BIOGAS PRODUCING TECHNOLOGIES IN LATVIA

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Abstract. The process of anaerobic digestion of waste with production of biogas and organic fertilizer at present is one of more perspective and friendly for environment way for the waste utilisation. Technologies with principal technological schemes are presented for most widespread waste. Some benefits and faults of technologies and equipment are analysed. Some examples for biogas producing possibilities are described.

Key words: biogas, waste, anaerobic digestion, biogas production technology.

Introduction

Over the last decade considerable efforts have been invested in developing of biogas producing technologies in many countries of EU [1]. The first purpose for biogas plant is the manure treatment for environment advantages, and the second purpose is to meet the growing energy demands in situation, while prices on fuel and energy are increasing drastically. Advantages of biogas technology (2):

Environmental

- the essential ecological advantage of biogas technology is that less greenhouse gas e.g. methane, laughing gas and carbon dioxide is emmitted. For example, amount of carbon dioxide (CO_2) utilized in biogas production is equal to same amount of CO_2, that was earlier imbibed by plants from environment; so there is no additional release of this greenhouse gas into the atmosphere during life cycle of plant materials;
- the anaerobic treatment improves the quality of manure. Odour emmission is reduced because substances with strong odour, such as volatile fatty acids or phenols are effectively decomposed. Both pumping ability and flowability were improved, due to homogenization in anaerobic fermentation process, so manure spreading in the field can be provided with high uniformity and quality;
- instead of dumping of organic materials, the residual fraction of anaerobic treatment can be used as a source of plant nutrients. From the same point of view the biogas technology is an ideal example of the recycling concept and local conversion of waste. So farmers can to fulfill an entirely new function in the community, as they process the organic waste from towns and villages;
- fermentation reduces the number of pathogenic microorganisms and the germination of weed seeds;
- another advantage is that less fertilizer and pesticides are needed. Fermented manure is an efficient substitute of mineral fertilizer and reduces the risk of drinking water contamination;
- biogas systems contribute to the climate protection goal of at least doubling the share of renewable energies by 2010, and the construction of biogas plants can to advance the sustainable development and to disseminate an environmentally compatible technologies;
- the acidification of the precipitation can be reduced.

Energetics

- biogas is suitable for the production of electricity and heat;
- biogas is suitable as fuel in vehicles;
- biogas is a renewable energy source, based on local raw material.

Economics

- fermented manure is a more powerful fertilizer than unfermented manure, because the mineralization process is responsible for a narrower C/N ratio and uptake of nutrients by plants is ongoing more easily. The manure can be applied directly to the crop during the growth phase;
- power and heat are generated in a combined process. The heat can be used for heating of separate buildings or utilized in industrial heating systems. Generated electricity earns at least 0.10 €/kWh for owner of biogas cogeneration plant with power over 500 kW (in Germany);
- the economic viability of rural areas increases.

For economically sound biogas plant the general role plays the right choice of technology and equipment for anaerobic digestion.

Anaerobic digestion technology

Biogas is generated in 4 step process; each step requires a different process environment and the steps are interconnected with each other to some extent.

Table 1 (3) lists the optimal environment. If an average methane generation time is prolonged up to 10 days, the methane forming bacteria will have low activity and slowly responds to substrate changes.

Table 1. **Environments at the different process stepa** (after Ohly, 2006)

Parameter	Hydrolysis/acidification	Methane production
Temperature	25 – 35 °C	mesophilic: 32 – 42 °C thermophilic: 50 – 58 °C
pH	5.2 – 6.3	6.7 – 7.5
C/N ratio	10 – 45	20 – 30
Solids	DM < 40% WM	DM < 30% WM
Nutrients C:N:P:S	500:15:5:3	600:15:5:3
Trace elements	No spec. needs	Ni, Co, Mo, Se
Generation time	24 – 36 h	10 – 15 d

The target of efficient operation of biogas plant should be to obtain the maximum available methane gas volume during shortest possible retention time (HRT).

Principal technological scheme

There are many variations of biogas plant technological principal scheme.

Fig. 1 shows the principal scheme of widespread German biogas plant [4], it is applicable for implementation in Latvia also.

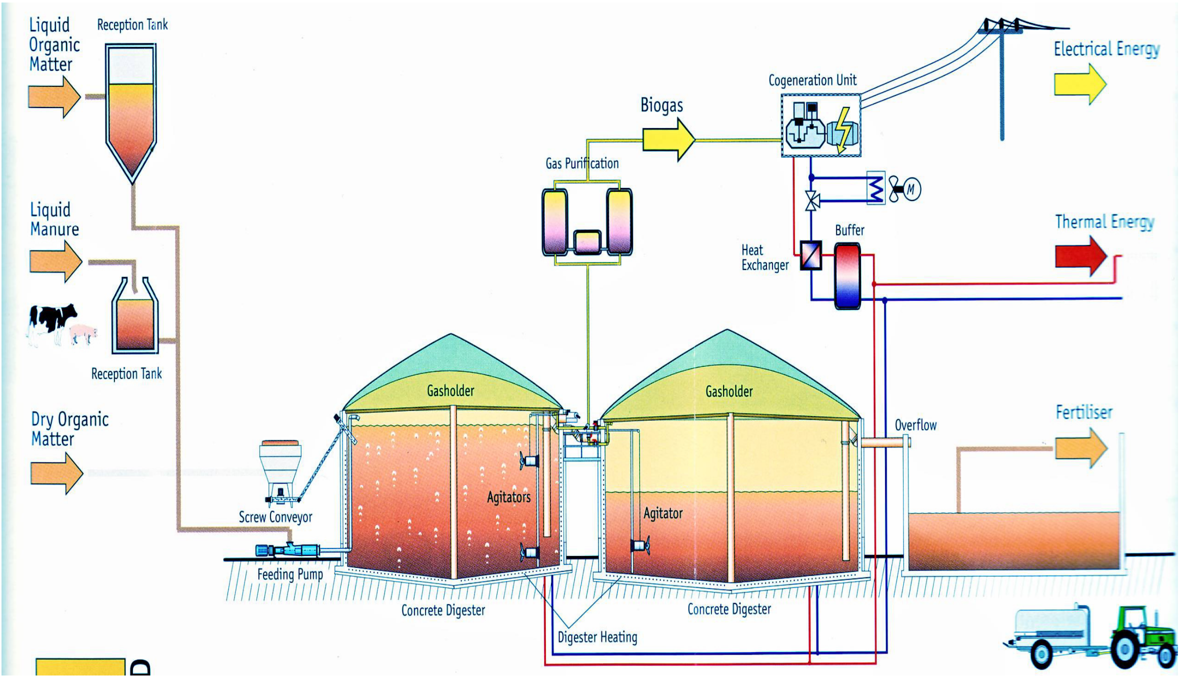

Fig. 1. **Principal scheme of widespread German biogas plant**

Elements of technological scheme

Choice of technological scheme for biogas plant is dependant from local environmental, technical and economical factors such as raw material, transporting distance, electricity and heat consumption needs etc. Many variations of technological schemes for utilisation of agriculture wastes can be combined from different biogas technology elements, see Fig. 2.

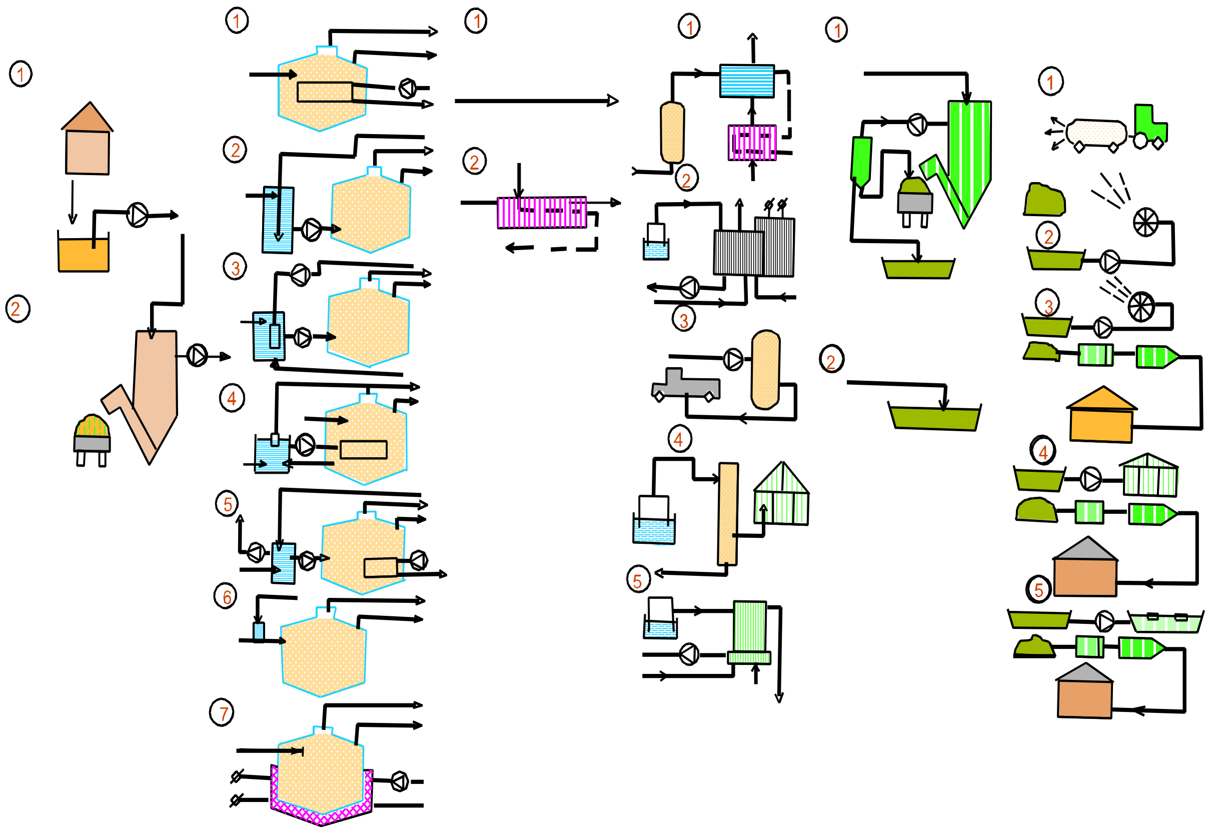

Fig. 2. **Biogas technology elements for design of biogas plant**

Description of elements

Pretreatment of raw materials:

1. without fractioning.
2. dividing to dry and wet fractions. Dry fraction to compost, wet to digester.
3. macerating and mixing.
4. sanitation.
5. silage or grass loading directly to fermenter help by conveyer.

Heating:

1. heating in digester.
2. heating in special heat exchanger outside of digester by hot water.
3. heating in special heat exchanger by steam.
4. heating in heat exchanger by gas-burner.
5. heating in heat exchanger by smoke gases and in digester
6. heating by steam in raw material flow
7. heating by electricity

Mixing:

1. mixing by mechanical device- horizontal.
2. mixing by propeller local.
3. mixing by biogas.
4. hydraulic mixing by pump.

Heat exchanging for digestate:

1. without heat exchanger to postfermentation tank or digestate storage.
2. with heat exchanger to digestate storage.
3. with heat exchanger to postfermentation tank.

Biogas utilization:

1. for steam and hot water.
2. for electricity and heat.
3. for vehicles.
4. fractioning of biogas into CH4 and CO2 (CO2 is utilised in greenhouse).
5. for regulated gas environments for conservation of agriculture products.

Digestate processing:

1. fractioning into dry and wet fractions in settling tanks, decanters, press or other equipment.
2. without fractioning.

Digestate utilization:

1. for fertilising by mobile transport.
2. dry fraction for mixing with compost for fertilising, wet fraction for watering of fields.
3. dry fraction as feed additive, wet for watering in green house.
4. dry fraction for feed additive, wet for watering of fields
5. dry fraction for feed additive, wet for fertilising of water hiacintes.

Schemes of digesters

Anaerobic digestion process is dependent from many factors. The main purpose for digesters is maintenance of enchanced media for bacteria activity. For agricultural wastes most well-known are schemes shown in Fig. 3.

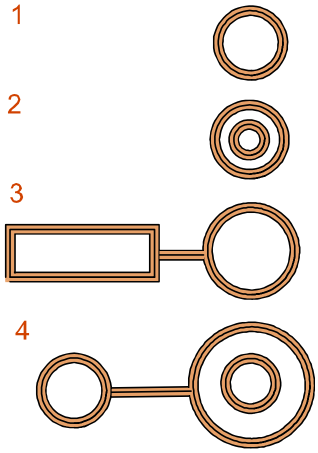

Fig. 3. **Well-known schemes of digesters for agricultural wastes**

Schemes (1-5) showed in Fig. 3 and Fig. 4 can be described as follows:

1. It is conventional mixing digester, where bacteria are mixed in single reservoir. It is simplest, but less effective.
2. Accordingly to this scheme digestion is provided in two stages, to ensure better conditions for bacteria for enhanced fermentation.
3. By this scheme hydrolysis stage takes place in horizontal tank mixing the different volumes. Better mixing ensures better bioconversion.
4. Two different variations are possible accordingly to this scheme: a) Fermentation process is divided into two stages, where after methane fermentation in central reservoir digestate is delivered to postfermentation section located in space surrounding the central section; b) When the hydrolysis process is completed, substrate is pumped to external section for next process stage with activation of acetogenic and facultative methanogenic bacteria and then delivered into central section, where are treated in media of strong anaerobic methanogenic bacteria. Such a method can be named as 3 stage fermentation process and can to provide the better bioconversion procedure.
5. In Fig.4, the horizontal digester is used for our module digester [5], that fit up the demands of bacteria to active in the most optimal conditions and as a result, there is a good bioconversion. Containers for c of bacteria are introduced to keep bacteria within same volume. Our technology based on:

- high temperature 54 ^{o}C thermophilic process, because it gives sanitation effect;
- short time HRT, because it can destroy only general part of quickly degradable part of organic matter;
- benefits for soil microorganisms for humus building.

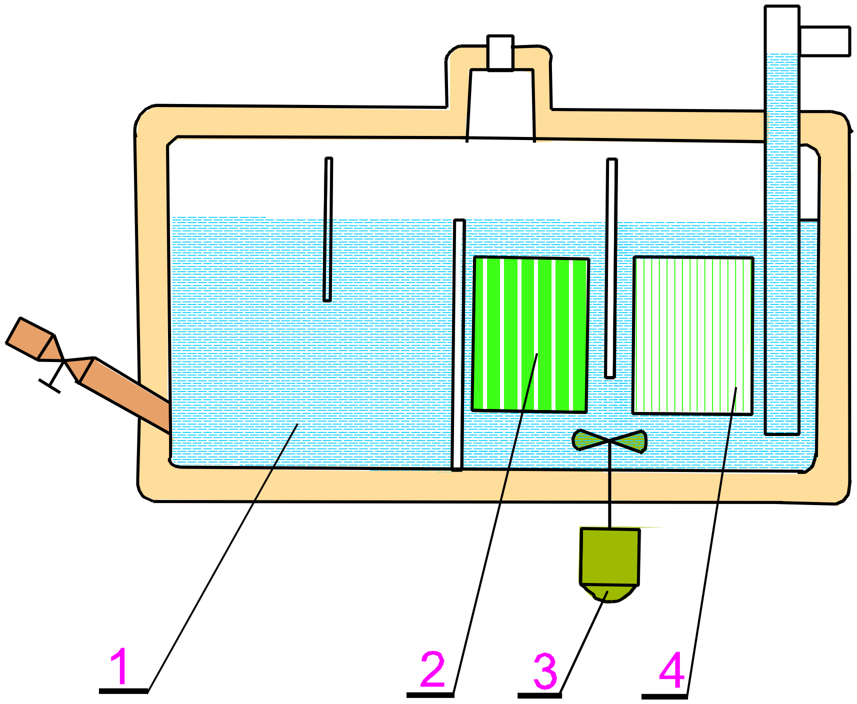

Fig. 4. **Horizontal module digester for optimal anaerobic treatment of biomass**:
1 – substrate; 2 – container for bacteria immobilization; 3 – mixing device;
4 – container for immobilization of methane bacteria

Every of above mentioned schemes have advantages and some disadvantages. Local recourses, technical and economical conditions should be considered for proper selection of suitable technology.

The most common schemes, used in Germany [6] are shown in Fig. 5.

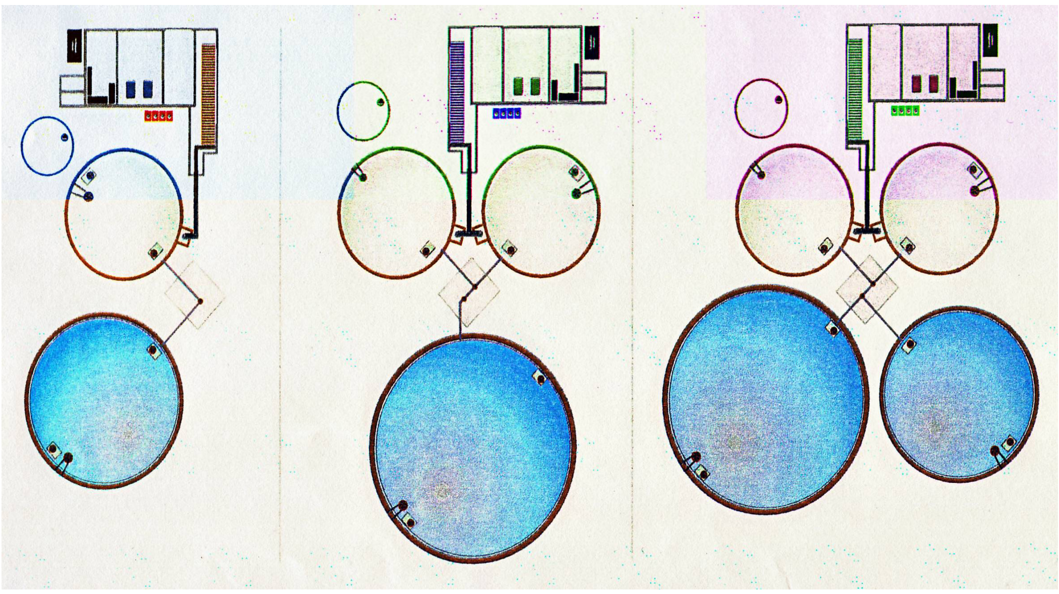

Fig. 5. **Most common schemes of digesters, used in Germany**

There is tank for homogenisation, device for loading of silage or other raw material, one or more large digesters and postfermentation storage together with gasholder of large volume. Large digesters are built in Germany, due to very long hydraulic retention time (HRT) of treated biomass.

In Denmark is obtained the vast experience for anaerobic digestion of agricultural waste [7], and digesters there are smaller, HRT is shorter, as the manure degrades more quickly, therefore many biogas plants are working at thermophilic temperatures. Fermentation process schemes are similar in both countries, but in Denmark usage of two smaller digesters are preferred rather than one large, that is usual scheme in Germany. It gives possibility for fast renovation of stable anaerobic digestion process, if there failure of process happens. As the digesters features relatively simple construction with high materials and labour consumption, it is foreseeable establishing of domestic companies for production of elements and units for biogas production plants in Latvia.

Conclusions

1. Introduction of biogas technologies in Latvia can give benefits for environment, energy producing and economy.
2. Appropriate technology for biogas production can be selected, based on analytical consideration of presented elements of technological schemes.
3. Presented schemes of digesters give initial information on advanced Western European equipment for usage in adequate local conditions.
4. Biogas production equipment and technologies can be transferred from Denmark or Germany, but there are not principal problems to initiate the low-cost production of some domestic elements or whole biogas plants in Latvia.

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