BDI
BioEnergy International

BDI BIOGAS

Sustainable Brewing Solutions: Obtaining Biogas from Spent Grains

Introduction

In the context of brewery production, high-quality organic by-products, in particular spent grains, are produced. These valuable by-products have to be disposed of in a time-consuming and often cost-intensive manner.

This white paper discusses the benefits of biogas technology, provides insights into the 3-stage fermenter BDI BioGas process for achieving maximum yields of energy production from spent grains, and explains the various aspects that must be considered during implementation.

The brewery industry is one of the most energy-intensive sectors of the food industry. A central task in this context is to reduce energy requirements and to switch to renewable energy sources. Further challenges of the industry are the impact on climate change, the development towards a sustainable society, price stability and reducing dependence on suppliers in the energy sector.

An additional concern for the brewing industry is the disposal of brewers' spent grains (BSG), spent hops and yeast. BSG has a short shelf life due to its high moisture content and susceptibility to microbial spoilage, with current outputs mainly restricted to low-value animal feed or landfill. The amount of BSG produced often exceeds the livestock feed demands of local farmers. Furthermore, each ton of BSG which is not valorized must be disposed of at high cost, and ultimately releases over half a ton of CO2 equivalent of greenhouse gases.

However, by using BSG as a feedstock for BDI BioGas technology, which is based on a unique process technology that has been proven over many years, breweries can valorize their by-products and overcome the abovementioned challenges.

Biogas plant of the Göss brewery in Leoben, Austria

The strengths of BDI Biogas Technology can thus be summarized as follows:

- Security of energy supply with predictable prices and reduced dependence on energy suppliers.
- Flexible and easy to integrate into the brewery's infrastructure, since biogas is a fossil fuel substitute for existing technologies (e.g. CHP, boiler house, etc.).
- Wide range of applications of biogas for the production of thermal and electrical energy, replacement of fossil gas in the gas grid, as a precursor to hydrogen, and as a fuel for logistics (LNG).
- Established technology with maximum gas yield that can be easily and retroactively adapted to meet future requirements, such as the conversion of biogas to biomethane use or the implementation of a protein extraction from spent grains.

1. Technology Overview

The current state of the art for biogas plants involves various technological advancements that have improved the efficiency and effectiveness of the process. Some of the most notable developments are listed below.

1.1 Advanced feedstock management

The ability to manage various types of feedstock, including agricultural waste, food waste and industrial waste, has improved significantly. This has allowed for more flexibility in the types of materials that can be used to produce biogas. For each feedstock, including BSG, the process must be customized to ensure the maximum yield.

1.2 Advanced Anaerobic Digestion Technology

Innovations in anaerobic digestion technology have made it possible to achieve and secure higher levels of biogas production. But what does this mean in detail?

- Exact knowledge of the composition of the spent grain
- Upstream gas potential analysis
- Adaption of spent grain for efficient bacteria degradation
- Customized systems and process technology.

1.3 Biogas Upgrading

Technologies for upgrading raw biogas to higher purity biomethane have improved in recent years, making it possible to inject it directly into natural gas pipelines or use it as an automotive fuel. Multiple suppliers developed a standard unit configuration for the raw biogas treatment, which led to an increase in offers and low-cost applications.

1.4 Process Automation

The use of advanced process control systems and automation technologies has improved the efficiency and reliability of biogas production, reducing operating costs and increasing profitability.

1.5 Resource Recovery

Biogas plants are increasingly being designed to recover valuable by-products, such as certified fertilizer and soil conditioner, as well as compost from the residual digestate. This increases the degree of raw material utilization and adds additional value to the biogas production process, closing the loop for circular economy. To date, the number of biogas plant constructors that have tailored their processes to efficiently utilize spent grain to ensure a maximum gas yield and demonstrated operational success over several years, is limited.

2. BDI BioGas for Breweries

The biogas plants specially developed by BDI for large-scale breweries (more than 1 mio Hl/y) can be incorporated into existing infrastructure. The integration process involves determining the necessary pipe bridges and installation costs, as well as solving challenges that may arise, including a small area allotted for plant construction and complicated authority approval procedures.

The BDI biogas plants are so-called 3-stage fermenter plants. This specially designed process enables organic substrates rich in solids to be processed in high concentrations, with a high organic fermenter space load that can be implemented continuously.

2.1 The Process

Spent grain is mixed with recycled digestate from the biogas plant. This slurry is then pumped to the hydrolysis tank, which constitutes the first stage of the anaerobic system. Additional yeast can also be added. In the downstream fermenter and post-fermenter tanks, perfect process conditions and an optimized plant design lead to a maximum conversion of carbon and hydrogen into biogas.
The fermenters are designed in such a way that an intensive contact between substrate and bacteria is guaranteed, despite the high viscosity. Each fermenter is built to be a fully-fledged fermentation room (stirring, insulation, heating, gas collection system, sludge management, etc.).
Diagram 1 shows the fermentation process, which is based on a three-stage fermenter system:

- Hydrolysis
- Fermenter
- Post-fermenter

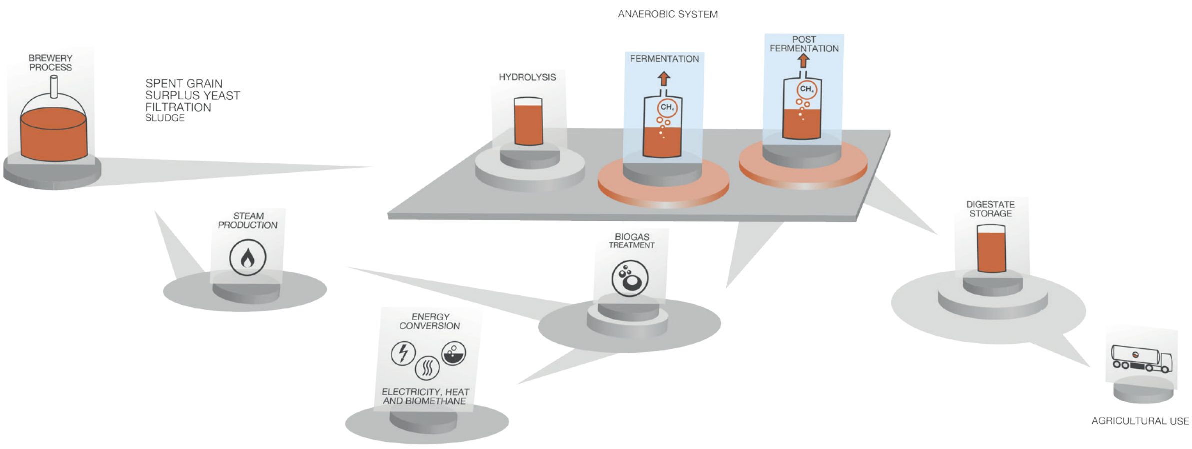

Diagram 1: schematic diagram of a BDI biogas plant for breweries

2.2 Hydrolysis

The substrate (mixed spent grain) is pumped from the substrate mixing station into the hydrolysis tank. During hydrolysis, long-chain compounds (proteins, fats and carbohydrates) are broken down into units such as fatty acids, amino acids and sugars. Fibers, remains of shells/husks, are soaked and broken down in the acidic environment. The hydrolysis is carried out by endemic enzymes, which are recirculated from the fermentation stage. There are no external enzymes or chemicals required.

The hydrolysis tank is equipped with a central agitator, and various sensors for process control. A tube-in-tube heat exchanger, located in the central pump station, optimizes the heat transfer between the stages.

The hydrolysis process is operated at temperatures over 40°C at a low pH value to ensure a fast degradation of the long-chain compounds, enabling a short retention time of the substrate (less than 4 days). Furthermore, the hydrolysis tank works as a buffer to secure a continuous biogas production process, despite the discontinuous brewery operation (batch cooking or no production over weekends).

2.3 Fermenter and Post-fermenter

In the fermenter, the substrate is kept airtight in an anaerobic environment at a temperature between 38°C and 41°C, where the carbohydrates, fats and proteins contained in the substrates are fermented.

In the last degradation step, the broken-down constituents are converted by methanogenic bacteria into methane (CH4) and carbon dioxide (CO2). As before, the fermenters are equipped with central agitators, various sensors for process control and a tube-in-tube heat exchanger to achieve stable temperature in both fermentation vessels. The biogas produced contains up to 60% methane, ideal for use in gas engines for the production of power and heat, or alternatively for burning in a boiler to produce steam. Thanks to the BDI process, the remaining digestate is used as a certified organic fertilizer for agriculture and contains all the valuable nutrients found in brewery residues.

Certificate for organic fertilizer, a by-product of BDI biogas production

3. Case Study

BDI's goal when conceiving the biogas technology was to develop an energy source utilizing a by-product as a feedstock to minimize the brewery's dependence on fossil fuels and reduce CO2 emissions. The following use case describes an existing international large-scale brewery, which operates with state-of-the-art energy and resource consumption technology.

Initially, a considerable share of about 60% of the brewery's energy and heat demand was being generated using fossil natural gas. Biogas was already being produced from wastewater at the plant site, representing a share of about 20%. Two combined heat and power plants (CHPs) were producing the necessary energy and heat from this natural gas and biogas, so that only a remaining 20% share of electrical energy had to be covered by the power grid.

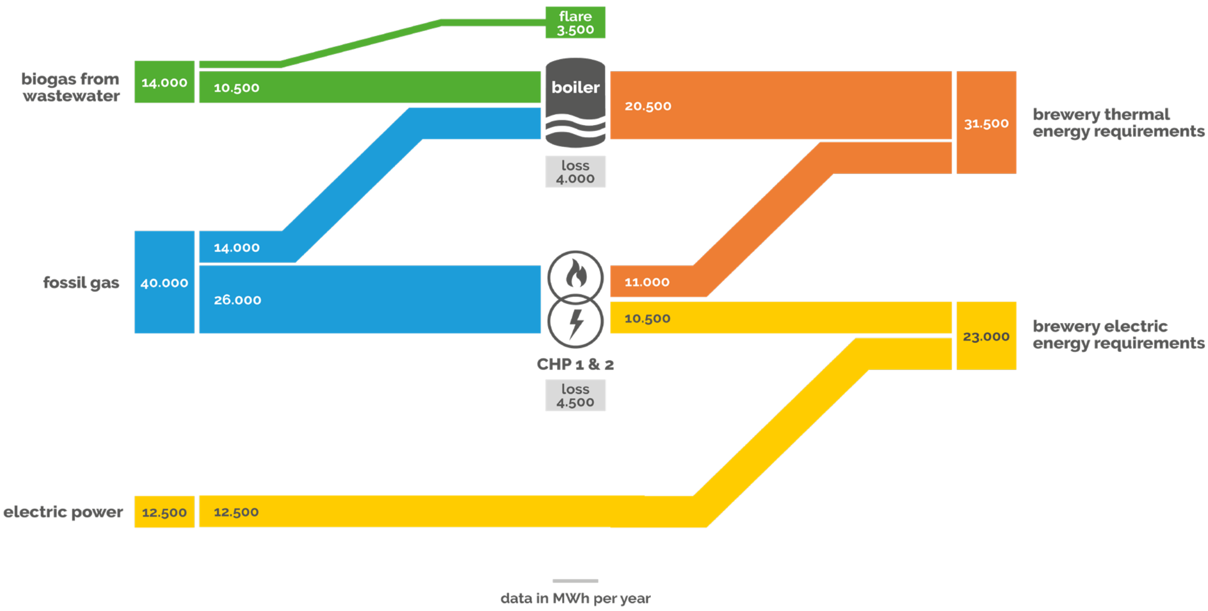

Diagram 2: Initial energy input distribution

As seen in Diagram 3, the BDI biogas energy concept reduces the amount of fossil gas required to less than 40%, with an option to reduce the amount to just 10%. Furthermore, the number of flare times is drastically reduced, because the gas extracted from the wastewater can now be temporarily stored in the gas tank of the new biogas plant.

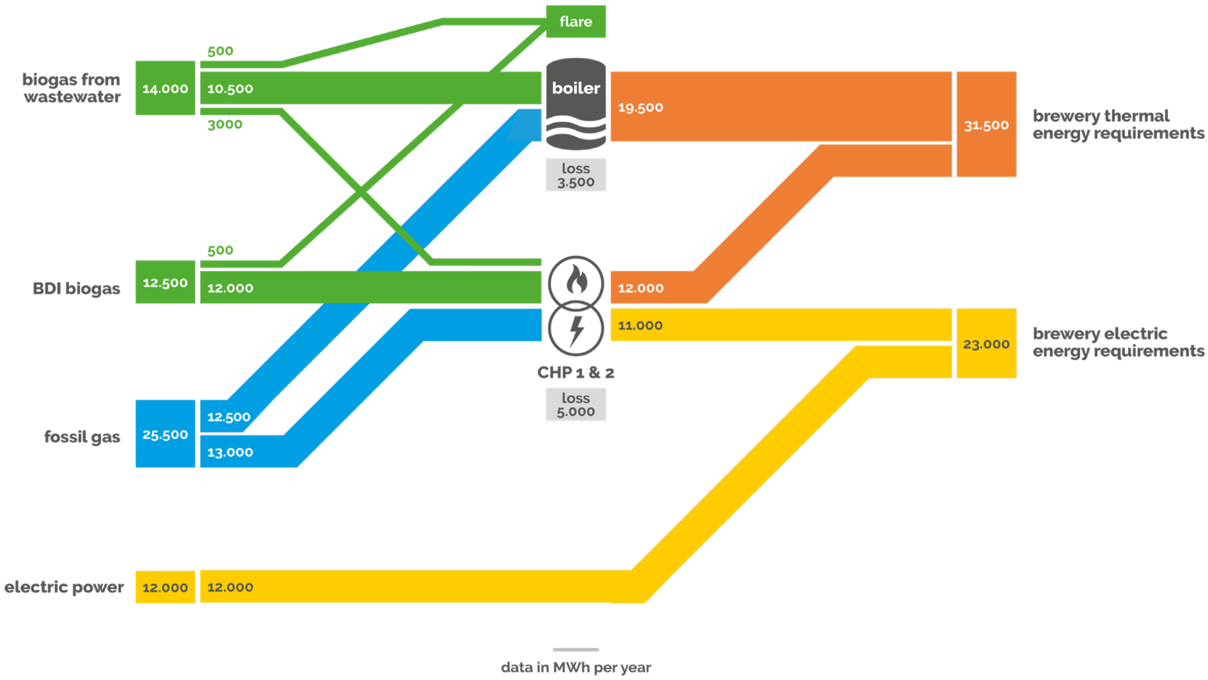

Diagram 3: BDI biogas energy concept

Summary and Conclusion

With the robust and reliable BDI BioGas plant, all organic residues from the brewery can be converted to valuable assets, thus eliminating the need for disposal and replacing costly conventional energy with cheap, self-generated energy. Further advantages of the tailor-made technology include advanced feedstock management, aligned with the unique characteristics of BSG, as well as efficient integration into existing infrastructure.

The incorporation of BDI Biogas Technology is pivotal towards propelling the brewery industry into a future where waste becomes energy and sustainability takes center stage.

Brewery and BDI biogas plant in Leoben, Austria

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About BDI

With over 25 years of experience with customers from various branches, BDI-BioEnergy International specializes in building industrial chemical plants all around the world, including biogas plants. The Austrian-based company addresses the typical needs and requirements of green technology and the oil and gas industries, as well as biotechnological applications. BDI is a pioneer in process solutions and plant engineering for the circular economy. As a market leader in the construction of biodiesel plants, BDI also offers environmentally friendly solutions for fermentation technologies in biogas plants and the upcycling of plastic waste.

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