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Agricultural Biogas Plants in Baden-Württemberg

A Statewide Survey on the Technical Set Up, Functions and Operation Modes of Biogas Plants

Through the amendment of the EEG (Renewable Energy Sources Act) in August 2004 and the improved socio-political framework resulting from it, biogas plant construction has advanced considerably. Through growing plant sizes and electrical power capacities, as well as more professional management, the importance of biogas as an energy source is continuously rising.

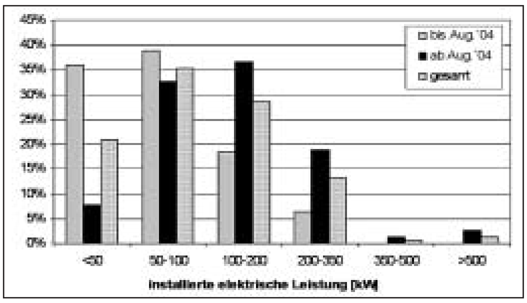

Fig. 1: Installed electric power of CHP-aggregates in Baden-Württemberg (230 plants)

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Within the framework of a research project of monitoring practical agricultural biogas plants, over 400 questionnaires were sent to biogas plant operators in Baden-Württemberg by State the Institute of Farm Machinery and Farm Buildings of the University of Hohenheim. 230 operators replied, which corresponds to a representative response of 55 %. With these authentic data, the technical configuration of plants, the changes of the last few years and tendencies of plant manufacturing can be derived.

According to the above information and together with the statement from the public biogas consultancy, there are 480 agricultural biogas plants currently producing energy out of biomass in Baden-Württemberg. Since the amendment of the EEG became effective in August 2004, the number of biogas plants has doubled, mainly due to the improved conditions for electricity generation. The result of the tendency of building bigger plants is that the whole installed electrical power increased to 96 MW during that time, which is five times higher than in 2004 [1]. It is estimated that approximately 770 Mio. kWh of electric energy can be produced per year in Baden-Württemberg from digesting biomass in agricultural biogas plants.

Construction

In Baden-Württemberg and in the whole of Germany vertical standing constructed digesters still dominate with a proportion of over 90% the design of biogas plants. Concrete building material is favourably used and mostly influences the construction style of digesters. It is is very steady, stable and reliable to carry heavy loads. Therefore it can be used for building digesters in different types of areas e.g. hillside or underground and as cover material.

70% of the digesters are equipped with a concrete cover. In this case there is no possibility for storage of biogas in the digesters or on top of it.. About 2/3 of these plants have an external gas storage, which is accomodated as a foil cushion inside of a building or as a foil bag in a silo. 1/3 of the plants store the gas directly in the system on the second stage digester or the storage is built above the cover of the main digester. The use of double-layer air foil roofs on digesters is however increasing, as compared to the single-leaf foil roofs previously being used. The double-layer air foil roofs offer a flexible gas storage possibility without loosing e.g. stability under windy or snowing conditions. Despite the higher costs for installation, the portion of the use of air roofs has increased since the introduction of the EEG. Nevertheless, external storage forms still dominate.

Mode of operation

Approximately 85% of the plants are operated in the classical mesophile temperature range, thus between 36 °C and 42 °C. With higher fermenting temperatures, faster turnover rates can be obtained, however a more sensitive process stability must be expected. Apart from the combination of different operating temperatures with several operation stages within a plant, more plants were built in the last years, which run in pure thermopile conditions with up to 55 °C. Among them beside classical co-fermentation plants, also systems with no liquid manure fermentation can increasingly be found. Beside forgae maize, which is almost always used by approximatly 75 % of the farms, three or more different solids are used for fermentation. In view of the micro nutrient supply for processing, a continuous feed mix of this kind is regarded very positive.

Since the amendment of the EEG (August, 2004), available data reveals that approximately 11% of the new built plants are operated without additional feeding of liquid manure. Combining with the old plants the portion is 5%. For the forage maize, low in protein, which is predominantly used as the main substrate, a thermophile mode of operation is possible, because inhibitions due to high ammonia concentrations can hardly be expected. Since the buffering effect of the li-

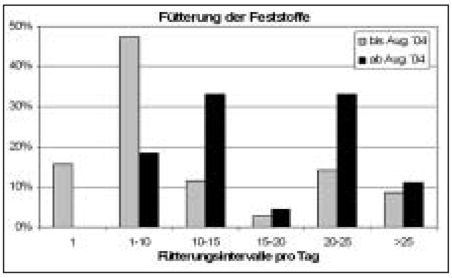

Fig. 2: Feeding intervals of solids before and after the EEG at 230 plants

quid manure is missing and still very few realizations are present over this mode of operation, most of these plants receive the so-called innovation bonus and therefore higher remuneration for the electricity generated. There are very few solid-state anaerobic digestion plants existing in Baden-Württemberg. Those plants are operated in intermittent garage fermenters.

Plant structure

In addition to a clear increase of the number of biogas plants in Baden-Württemberg, their sizes have also increased substantially. Before the amendment of the EEG, 2/3 of the plants were operating far below 100 kW of installed electrical power capacity. After the EEG amendment, 70 % of the plants were built between 100 and 250 kW. Currently 15 % of the plants operate within the range of 250 to 500 kW. This is not only shown in the total power capacity, but also by the individual installed aggregates (*Fig. 1*). The use of aggregates increased up to 350 kW, whereas, generator efficiency usually rises with technical progress and the aggregate size. New plant extensions and larger aggregates are remarkably in use. Quite often, branches of agriculture (e.g. dairy cattle husbandry) are shut down completely, so that the ranking of the biogas plants in agricultural enterprises is increasing further. Construction of large biogas plants is increasing in operation cooperations, to exploit cost degression due to cost sharing.

It can be assumed that this trend will continue. The installed electrical power capacity is already increasing in planning and building between 500 kW and 1MW.

Larger plants need an improved operational management, due to the increased importance of the biogas plant and the high capital expenditure for all sections, e.g installation of standard feeding systems, which can also weigh fodder. With this technology a weight-dependent feeding is possible and can give exact knowledge of the quantity of fed substrates. As many as desired, feed rations can be distributed by modern control automations during the day. Thus, most biogas plants are fed once or twice per hour (see *Fig. 2*). This is favourable for a stable process, because the digester does not have to degrade all the fast degradable substrates at once.

In order to evaluate accurately the efficiency of a plant and the ability to supervise the biological process, particular measuring instruments for large plants are very essential. Altogether, the employment of measuring technique is still relatively small opposite as expected Apart from the heat counters, the weighing of the solid substrates was estimated as the most important one by the operators. Since the EEG amendment, at least 2/3 of biogas plant operators have installed a technical possibility to weigh at the plant, in order to be able to quantify the amount of the input material and the exact need of the plant.

The efficiency of the plant can be known only when the information about the running performance of the CHP is available. Depending on the collected data of the mass of gas and of he quality of gas, an exact balance and an examination of the engine efficiency can take place. If the engine performance drops, it can only be discovered with appropriate measuring technique, if there is an engine-technical or digesting-biological problem. Meanwhile 56 % of the biogas plants have a gas volume measurement system.

Biogas yield potential of biogas plants effluents

With all usual installed systems, incomplete digested parts of substrates are to be found in the effluent. The efficiency of degradation can be very different, due to the used substrates, the modes of operation, the plant concepts and existing process stages between individual plants. Due to the structural conditions and setup of the plant, short-circuit streams in the digester can only be affected by adjusting the agitating management. Plants with high organic loading rates and short retention times have a tendency to a lower efficiency of degradation, and a high biogas yield potential remaining in the effluent. As an earlier research project showed, biogas yield potential in the biogas plants effluent can reach between 3 and 30 % [2]. Plants with a second digester stage can exploit this potential to a large degree. Already over half of the plants in Baden-Württemberg have two or more stages. Because of increasing risks of methane emissions into the atmosphere with high biogas yield potentials of the biogas plants´ effluent, it is to be evaluated as very positive that already 20 % of the plants have a gas-tight covered storage tank for the effluents.

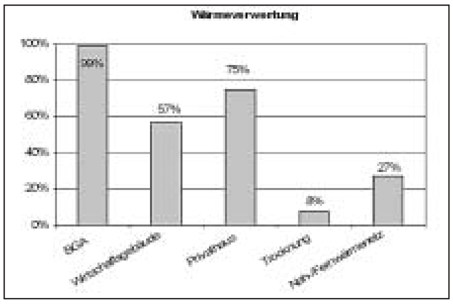

Fig. 3: Utilization of heat produced by 230 biogas plants

Heat utilization

By introducing a bonus for using thermal energy out of cogeneration ("KWK-Bonus" – "CHG-bonus") the heat utilization of heat energy produced by of the biogas process has increased strongly. This can be shown by the increased number of installed thermal-energy-counters (heat meter). Therefore already 70 % of the new plants are equipped with heat meters, which are necessary to measure the quantity of heat to get the CHG. With the CHG bonus, only the amount of heat is compensated which is purposefully used, less the quantity of heat, which is needed for the process of heating the digesters. Primarily heat is used in the private houses (75%) and the associated farm buildings e.g. the stables of the farms. In most cases further heat surplus still exists, it can be predicted, that there's an extremely developable utilization of heat potential. This is justified by the fact that the internal heat requirement of a digester has an annual average of approximately 30 % of the available heat. Only 35 % of the plants use their remaining usable heat to a larger degree. In 27 % of these cases there is a connection to a district or local heating system or net. Besides, adjoining houses or small housing developments, social institutions or municipal buildings (school, city hall, etc.) are also involved in the utilization of heat. With 8 % of the biogas plants the heat is used for the drying process of e.g. agricultural goods (hay, grain), wood (firewood, hogged wood) or local wastes (sewage sludge). Altogether only a 1/4 of the operators can deliver their surplus heat to external users.

In a farm the use of surplus heat energy contributes to the improvement of economy, as far as an existing infrastructure can be used. In addition to remuneration of each used kilowatt/hour (kWh) by the CHG bonus, direct fuel (fuel oil) can be saved or thermal energy can be sold to external users.