TECHNOLOGIES FOR BIOGAS PRODUCTION IN AGRICULTURE OF LATVIA

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Abstract. 40 % of energy in Latvia is foreseen to be produced in 2020 from renewable resources. Fast development of biogas production, as most perspective, started in recent years. The Ministry of Economics of Latvia planned for 2011 quotas for producing 467 000 MWh electricity from biogas with increased tariffs. 58 new biogas plants will be built. The owners are mostly farmers, which have big farms and land. The proposed technologies and equipment suitable for the local conditions of Latvia are analysed. The advantages and disadvantages are presented, conclusions and proposals are elaborated.

Keywords: biogas; waste; anaerobic digestion; biogas production technology.

Introduction

The process of anaerobic digestion of waste with production of biogas and organic fertilizer at present is one of the most perspective and friendly for environment ways for waste utilization. Over the last decade considerable efforts have been invested in developing of biogas production technologies in many countries of the EU [1]. The first purpose for biogas plant is manure treatment for environment advantages, and the second purpose is to meet the growing energy demands in the situation, while the prices on fuel and energy are increasing drastically. The 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 are emitted.
- the anaerobic treatment improves the quality of manure. Odor emission is reduced because the substances with strong odor, such as volatile fatty acids or phenols are effectively decomposed.
- instead of dumping of organic materials, the residual fraction of anaerobic treatment can be used as a source of plant nutrients.
- fermentation reduces the number of pathogenic microorganisms and the germination of weed seeds;
- another advantage is that less fertilizers and pesticides are needed. Fermented manure is an efficient substitute of mineral fertilizers 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.

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

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.
- 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.
- the economic viability of rural areas increases [3].

Activities for rapid development of biogas technologies started only some years ago after the government support with increased feed in tariffs. This year 58 biogas plants are planned to be built. The quota for selling electricity in grid is shown in Table1.

For an economically sound biogas plant the general role is played by the right choice of the technology and equipment for anaerobic digestion.

Table 1

Power of electricity production from biogas in Latvia MWel

Years	2001-2009	2010.1.10	Forecast 2011	Quota 2011 MWh	According to Action Plan 2020
Landfills	6.11	6.11	6.11	-	-
Sewage	2.10	2.10	2.10	-	-
Agriculture	0.26	1.76	62.25	-	-
Stillage	-	-	2.50	-	-
Total	8.47	10.37	72.96	467959.00	92.00

Materials and methods

Anaerobic digestion technology

Biogas is generated in a 4 step process; each step requires a different process environment and the steps are interconnected with each other to some extent. If the average methane generation time is prolonged up to 10 days, the methane forming bacteria will have low activity and slowly respond to substrate changes. The target of efficient operation of a biogas plant should be to obtain the maximum available methane gas volume during the shortest possible retention time (HRT).

Principal technological scheme

There are many variations of biogas plant technological principal schemes. The principal technological schemes for biogas plants, which are developing in Latvia, are shown in Fig.1. There is a tank for homogenisation, device for loading of silage or other raw material, one or more large digesters and postfermentation storage together with a gasholder of large volume. The large digesters are built in Germany, due to very long hydraulic retention time (HRT) of the treated biomass. In Denmark vast experience is obtained for anaerobic digestion of agricultural waste, and the digesters there are smaller, HRT is shorter, as manure degrades more quickly, therefore many biogas plants are working at thermophilic temperatures. The fermentation process schemes are similar in both countries, but in Denmark the usage of two smaller digesters is preferred rather than one large, that is a usual scheme in Germany. It gives a possibility for fast renovation of a stable anaerobic digestion process, if failure of the process happens. As the digesters feature a relatively simple construction with high material and labour consumption, it is foreseeable establishing of domestic companies for production of elements and units for biogas production plants in Latvia.

Scheme 1 – widespread in Germany for biogas production from silage and manure. The advantage of this scheme is a possibility to collect biogas from biomass, which has not been digested in the fermenter from the postfermenter. The disadvantage is a need for additional investment for the postfermenter.

Scheme 2 **–** a biogas plant working without a postfermenter, but there is special equipment for good macerating, homogenisating and weighting all kinds of raw material. This gives an advantage better through computer to control and to manage the processes. The disadvantage is – some part of biogas from not digested biomass is not collected and additional expenses for the equipment for homogenization.

Scheme 3 **–** there are used two (or more for big plants) parallel fermenters and postfermenters, which are made of one module volume. The advantage is that if there are some problems with the biological process in one fermenter, then it is possible to take help from the other fermenter and to stabilize the process quicker. The disadvantage- more expensive.

Scheme 4 **–** similar as scheme 3, but for postfermentation one tank is used. The advantage-cheaper than scheme 3.

Scheme 5 **–** the fermenter and postfermenter have one roof, there is a space for hydrolyses, too. The plant is working as a three stage plant. The advantage is less energy consumption for heating. The disadvantage is mixing by biogas, which is circulating from the gas space through the substrate and air gets in contact with methanegens.

Scheme 6 **–** used for big biogas plants, when raw material loading in the fermenter is needed to be organized from more places, but it is possible to build the postfermenter larger. The advantage- economy of money, but disadvantage- for a big tank there is a need for additional mixers.

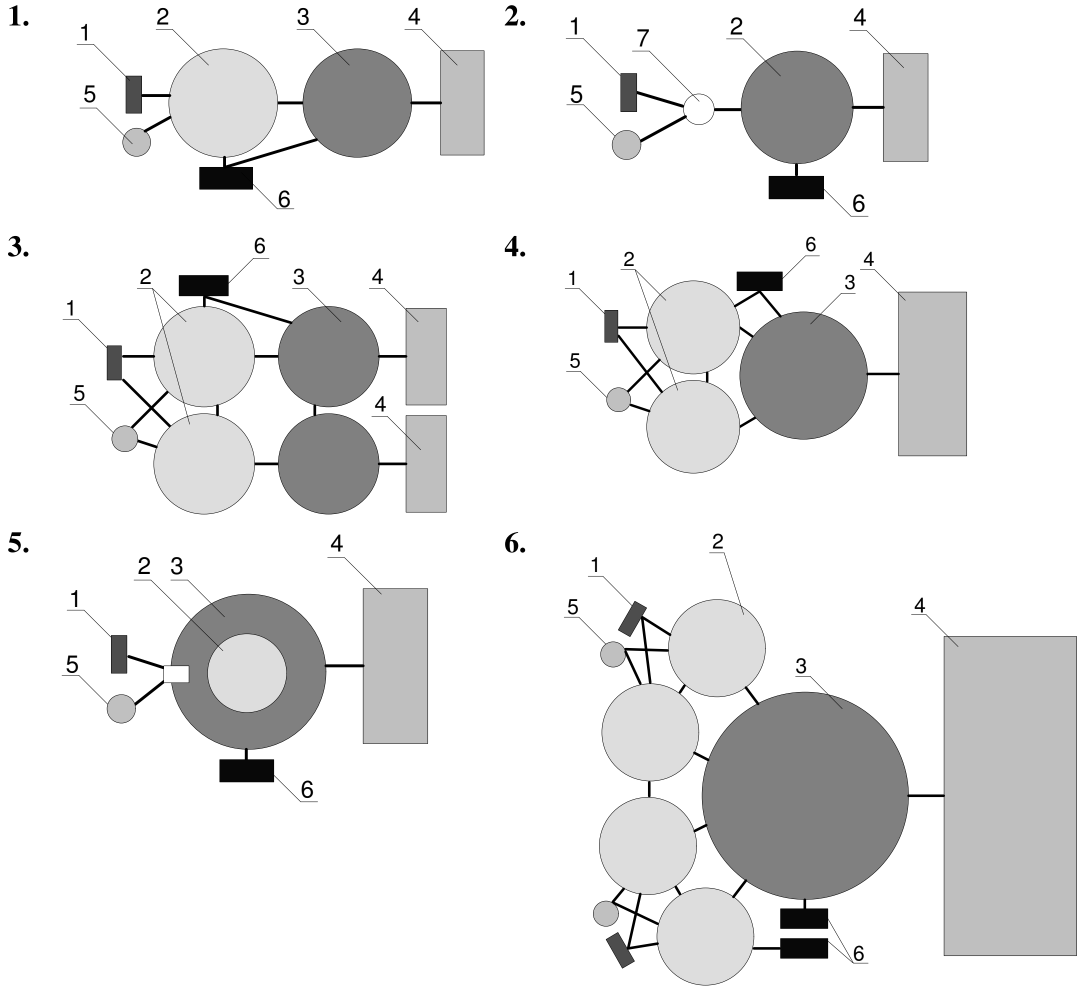

Fig. 1. **Principal technological schemes for Latvia biogas plants:** 1 – tank for dry biomass; 2 – fermenter; 3 – postfermenter; 4 – digestate storage; 5 – wet biomass tank; 6 – CHP unit; 7 – tank for homogenisation

Elements of technological scheme

The choice of the technological scheme for a biogas plant is dependent on the local environmental, technical and economical factors such as the raw material, transporting distance, electricity and heat consumption needs etc. Many variations of technological schemes for utilization of agriculture waste can be combined from different biogas technology elements, see Fig.2

Description of elements

Pretreatment of raw materials: 1 – without fractioning. 2 – dividing to dry and wet fractions. Dry fraction for compost, wet to the digester. 3 – macerating and mixing. 4 – sanitation. 5 – silage or grass loading directly to the fermenter by help of a conveyer.

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

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

Heat exchanging for digestate: 1 – without a heat exchanger to the postfermentation tank or digestate storage. 2 – with the heat exchanger to the digestate storage. 3 – with the heat exchanger to the postfermentation tank.

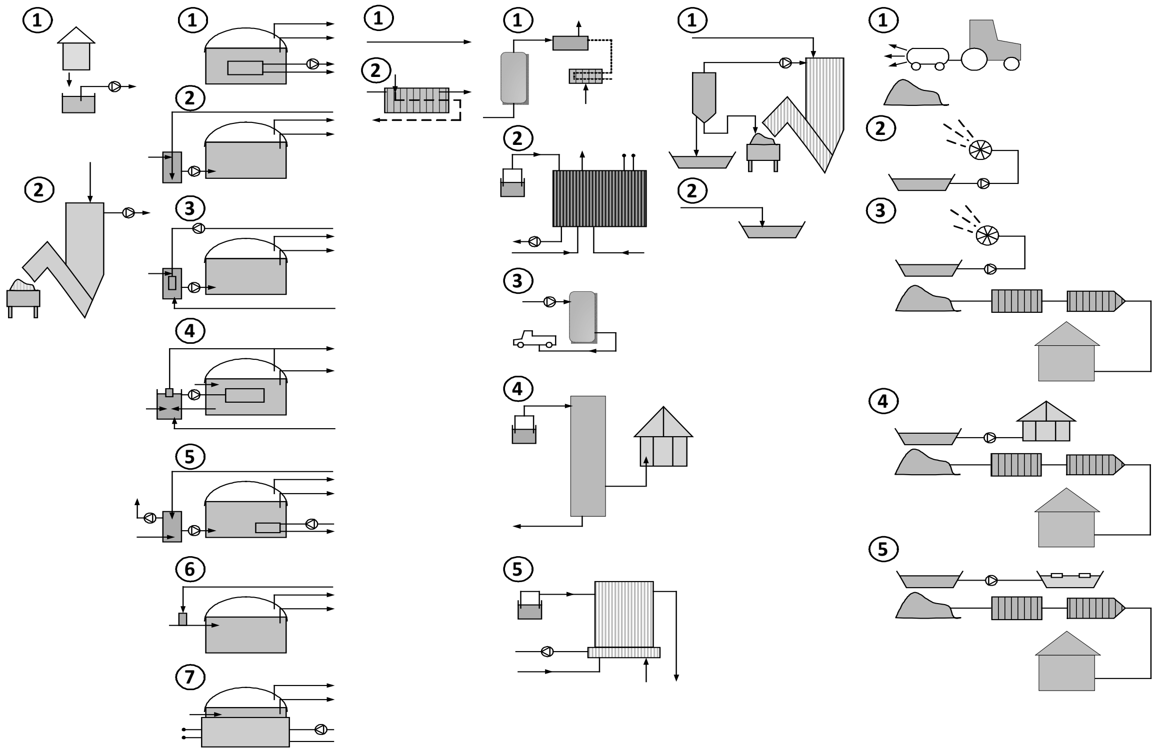

Fig. 2. **Biogas technology elements for design of biogas plant**

Biogas utilization: 1 – for steam and hot water. 2 – for electricity and heat. 3 – for vehicles. 4 – fractioning of biogas into CH_4 and CO_2 (CO_2 is utilized in greenhouses). 5 – for regulated gas environments for conservation of agricultural 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 fertilizing by mobile transport. 2 – dry fraction for mixing with compost for fertilizing, wet fraction for watering of fields. 3 – dry fraction as feed additive, wet for watering in greenhouses. 4 – dry fraction for feed additive, wet for watering of fields. 5 – dry fraction for feed additive, wet for fertilizing of water hyacinths.

Schemes of digesters

The anaerobic digestion process is dependent on many factors. The main purpose for the digesters is maintenance of enhanced media for bacteria activity. The schemes shown in Fig.3 are the most well-known for agricultural waste.

1. It is a conventional mixing digester, where bacteria are mixed in a single reservoir. It is the simplest, but less effective.
2. According to this scheme digestion is provided in two stages, this ensures better conditions for bacteria for enhanced fermentation.
3. By this scheme the hydrolysis stage takes place in the horizontal tank mixing the different volumes. Better mixing ensures better bioconversion.
4. Two different variations are possible according to this scheme: a) The fermentation process is divided into two stages, where after methane fermentation in the central reservoir digestate is delivered to the postfermentation section located in the space surrounding the central section; b) When the hydrolysis process is completed, the substrate is pumped to the external section for the next process stage with activation of acetogenic and facultative methanegenic bacteria and then delivered into the central section, where treated in media of strong anaerobic methanegenic

bacteria. Such a method can be named as a three stage fermentation process and can provide better bioconversion procedure.

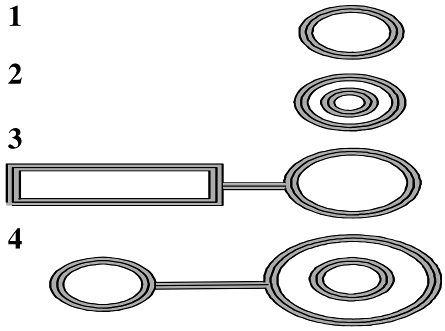

Fig. 3. **Schemes of digesters for agricultural waste**

In Fig. 4 the four stage digester made in our laboratory is shown, which is used for our module digester , that fits up the demands of bacteria to be active in the most optimal conditions and as a result, there is a good bioconversion.

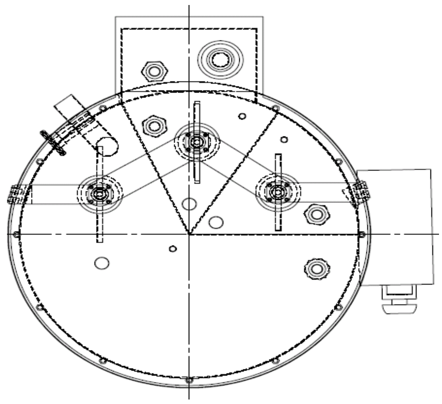

Fig. 4. **Four stage digester for anaerobic treatment of biomass**

By this scheme the hydrolysis stage takes place in the compartment 1 and partly the second compartment of the bioreactor, acidification in the second compartment and partly compartment 3, acetofication in compartment 3 and partly compartment 4, but methanegenesis in compartment 4. Substrate mixing proceeds in each volume. Better mixing ensures better bioconversion.

Results and discussion

Preliminary results for digesting of cow manure in this digester are shown in Fig.5 and Fig.6.

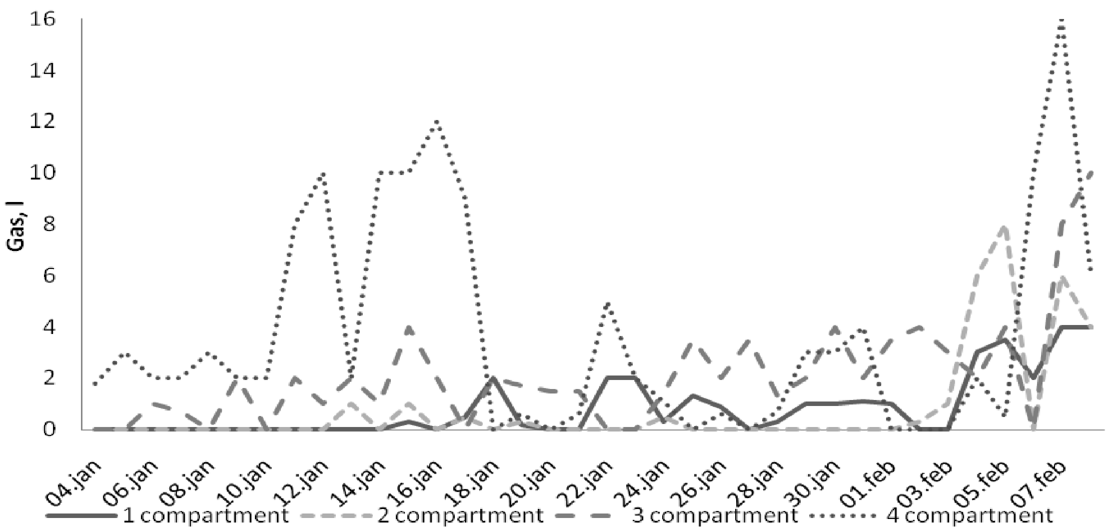

Fig. 5. **Preliminary results from four stage digester for anaerobic treatment of biomass:** the yield of gas from compartments

Every of the above mentioned schemes has advantages and some disadvantages. The local resources, technical and economical conditions should be considered for proper selection of the suitable technology.

Study during the first biogas significantly more benefits from compartments 3, 4 and some of the compartments 1 and 2. After a month of gas production in the second and compartment 1 increased. This could be explained by higher facultative anaerobic microorganisms present in these compartments.

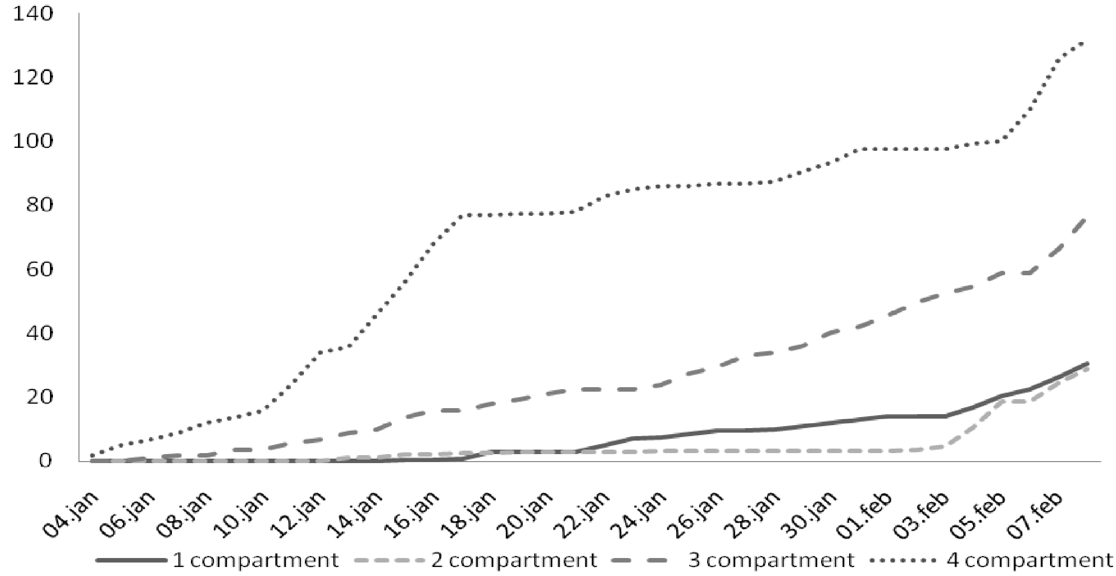

Fig. 6. **Preliminary results from four stage digester for anaerobic treatment of biomass:** cumulative gas evolution

Conclusions

1. Introduction of biogas technologies in Latvia can give benefits for environment, energy producing and economy. Latvian biogas production is well placed to continue the success.
2. An appropriate technology for biogas production can be selected, based on analytical consideration of the presented elements of the technological schemes. The choice depends on the available raw materials, heat and digestate using options.
3. The presented schemes of digesters give initial information on advanced Western European equipment for usage in adequate local conditions. The biogas production equipment and technologies can be transferred from Denmark or Germany, but there are not principal problems to initiate low-cost production of some domestic elements (such as conveyors, tanks, ladders, etc.) or whole biogas plants in Latvia. The results from our digester show it.

References

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