydrogen (H_2) is introduced into the gas stream, where it reacts with carbon dioxide (CO_2) in the methanation reactor to form methane. The amount of hydrogen added is precisely adjusted to match the CO_2 concentration in the gas.
   After methanation, the gas is depressurized and cooled, allowing water generated during the reaction to condense and be separated. Finally, any residual CO_2 is removed using a two-stage caustic soda scrubbing process, resulting in high-purity methane suitable for use as a fuel.
   The methanation reactor is designed as a tubular reactor with an internal diameter of 26.9 mm. It contains a fixed-bed catalyst through which the reaction gases flow. Embedded within the catalyst bed is a multipoint thermocouple, which continuously measures and monitors temperature along the reactor's entire length. In addition to processing biogas during standard operation, the reactor is also capable of running with technical (pure) gases. Methane (CH_4), carbon dioxide (CO_2), carbon monoxide (CO), hydrogen (H_2), and nitrogen (N_2) are available as pure gases. These gases can be precisely blended in custom ratios through a dedicated control system and fed into the reactor for various testing and research scenarios. This setup enables the evaluation of new catalysts with a high level of comparability under realistic operating conditions. Furthermore, it

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allows for the rapid generation of measurement data for any desired biogas composition without requiring large volumes of biogas or extended start-up times.

Figure 5: Introductory banner of the Catalytic Methanation Process section

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Figure 6: The Catalytic Methanation Reactor

3. **Hydrothermal Processes:** The core component of the hydrothermal processing unit is a 500-liter stainless steel reactor, designed for both the pretreatment of complex biomass before anaerobic digestion and the post-treatment of digestate. A distinctive feature of the system is its specially designed near-wall, coil-shaped stirrer, which enables effective handling of diverse biomass types with dry matter contents of up to 25%. Additionally, an integrated steam generator provides a significant heating capability, achieving temperature increases of up to 2 K per minute despite the reactor's large volume.
   Comprehensive process monitoring ensures precise control and balancing of reactions under operating conditions of up to 240°C and 40 bar. At these elevated temperatures and pressures, the polymeric components of biomass are hydrolyzed into monomers, which subsequently decompose and recombine to form hydrochar and water-soluble products. When operated at lower temperatures and shorter reaction times, this process can effectively break down the lignocellulosic structure of biomass, making it more accessible and digestible for microorganisms involved in anaerobic fermentation, thereby enhancing biogas yields in a shorter timeframe.
   In contrast, when processing digestate, more severe conditions are employed to carbonize the material and produce hydrochar. Upon completion of the reaction, the product can be actively cooled using thermal oil circulating in the reactor's jacket.

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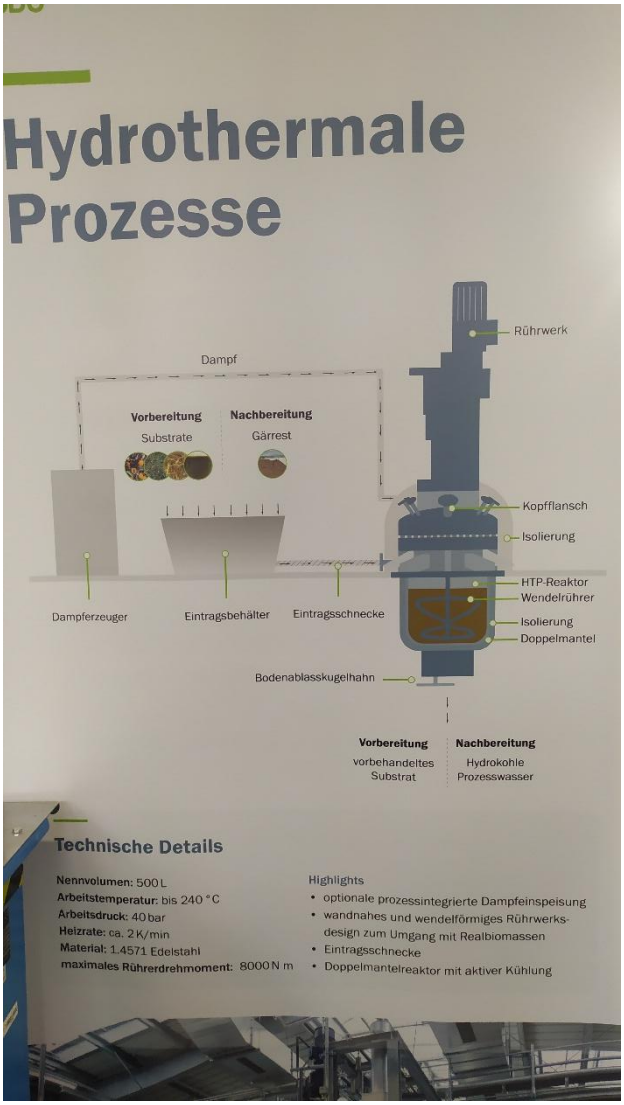

Figure 7: Introductory banner of the HTP Process section

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Figure 8: The HTP Unit

4. **Digestate Treatment:** The digestate treatment module is a multi-stage system designed to process and valorize by-products from anaerobic digestion. Through this process, the system produces dischargeable water, a solid organic fertilizer rich in nitrogen and phosphorus, and a liquid inorganic fertilizer high in nitrogen and potassium. Throughout the treatment, all critical process parameters are continuously monitored to oversee the separation stages and to establish accurate mass and energy balances.

   Operating as a separation cascade, the module progressively refines the digestate. Initial mechanical separation removes coarse solid fractions, while subsequent treatment stages focus on finer particles and dissolved substances. This systematic approach enhances resource recovery, minimizes waste volumes, and ensures compliance with environmental regulations.

   A standout feature of this module is its adaptability—it can be configured to accommodate various feedstocks and operational objectives. The design supports circular economy principles by recycling nutrients and reclaiming water for either reuse or environmentally safe discharge. Additionally, it mitigates challenges associated with the direct land application of raw digestate. By transforming waste streams into valuable products, the module exemplifies a sustainable and resource-efficient waste management strategy.

   This digestate treatment module comprises four main steps. Each step targets specific components in the digestate stream. Those steps are: Initial dewatering, Decanter centrifuge, Ultrafiltration (UF), and Reverse osmosis (RO).

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Figure 9: Introductory banner of the Digestate Treatment section

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Figure 10: A view of the Digestate Treatment Section

Plant visit 2: Biomethane plant Gordemitz

BGA Gordemitz - BALANCE Erneuerbare Energien GmbH

The biomethane plant in Gordemitz is an excellent case study for the importance of good cooperation among the stakeholders involved in a biomethane project. The plant was initially designed as a typical biogas plant that would be fed by agricultural wastes, generating electrical power after the combustion of biogas in its CHP engines. The plant was designed by UTS Biogastechnik, and its construction commenced in 2013. In 2014, the initial investor went bankrupt, the work was stopped immediately, and the unfinished project became part

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of the insolvent estate. In 2018, two experienced biogas entrepreneurs from the German Westphalia district discovered the project for themselves, bought it, and energetically started to plan its reactivation, but before starting to implement the new plans, the Westphalian investors decided to sell the project again. And, as a result, in late 2019, the plant became the property of BALANCE Erneuerbare Energien GmbH. The new owner BALANCE brought in the plant consortium, the company Schmack Biogas Service, as an established partner. Although UTS and Schmack were competitors since both are designing and constructing biogas plants, given the tight schedule and budget, UTS and Schmack had to work together. Schmack constructed and coordinated the entire plant as the general contractor, and UTS was responsible for fitting out and constructing the raw biogas line from the input of solids to the gas output at the tank.

The Gordemitz plant became operational by late 2020, and commissioned by end of January 2021

Figure 11: Aerial view of the plant

All data about the history and the technical features of he project are taken from the website:

https://www.anaergia-technologies.com/en/industries/success-stories/success-story-2/

2.1 Description of the plant

The Gordemitz plants use for substrate, in its anaerobic digestion process, renewable raw materials such as corn and grass silage, as well as approx. 10-15% of dry chicken manure from regional farms. Some 45,000-50,000 metric tons of input materials are processed in the plant under full load per year, resulting in approx.700 Nm^3 of biomethane is being produced or fed into the grid per hour, enough to supply approx. 3,000 to 4,000 households with energy. The

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plant consists of 5 digesters. Two of them are pre-digesters, and three are the main digesters. In 2014, UTS Biogastechnik provided the two pre-digesters with concrete ceilings in order to ensure intensive mixing, proper desulphurisation, a stable gas pressure, and low heat losses, while excluding any weather influences. Two Havelberger solids feed-in systems with capacities of 120m³ and 150m³, and the conveyor technology that is typical of UTS plants feed two pre-digesters and two of three main digesters with solid substrate. Besides being very robust, the Havelberger scraper chain conveyors with milling rollers and the installed conveyor technology offer the advantage that they can convey fibrous material into the tanks without any obstructions and with low energy consumption. If required, liquid manure can also be supplied and introduced via a preliminary pit. The entire set of equipment is designed to achieve the efficient, trouble-free, economical, and above all safe operation of the plant through- out the fermentation process. If required, liquid manure can also be supplied and introduced via a preliminary pit.

Figure 12: Gas meter showing the biomethane produced at its nominal flowrate, 700 Nm³

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Figure 13: The 2 pre-digesters and the two of the digesters, along with the Havelberger solids feed-in systems

The contents of the five digesters are mixed by a total of 14 state-of-the-art UTS PSM mixers with gearless direct drive and intelligent DMC control. These mixers not only provide the necessary thrust and mixing, but thanks to their power consumption of approx. 7 - 9kW, they are also one of the most energy-efficient mixing systems on the market.

The central pumping station of the plant is equipped with progressive cavity pumps and numerous pumping options in all directions, ensuring sufficient operational flexibility. Two UTS FSP-B 78/15 separators ensure high solids separation of already fermented material and enable the dry matter content to be regulated by returning the filtrate to the digesters or, optionally, to the fermentation product storage.

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Figure 14: Digestate solid separation unit

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Figure 15: Sillage storage

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Figure 16: Biogas in line to the upgrade unit

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Figure 17: Biogas upgrade to biomethane unit

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Figure 18: Biomethane out line from the upgrade unit

Plant visit 3: Biowaste digestion plant Dresden

Biowaste fermentation plant in Dresden-Klotzsche - MVV Energie AG

The biowaste fermentation plant in Dresden—Klotzsche belongs to MVV Energie AG. MVV is one of Germany's leading energy companies, with over 6,600 employees and annual sales of approximately € 7.2 billion in the 2024 financial year (https://www.mvv.de/en/about-us/group-of-companies/mvv-umwelt/renewable-energies).

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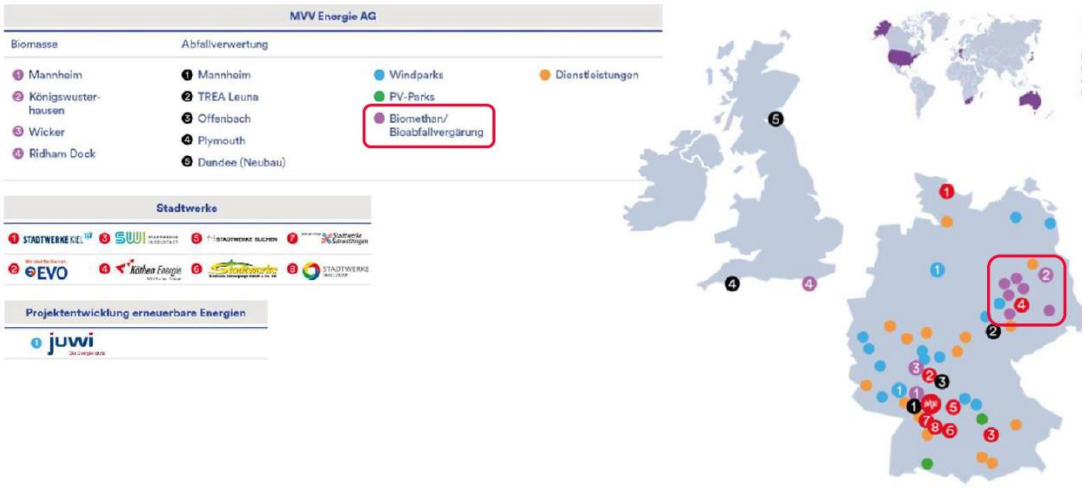

Figure 19: Sites of MVV energy plants. With the magenta colour are the biogas/biomethane plants

The plant in Dresden-Klotzsche was the first biowaste plant of the company. It started its operation in 2017 and was initially capable of processing 32.000 tons per year of organic municipal waste from Dresden and the surrounding area. The plant was using the technology of dry fermentation with percolation. This is a thermophilic fermentation process that needs heat and water to work. It can process dry substrates, and it is a batch process. The plant initially had 8 fermenters and a CHP unit, which was using the produced biogas to deliver power and heat. In 2018, it was expanded by the addition of 4 more fermenters, and since then, it has been capable of treating 46.500 tons of organic municipal waste per year. In 2021, a biogas upgrading unit was added to the plant, so now it is producing biomethane, which is fed into the grid (On-site presentation by Richard Hempel).

3.1 Description of the plant

The aerial view of the plant is shown in the following Figure:

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Figure 20: Aerial view of the Dresden--Klotzsche plant

The plant has two reception halls, where the organic wastes are collected and stored before their introduction to the fermenters, **Figure 21**.

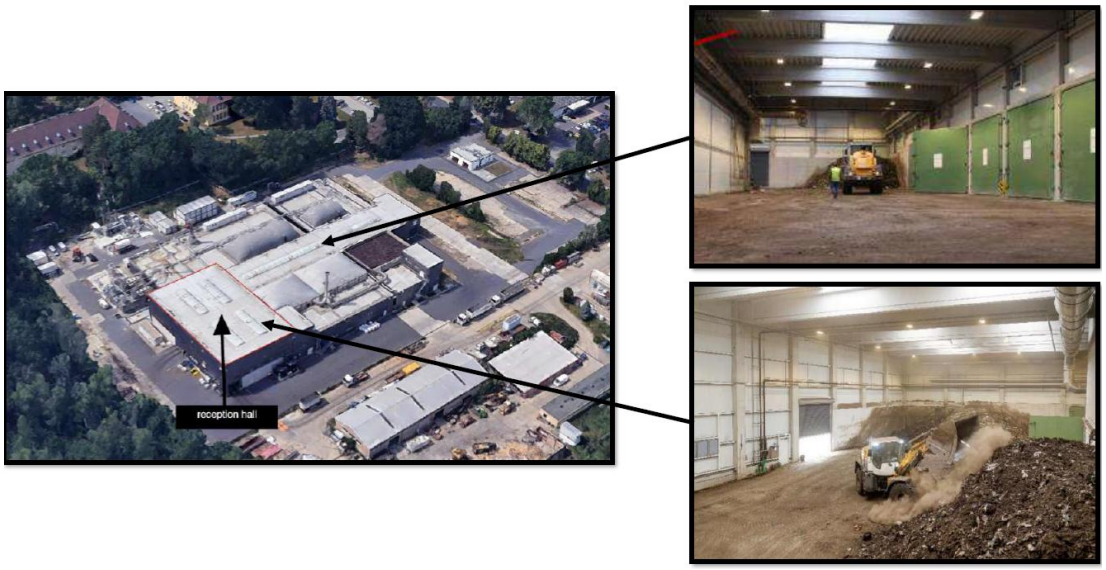

Figure 21: Pictures of the reception halls and their location

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Then the wastes are loaded into the fermenters. Their location is shown in **Figure 22**.

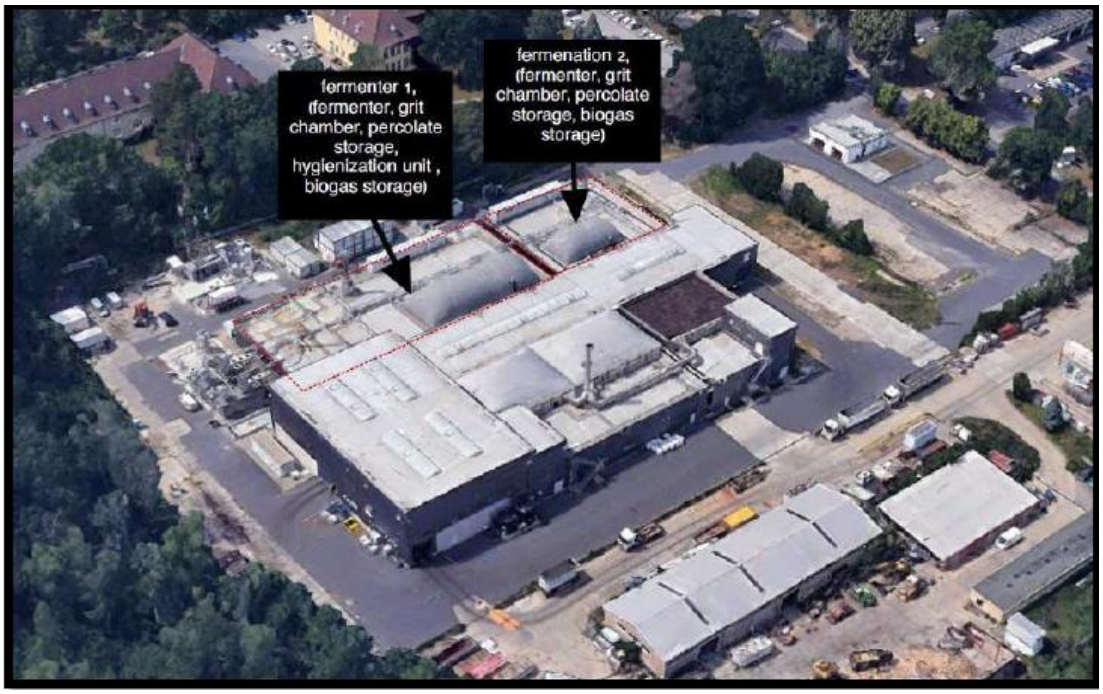

Figure 22: Location of the fermenters

The fermenters are heated by an underfloor heating system, so that the fermentation takes place in the thermophilic region. There is also a percolation system helping the circulation of the volatile matter and the produced biogas, as well as the more efficient distribution of the microorganisms.

Figure 23: The underfloor heating system

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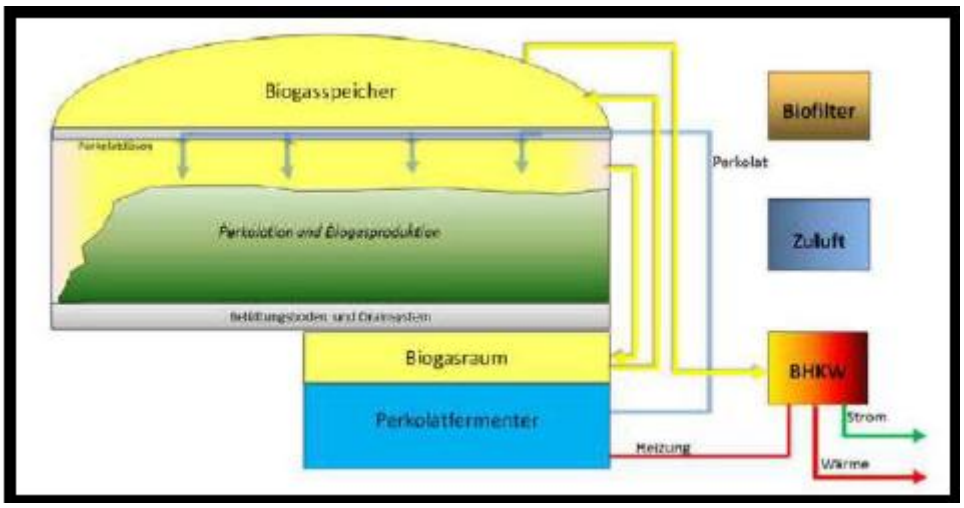
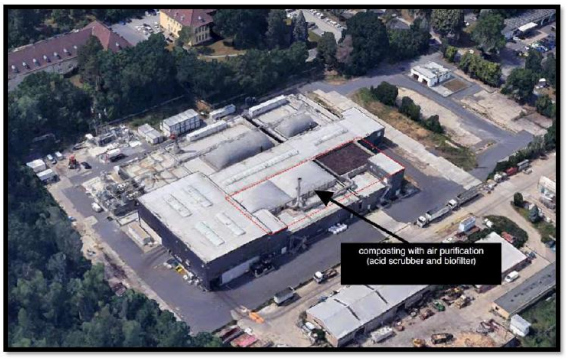


Figure 24: Schematic diagram of a dry fermenter with a percolating system

The fermented substrate then goes for composting.



Floor of a composting box with underfloor heating

Biofilter and chimney

Figure 25: The composting section of the plant and its components

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Figure 26: The biogas upgrading unit and the visiting team

The plant produces 2,5 Mil cbm of biogas per year (55% CH4). 70% of it is consumed in the CHP Units, producing power for the grid and heat that is used by the fermentation process of the plant. 30% of the produced biogas undergoes the upgrading procedure to biomethane, so 750.000 cbm/a of biomethane is injected into the grid. The company plans to increase the yield of biomethane by replacing the CHP units with biogas burners to increase the heating efficiency, optimising the start-up and shut-down procedures to prevent poor gas quality occurrences, by adding trace elements to enhance biogas production, and by adding preparation of the organic waste

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Conclusions

Although this was the only business mission organized by the project, the participants had the chance to visit three distinguished and diverse biomethane plants that helped them to have a global view of the available technology. In the first visit, they saw the state-of-the-art technology available for biogas and biomethane as it is presented in the pilot plant of the DBFZ Institute. In the second visit, they saw a typical, large, and very productive biomethane plant that was constructed because of the very good cooperation of different stakeholders that may initially have had opposing interests. In the last visit, the participants had the chance to see a not very common biomethane plant that uses solid organic municipal waste as substrate. They saw the technology of dry fermentation, so they are now familiar with a very efficient method of municipal waste treatment.

From the above, it is clear that the scope of the business mission was covered in the best possible way.

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