Autor: Rolf Kloss

Titel: A model as an instrument for determining the optimal layout of biogas plants with regard to technical and economical aspects

Institut: Institut für Technologie, Bundesforschungsanstalt für Landwirtschaft, 1983

Ursprünglich erschienen in:

Energy from biomass : 2nd E.C. Conference , International Conference on Biomass, Berlin, Federal Republic of Germany, 20 - 23 September 1982 / ed. by A. Strub .. . - London [u.a.] : Applied Science Publ., 1983. – ISBN 0-85334-196-6

A MODEL AS AN INSTRUMENT FOR DETERMINING THE OPTIMAL LAYOUT OF BIOGAS PLANTS WITH REGARD TO TECHNICAL AND ECONOMICAL ASPECTS

R. Kloss
Institut für Technologie, Bundesforschungsanstalt für Landwirtschaft,
Braunschweig-Völkenrode, Fed. Rep. of Germany

Summery

The aim of this work is to find out the best layout possible for a biogas plant under special concideration of technical and economical aspects. As method to answer this question a model has been created. In order to see the importance of the more than forty in this model implemented parameters they have been variated under practical conditions. The result of this investigation was that parameters as aim of the process, degree and method of gas utilization, related gross energy yield of the substrate fed, retention time, digester insulation, substrate temperature before feeding and the structure of the investment costs have a great influence on the economy of biogas plants.
The consequence is, that under the individual conditions of farms in the FRG, a certain chance can be seen, if the plant is optimated, which makes the use of biogas technology promising.

1. INTRODUCTION AND METHOD

The efficiency margin of a biogas plant is limited by the individual operational peripheral conditions of the very differantly structured farms and determined by the quality of the planning.

If a farmer wishes to start a biogas plant on his farm, than the relevant peripheral conditions must be analysed, and the best biogas plant from the technical and economic point of view must be determined under these conditions.

This solution must finally be examined by the farmer or by his agricultural adviser under economic criteria. A check should be made whether these investments have a certain advantageousness or relative superiority compared with others which can be made on the farm.

This kind of preparation demands a systematic way of working from the plant planner due to the manifoldness and interaction of the factors to be considered. In conjunction with a study using the example of the planning of a biogas plant for the production of heat for a pig-fattening farm, a model was developed which embraces all the essential factors determining the efficiency of a biogas plant. Subsequently the model was further supplemented so as to be suited to answer the question whether the biogas should, from an economic point of view, be used in each individual case for producing electricity and heat, alternately electricity and heat or only heat. For the purpose of advice, the model was used frequently. As the best solution for the plant can in many cases only be found by using a repetitive method, the model proved itself - as was to be expected - as full of figures. For this reason it was transferred to a microcomputer, which greatly simplified the application of the model. (1, 2)

More than 40 parameters are used in the model. The factors which determine the efficiency of a plant can be split up into three groups: annual receipts, annual expenditure and the necessary investment for the plant.

The annual receipts come about due to the savings in energy costs in the farm if a part of the operational energy is covered by biogas. Further savings or receipts can accrue to the farm through economic and egological advantages of the method. Receipts can possibly also be achieved by the advantages of some methods of manure economics.

However this point could not as yet be scientifically guaranteed.

The annual expenditure is composed of the wage costs for servicing the plant, the charges for various mechanisms such as pumps and stirring equipment, repair charges and the operational costs for the gas-using site of plants. The investment needed can be split up into the costs of the infra-structure, the reactor, the gas preparation, machine and installation rooms, adjustment to the energy needs, the gas-using side, the elimination of excess gas, engineer's contracts, building permits and other factors.

In order to establish whether general hints can be given about the planning of biogas plants, many of the above-mentioned parameters were, after previous analytical observation, altered within the area of values found in practice and their influence on plant efficiency was registered.

2. RESULTS

It was shown that, when planning any biogas plant, certain points should unconditionally be observed. The following realizations and principles should be considered:

- o the use of biogas is as its most efficient, if all the above-mentioned advantages of this process bear fruit. Normally, the energetical and ecological advantages of the method are highly inportant.
- o the use of the biogas process with the sole purpose of preparing energy is only promising if the peripheral conditions listed below can be fulfilled:
- the investment required per m^3 digester volume should, when fitting out the plant with a view to 20 days retention time for the freshly fed substrate, not exceed DM 1000/m^3, if the gas is exclusively to be burned. If the use of a heat-power-combination is being considered, then one should not exceed DM 1300/m^3.
- if the biogas is burned, the efficiency of the gas available from the plant should at least be higher than 50 %.
- in the case of a combined production of electricity and heat by a block heating-power unit, attention should be paid

to the fact that the electricity produced can fully be used on the farm. We do not advise feeding into the public mains. The heat produced should be used to more than 50 % on the farm.

- the use of a block heating-power unit is, with a view to the current market situation, only a serious opponent for mere gas-burning (under favourable peripheral conditions) from an electrical performance of at least 14 kW. For this, more than 100 livestock units are necessary.
- in order to gain a good energy balance, the plant should be fitted out in such a way that the gross energy output relating to the amount fed in exceeds 120 kWh/m^3. For an average biodegradability of the substrate, this means that it's dry matter content should be higher than 7 - 8 %.
  Plants with an even higher total solids concentration (e.g. through addition of plant material like straw or silage) or easily decomposible organic substance (liquid poultry manure) are because of their high performance output correspondingly more efficient.
- the best retention time for mesophilic biogas plants is between 20 and 25 days. It is only sensible to reduce it under quite special conditions (1).
- further, one should consider, when planning the plants, that even in winter the fresh substrate is fed in as warm as possible (10 - 15° C) and that the digester is well insulated against loss of heat (overall heat transfer figure k = 0,3 w/m^2 K).
- when adjusting the energy flow leaving the plant to the energy flow on the farm, one must take care that the energy stores (gas, warm water) necessary to solve this problem should, in order to keep costs low, not be made too large. Frequently, store capacities of merely some hundred kWh are satisfactory.
- the cost structure of the biogas process is characterized by the fact that a large part of the costs is almost entirely independent of the size of the digesting tank and thus comes up to a constant size. Thus the lower border of the economic operational area of the method is found, which, apart from a few exceptions, is between 50 and 100 livestock units.
- further decisive for the use of the biogas method is a good logistic arrangement of the substrate production point, the reactor, the manure storage tank and the place of gas utilization.

3. CONSEQUENCES

If we transfer the above-mentioned points to agricultural practice, then it is easy to recognize that the gaining of biogas is not attractive for the majority of the farms in the FRG. However there are small areas which make the use of the method appear interesting, above all if all the advantages of the method have been unequivocally recognized, correspondingly investigated and thus economically made evaluable.

The efficiency of various plants was investigated in several studies and reports. If in these cases we use the simplified calculation method described in (2) to define the plant's efficiency, then the probable point in time of paying-off the plants could, using the peripheral presumptions listed there, be estimated. They are between 12 and 16 years. This is of course only true if the plants totally fulfit the conditions to be imposed expecially from a technical point of view, i.e. if they function without error and reach the presumed life expectation of an average of 20 years.

If we ignore the teething troubles of the newer plants which have been running in the FRG for a maximum of 3 years, then the expectations associated with the biogas process do not appear totally unjustified.

4. LITERATURE

(1) Kloss, Rolf: Planning of energy-providing biogas plants by the example of a pig-fattening farm. Grundl. Landtechnik vol. 31 (1981) no. 2, pp. 64-74.

(2) Kloss, Rolf: Electricity or heat production from biogas? A model to determine the optimal form of biogas use in a technic-economic view. Grundl. Landtechnik vol. 32 (1982) no. 2, pp. 29-41.