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Research biogas plant „Unterer Lindenhof“

Biogas research at Hohenheim University has a long tradition. As early as in the 80s, the first laboratory for continuous fermentation tests was built. Today, the biogas laboratory has more than 450 fermentors for batch fermentation tests and ten fermentors for solid matter fermentation. An additional 28 fermentors with an effective volume between 17 and 400 l are available for continuous tests. In addition to the extensive laboratory capacities, a research biogas plant with an electric output of 190 kW along with other facilities is currently being built at the research station “Unterer Lindenhof” in Eningen u.A..

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Keywords

Research biogas plant, biogas, biogas laboratory

Literature

- [1] Faulstich, M., und K. Greiff: Biogas – ein nachhaltiger Beitrag zur Energieversorgung? Ergebnisse des SRU-Sondergutachtens 2007. In: Biogas – effizient und verlässlich. Tagungsband, 17. Jahrestagung Fachverband Biogas (Hrsg.), München, 2008, S. 79 - 92

The energetic use of biomass is one of the important measures which can be realized in the short and medium run in order to increase the percentage of renewable energies in the total energy consumption of Germany. Biogas technology, which is characterized by great substrate flexibility, high energy conversion rates, and the recirculation of biogenous nutrients into the natural substance cycle, has a key function in the energetic use of biomass. According to the experts' panel report on environmental questions, biogas belongs to those renewable energy carriers which can be produced with the greatest energy efficiency [1].

For this reason, biogas research in Hohenheim is intended to be intensified even more. As a supplement to the laboratory facilities at the Institute of Agricultural Engineering in Hohenheim, a biogas plant for research purposes is currently being built at the research station “Unterer Lindenhof” in Eningen unter Achalm. The construction of this plant is pursuing the following goals:

- Studies on the optimization of the supply, conservation, and processing of biomass. On the experimental fields of the research station “Unterer Lindenhof”, the entire supply chain from plant cultivation to the utilization of the plants in the biogas unit can be modelled and optimized taking efficient water use in multiple-element crop sequences and economical energy consumption into special consideration.
- Studies on the applicability of the results gained at the laboratory scale to large-scale plants and farther-reaching studies on process stability in combination with extensive data collection for the drawing up of a comprehensive balance of the biogas technique (energy consumption, work time requirements, economic parameters)
- Supply of conditioned biogas for gas cleaning and utilization. Low-pollutant combustion as well as the use of biogas as fuel require the elimination of hydrogen sulphide and the enrichment of methane. The research plant enables the gas quantities needed for the studies to be provided.

Technical description of the research biogas plant

Research station “Unterer Lindenhof”

The research biogas plant “Unterer Lindenhof” is being built at the Research Station for Livestock Farming and Animal Breeding in Eningen unter Achalm near Reutlingen. Liquid and solid manure from approximately 300 livestock units forms the basic substrate for biogas production. At the same time, the research station, which also has an instructional kitchen and its own slaughtering house, has high heat requirements during the entire year. A reflux temperature increase adjuster enables the biogas plant to be included in the existing district heating network, to which all buildings are already connected, so that a very high total efficiency of the biogas heating and power station is guaranteed all year round.

Operation sequence

In addition to the manure produced on the farm, renewable raw materials grown on the areas of the research station are used in the biogas plant. After the harvest, these plants are stored in horizontal silos. For ensilage trials, five equally sized horizontal silos (7.70 m • 2 m • 35 m each) are available in two different design variants. Every horizontal silo has a separate silage effluent drain so that the quantity and quality of the silage effluent can be measured if suitable measuring instruments are installed.

The liquid manure produced at the research station is temporarily stored in a slurry pit from which it is extracted by a screw pump and distributed over the fermentors after it has passed a central pump station. The slurry pit, the two fermentors, the refermentor, as well as the two intermediate storage pits are connected to this central pump station by separate suction and pressure pipes. In both directions, sealing stainless steel plate slides with a pneumatic direct drive are immediately attached to the distributing bar. The delivered substrate quantities are measured by an inductive flow meter, and the data are sent to the central plant control system. It is also possible to take samples

here. Since the centrally arranged pump is housed in a large pump room, additional sensors, automatic samplers, or substrate processing units can be installed for future trials.

Both the two fermentors and the refermentor have a diameter of 14 m and a height of 6 m (gross volume: 923 m³) and consist of monolithic concrete. The two fermentors feature a concrete cover. The concrete of the container walls in the gas area and the cover including the central pillar is protected against chemical corrosion by PE-HD film. The installation of two heating circuits consisting of corrugated and plain-ended pipes which can be closed individually as well as additional floor heating in fermentor I enable the heat transfer capacity of different heating systems to be compared. For the control of heat distribution, exchangeable heat sensors are installed at three different heights at the outer wall and the central pillar. In each of the fermentors, a submerged motor agitator and a frequency-controlled sloping-axle agitator with an outside motor mix the fermentation substrates. The concrete covers of the fermentors each feature 12 sampling openings. Dip pipes can be introduced into these openings, which are normally sealed by a permanently gas-tight lid, so that samples can be taken at virtually any place of the fermentor using a special sampling unit. For the first time, this allows the influence of parameters such as substrate characteristics, fermentor temperature, or agitator settings on nutrient distribution and fermentor biology to be studied in a fermentor at a practical scale.

Each of the two fermentors is equipped with a stationary vertical mixer which feeds the silage into the fermentor. In the central plant control system, the set feed quantities are determined in recipes. When filling the solid matter metering units, the driver of the telescopic loader receives information about the quantities of the individual silage types to be fed into the fermentor via radio from the central plant control system. The actual feed quantities which vary from these set quantities are registered by the central plant control system and are considered in the calculation of the actual feed mixtures. This allows the "feed quantity" per fermentor and component to be registered precisely. The feed mixtures are fed into the fermentors in the preselected intervals depending on their weight. In addition, a 1 m³ container with a metering pump and separate pipes leading to



Fig. 1: Design model of the research biogas plant „Unterer Lindenhof“

the fermentors and the refermentor is installed for the metering-in of grain and process additives.

From the two fermentors, the biogas produced flows into the gas area of the refermentor. At the exit of each fermentor, the measuring instruments for the determination of gas quality, gas quantity, gas temperature, and pressure are installed in an exchangeable bypass pipe. For maintenance, this bypass pipe can be closed and removed while the plant is running. The biogas is stored above the substrate in an air-supported double-membrane roof in the refermentor, which is attached to the top of the container wall using a Seeger lock. The refermentor can also be heated with the aid of one heating ring consisting of plain-ended pipes and one corrugated pipe ring.

After desulphurization in the fermentors and in the refermentor, the biogas is cooled for steam separation in an actively cooled pipe bundle heat exchanger before it is used in the block-type thermal power station. In the following activated carbon filter, the remaining hydrogen sulphide in the biogas is adsorbed.

In a gas-petrol thermal power station with an electric output of 190 kW, the biogas produced is converted into electricity and heat. While the electricity is directly fed into the medium-voltage line of the energy supplier, the heat can be fed into the district heating network and used for climate control in animal houses and farm buildings almost all year round.

The central plant control unit fully automatically controls the entire operation sequence of the biogas plant. The values of all measuring instruments are stored and archived centrally in a data base. From a work place in Hohenheim, the plant and the operational data can be accessed at any time so that the trials can be evaluated quickly.

Initial research projects

Special thanks are due to Hohenheim University for providing the investment means and choosing a future-oriented concept for the supply of a research station with renewable energy. As part of the Future Offensive IV of the state of Baden-Württemberg, an integrated biomass research platform connected to the biogas plant "Unterer Lindenhof" will be created in the coming years, in which the leading universities, colleges, and research institutions of the state of Baden-Württemberg will participate by carrying out interdisciplinary research. This scientific research platform also serves as a demonstration project and will be subsidized by the Ministry of Food and Rural Areas of the state of Baden-Württemberg, which will provide an amount of € 2.4 million for this purpose. In addition, the Baden-Württemberg State Foundation has granted financial means for research projects on biomass utilization.