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Technical and Economical Operating Figures of Agricultural Biogas Plants

Operating figures are gaining in importance for evaluating biogas plants. Besides providing an insight into an individual plant, they allow vertical and horizontal ratings as well. For that purpose the evaluation criteria must be coordinated throughout the whole branch. The objective of this project was to catalogue operating figures to be the basis for successive projects and for discussions to attain a general consensus.

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This article is a result of the research project "Operating figures of agricultural biogas plants" by order of the BayStMLF. The project is a module of an external dissertation at the chair for agricultural economics at the Technical University of Munich (professor in ordinary: Prof. Dr. A. Heißenhuber).

Keywords

Agricultural biogas plant, term definitions, operating figures

The agricultural biogas plant increasingly establishes itself as a new branch of industry. Optimizing a single plant demands its permanent evaluation by technical and economical operating figures. For analyses or horizontal or vertical comparisons, the presently known operating figures apply only conditionally. The reasons are literal intersections as well as the missing of a close coordination between the collection of the data basis and the definitions of farm accountancy basic data.

So far, resulting disaccords were marginal because the making up of balances of biogas plants took place inside of institutions or associations. There, a uniform application was granted by the internal coordination. Rules and regulations were only published incompletely [1, 2]. Acting in the scope of the team "biogas" of the Bavarian State Research Centre for Agriculture (LfL), an interdisciplinary approach with researchers of the sections economics, agricultural engineering and plant cultivation is chosen. The database is from selected agricultural biogas plants, monitored and advised by researchers. The conclusions should be available directly or via the adviser for the single plant owner. The outcome of this is an information flow in many directions between the owners of the plant, the adviser, the consultants and last but not least the members of the biogas team. In order to avoid mistakes and get an efficient exchange of information, all members need and should apply a catalogue with biogas specific terms and operating figures. This catalogue was defined by the project "Operating figures of agricultural biogas plants." As far as possible, existing terms and definitions, conventions, standards and methods were borne in mind. The catalogue of operating figures is the proposal for a current coordination. A review takes place in the following project "Controlling the operating efficiency of agricultural biogas plants".

Modelling agricultural biogas plants

The definition of biogas specific terms and operating figures is based on a concept with five steps:

1. Definition of terms
2. Scope of accounting
3. Areas of accounting
4. Stock flows
5. Operating figures

To establish a basis for modelling agricultural biogas plants, biogas specific terms were defined (step 1). The definitions gather objects of a similar type under a similar term. This is like a first pre-modelling. For example labels the term "fermenting vat" every vat that has the function of pre-digestion, the main-digestion or after-digestion of a fermenting mixture.

These definitions enable to determine a border of accounting (step 2). The border of accounting explicitly marks off the biogas-specific things of a farm (i.e. investments, labour-input) to other non-biogasspecific things of a farm.

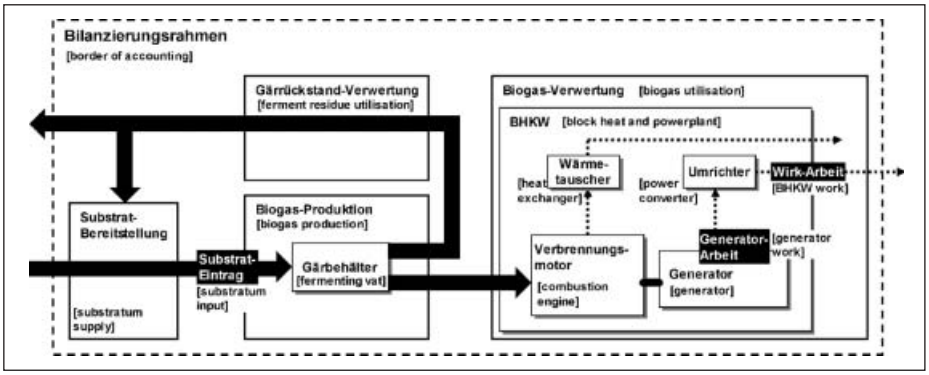

Fig. 1: Scheme of biogas production and energy recovery with selective objects and stock flows

Next, defined areas of accounting divide the border of accounting into several zones (step 3). Such sections are e.g. the substrate production, the substrate harvesting as well as the substrate transportation. This higher level of detail makes the handling of special problems, regarding to the biogas production and biogas utilisation, possible. Analysing the biogas plant, it is possible to group several areas of accounting individually. *Figure 1* shows the four procedural groups substrate-supply, biogas-production, biogas-utilisation and fermentation-residue-utilisation. The first group contains the above mentioned - but not shown in figure 1 - sections production, harvesting and transportation of substrate.

Border of accounting, areas of accounting and the groups of areas are identically for the economical, the procedural and the ecological accounting. So the figures of these three disciplines are comparable and can be related to each other.

Furthermore, stock flows were defined between the single areas of accounting (step 4). The term stock flow labels every flow of goods, services and rights into or out an area of accounting. On this note, stock flows are the labelled mapping of actually occurring flows of materials, money or other resources. Stock flows define what type of material is considered, what area of accounting is affected and whether it is either an inflow or an outflow. The stock flow substrate input for example labels exactly the substrate that passes the input aperture of the fermenting vat and hence is an inflow for the fermenting vat (Fig. 1).

It is important to distinguish between absolute (measurable) and derivative operating figures [3] (step 5). The definition of absolute operating figures is based on the information associated to the stock flows. In that context, stock flows have a multitude of attributes. E.g. imaginable attributes of the stock flow substrate input are the attribute fresh-mass or the dry matter contents. In that way every single combination of an attribute and a stock flow or an object determine an absolute operating figure. In the mentioned example these are the absolute operating figure fresh-mass-input and dry matter contents at the substrate input. Within this scheme, to every single value, directly collected on the biogas plant, a label of an absolute operating figure is assigned. Therefore every individual value is associated with the model by his label. Finally, also a computer software with the structure of the model is able to understand the values and calculate with this operating figures.

$$\text{Arbeitsausnutzung BHKW [ ]} = \frac{\text{Wirkarbeit BHKW [kWh]}}{\text{El. Nennleistung BHKW [kW] * Nennzeit BHKW [h]}}$$

$$\text{Auslastung BHKW [ ]} = \frac{\text{Wirkarbeit BHKW [kWh]}}{\text{El. Nennleistung BHKW [kW] * Betriebszeit BHKW [h]}}$$

$$\text{Arbeitsausnutzung Generator [ ]} = \frac{\text{Generatorarbeit Generator [kWh]}}{\text{El. Nennleistung Generator [kW] * Nennzeit Generator [h]}}$$

$$\text{Auslastung Generator [ ]} = \frac{\text{Generatorarbeit Generator [kWh]}}{\text{El. Nennleistung Generator [kW] * Betriebszeit Generator [h]}}$$

Fig 2: Calculated operating figures of the process

Derivative operating figures result from the mathematical accounting of several absolute operating figures. For example, the product of the two absolute operating figures fresh mass input and dry matter contents at the substrate input is equal to the derivative operating figure dry mass input.

Operating figures

The two easily confusable derivative operating figures degree of utilisation and load show the need for this methodical procedure:

Figure 1 schematically shows the stock flows generator energy (Generator-Arbeit), active energy (Wirk-Arbeit) as well as the objects combined heat and power unit (CHP [in Fig. 1 and 2 = BHKW]) and its integrated generator. At the biogas plant, the attributes work (Arbeit) of the stock flows are collected. The asset analysis contains the information about the attributes electrical nominal output (Nennleistung). Machine uptime (period of non use, no load, partial and full load) and the machine time on duty (period of no load, partial and full load) of the two objects CHP and generator is directly collected at the plant. Resultant is the data pool of *Table 1*.

These absolute operating figures can be used as data base to calculate several plant internal or spanning derivative operating figures. *Figure 2* shows the calculation of the derivative key figures degree of utilisation and load for the object CHP as well as for the object generator. Calculating the key figure load a nearly, a steady or semi-steady operation is assumed (that means at a constant load).

Stoffstrom / Objekt	Eigenschaft	Bezeichnung Kennzahl	Einheit
Generator-Arbeit	Arbeit (el. Energiemenge)	Generatorarbeit Generator	[kWh]
Wirk-Arbeit	Arbeit (el. Energiemenge)	Wirkarbeit BHKW	[kWh]
BHKW	Nennleistung (elektrisch)	El. Nennleistung BHKW	[kW]
BHKW	Nennzeit	Nennzeit BHKW	[h]
BHKW	Betriebszeit	Betriebszeit BHKW	[h]
Generator	Nennleistung (elektrisch)	El. Nennleistung Generator	[kW]
Generator	Nennzeit	Nennzeit Generator	[h]
Generator	Betriebszeit	Betriebszeit Generator	[h]

Tab 1: Measurable operating figures of the process

Conclusions

In this method, over 200 terms and key figures were defined. Every definition contains a unique term with description as well as – if existing - synonyms. The definitions of absolute key figures also contain the method of collecting and the classification into the above-mentioned biogas plant model. Regarding to derivative key figures, the definitions describe the calculating formula in detail und carry out a control of the units.

The definitions provide a basis for the development of a software in order to check the profitability of agricultural biogas plants. For the purpose of the project, the objective also is to use these definitions as a template for an upcoming and wide-accepted coordination. This coordination is necessary to enable supra-regional comparable technical and economical analyses of biogas plants. The editors of this article are aware of the fact that it is mere possible to establish this catalogue of key figures by finding a wide-spanning acceptance in the group of the biogas experts.

Literature

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