OPTIONS FOR REDUCTION OF MAIZE SILAGE IN BIOGAS PLANT DRAZENCI

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Abstract: *The aim of the research is to compare the yield of biogas and methane in the biogas plant Drazenci in the current production of biogas compared with biogas produced using a lower proportion of maize silage on the basis of theoretical calculations. Calculations for three different scenarios for the recovery of biogas and methane have been made and then the scenarios compared. For the current production the biogas plant uses poultry manure, corn silage and waste fats in the ratio 70:25:5. The total yield of 148* m^3 *of biogas/t fresh weight and the yield of 90.16* m^3 *of methane with one ton input substrate mixture were calculated. It was found that the highest yield of biogas and methane was obtained in scenario 1 which is currently applied in the biogas plant Drazenci. When comparing the calculated values for yield, it has been found that there are options for reducing corn silage in the input substrate, which may be replaced by waste fats that feature high energy potential.*

Key words: *biogas plant, poultry manure, biogas production, corn silage, methane*

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1. Introduction

Agricultural residues, including manure and energy crops, represent an important source of biomass that can serve as a substrate in anaerobic digestion, resulting in the production o f renewable energy. Within EU, these types of biomasses could amount to 1545 million tonnes per year, if 760 tonnes of energy crops were produced each year (Vindis et al., 2008). Sustainable biogas production from energy crops must not be based on maximum yields from single crops, but on maximum methane yield from sustainable and environmentally friendly crop rotations (Amon et al., 2007).

Traditionally it is primarily manure that is digested in farm-scale digesters. However, in Germany, where substantial subsidies are provided for electricity produced from biogas which is produced on a farm scale, energy crops are used as co-substrates in more than 90% of the digesters to increase the gas yield (Weiland, 2003).

Biogas is a mixture of gases resulting from the anaerobic fermentation (without presence of oxygen) in the biogas plant, under certain conditions (temperature, pressure). The collapse of biomass and animal by-products is carried out by means of decomposition of microorganisms or bacteria (Crolla & Kinsley, 2010). Biogas is most commonly used in cogeneration units allowing production of electricity and heat. Biogas as a renewable source of energy can be produced mainly from all organic materials containing a satisfactory ratio between carbon and nitrogen (Monnet, 2003).

In the process of anaerobic fermentation undesirable products are caused dangerous for the environment due to the presence of greenhouse gases. For biogas production the animal by-products, energy crops, municipal waste, waste processed in food industry and waste from households are used. When cleaning the biogas, which runs through various processes, it is particularly important to remove most of the unwanted impurities and raise the proportion of methane. Biogas cleaned up to the level where it can be replaced by natural gas, is known as bio methane (Jejčič, 2010).

The purpose of the study is to determine what the yield of methane and biogas in the biogas production in biogas plant Drazenci (Fig. 1) is compared with biogas produced from a lower proportion of maize silage in raw material input. We will compare the amount of input and output materials, the most important being the yield of biogas and methane. We are interested in the comparison of biogas in the plant Drazenci (current production) with biogas produced with a lower percentage of corn silage.

The aim of the research is to show different possibilities of maintaining the same level of production of biogas (methane) with a lower proportion of maize silage as input for biogas production and to obtain data of yield of biogas and methane production for different options of production.

Fig. 1. Biogas plant Drazenci

1.1 Biogas composition

Composition of biogas depends primarily on the biogas production method and the conditions in which it originates. In the process of anaerobic fermentation it is possible to use all kinds of biomass containing fats, proteins, carbohydrates, cellulose and hemicellulose (Braun, 2003) as main ingredients. The composition of the biogas is mainly affected by the efficiency of anaerobic fermentation process, the residence time and the substrate itself (Braun, 2007).

In general, the biogas composition is shown in Table 1.

Methane (%)	CH_4	50-75
Hydrogen sulphide (%)	H_2S	0-1
Hydrogen (%)	H_2	0-1
Nitrogen (%)	N_2	0-3
Oxygen (%)	O_2	0-1
Water steam (%)	H_2O	2-7
Carbon dioxide (%)	CO_2	25-45
Ammonia (%)	NH_3	0-0,5

Tab. 1. Biogas composition

2. Methods

2.1 Presentation of possible scenarios

Herebelow, 3 different possible scenarios will be presented assumed and calculated on theoretic basis. Substrates used in experiment are poultry manure with bedding, corn silage and floating fat. Table 2 shows the composition of materials and biogas yield for input materials in our experiment.

All ratios are listed in the following order: poultry manure, corn silage and waste fats, where maize silage was not used (the ratio of poultry manure and waste fats).

SUBSTRATE	Dry matter (% of fresh mass)	Dry organic matter (% of fresh mass)	m^3 CH_4/t dry organic matter	CH_4 (vol %)	m^3 biogas/t fresh mass
Poultry manure with bedding	32	24	350	65	130
Corn silage	33	31,7	330	52,5	200
Floating fat	15	13,5	680	68	140

Tab. 2. Substrates used in the experiment, their composition and yield of biogas

2.1.1 Presentation of scenario 1

In the first scenario the current production of biogas takes place in the plant Drazenci . They currently produce biogas from 70% of poultry manure, 25% corn silage and 5% fat. According to the available substrates, in two different possible scenarios a 10% increase of the share of poultry manure would be considered, because it abounds, while corn silage represents a cost and is originally intended for animal nutrition on their farms. Measurements of biogas and methane are measured automatically and are controlled via the on-line system as shown in Figure 2.

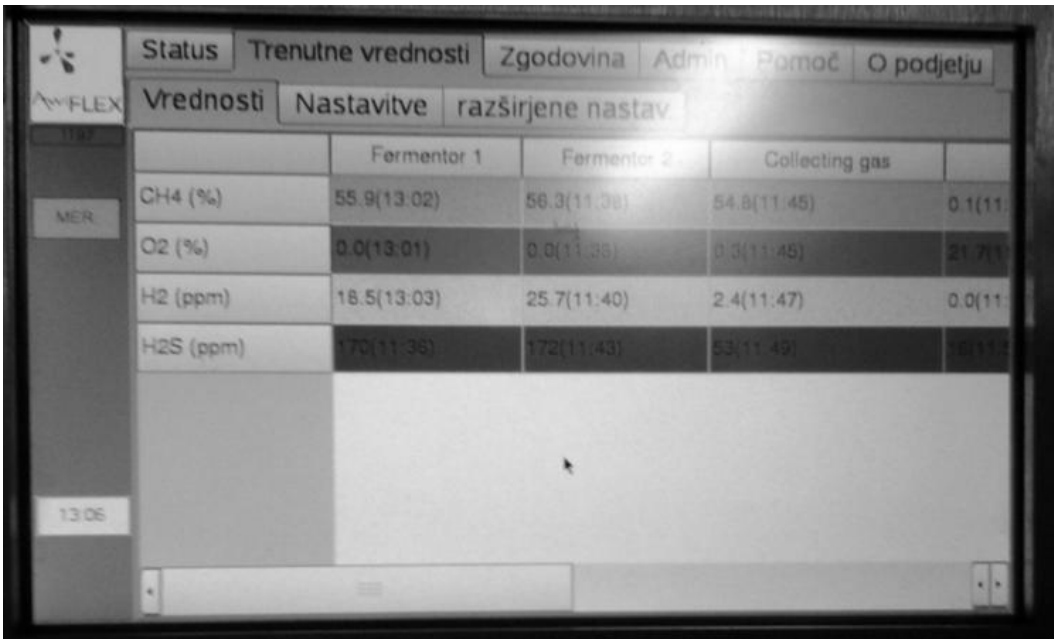

Fig. 2. Display of current values of individual gases in the substrate mixture

On the screen it is possible to see different values of individual gases for fermenter 1 and fermenter 2. It shows the measured values for methane, oxygen and hydrogen in percentages and sulphide (H_2S) in ppm. Figure 2 shows the current value of the biogas composition according to the first scenario, where the proportion of methane in the fermenter 1 is 55.9% and in the fermenter 2 56.3%. In the total biogas the methane proportion is 54.8%. Oxygen contents are under 1%, which indicates the anaerobic fermentation. The biggest problem is the sulphide (H_2S), since it is necessary to strive for its lowest possible value.

Figure 3 shows two horizontal fermenters, which are a specialty of biogas plant Drazenci and allow measurements of gas.

Fig. 3. Two horizontal fermenters of the biogas plant Drazenci

2.1.2 Presentation of scenario 2

In the second possible scenario, the content of maize silage in the input substrate was reduced for 10% and waste fat increased for 10%. The main input substrate poultry manure was retained in the same amount as in scenario 1. Substrates in scenario 2 appear in the ratio of 70% poultry manure, 15% corn silage and 15% of waste fats.

2.1.3 Presentation of scenario 3

In the third possible scenario, the content of the main substrate poultry manure was increased for 10%, ie from 70 to 80%. Taking into account the initial value, the content of corn silage in the input substrate was reduced for 15% from 25 to 10%. The content of waste fats was increased from the original 5% to 10%.

3. Results

In the results the amount of produced biogas and methane will be compared scenario by scenario. The results for each scenario were first shown in the tables. For illustration for each scenario graphic display showing the yield of biogas and methane was made. For scenario 1 the dry matter content and the dry organic matter were calculated in relation to the amount of input substrate mixture.

3.1 Results of scenario 1

Table 3 shows the calculation of dry matter content and the content of organic dry matter in relation to the quantity of the substrate and in relation to dry matter and dry organic matter in the substrate listed in Table 2. Table 3 shows that poultry manure constitutes 70% of the total input substrate, i.e. 0.7 ton of poultry manure per ton of input substrate. Dry matter represents 0,224 tons while dry organic matter 0,168 tons. Corn silage represents a quarter of the total input substrate. In the 0.25 ton of corn silage the dry matter content is 82.5 kilograms, the proportion of dry organic matter is 79.25 kg. The least proportion is waste fat which is only 5%. In the 50 kg of waste fat the percentage of the dry matter is 7.5 kg while the proportion of organic dry matter is 6.75 kg.

Substrate	Quantity (t)	Dry matter (t)	Dry organic matter (t)
Poultry manure	0,7	0,224	0,168
Corn silage	0,25	0,0825	0,07925
Used fats	0,05	0,0075	0,00675
TOTAL	1	0,314	0,254

Tab. 3. The amount of substrate (t), dry matter content (t) and the content of dry organic matter (t) per ton of substrate mixture according to the scenario 1

Table 4 shows the calculations for the biogas and methane yield for scenario 1 with one ton of the total input substrate. The poultry manure, which appears also in the maximum percentage in the input substrate, produces the maximum yield of biogas and methane, namely 91m^3 of biogas and 59,15m^3 of methane. With 25% share of maize silage in the input substrate the calculated yield is 50m^3 of biogas and 26,25m^3 of methane. Used fats which appear in the input substrate also in the lowest percentage give the lowest yield of biogas. The yield is 7m^3 of biogas and 4,76m^3 of methane. Total biogas yield for scenario 1 is 148 m^3/t fresh mass while total methane yield is 90.16 m^3 with one ton of input substrate mixture. The last column of Table 4 shows methane yield in m^3/t dry organic matter and can be compared with results from literature (Al seadi et al., 2010).

Substrate	Quantity of the substrate (t)	Biogas yield (m^3/t of fresh mass)	Biogas yield (m^3/ fresh mass)	Methane content (%)	Methane yield (m^3)	Methane yield (m^3/t dry organic matter)
Poultry manure	0,7	130	91	65	59,15	58,8
Corn silage	0,25	200	50	52,5	26,25	26,15
Used fats	0,05	140	7	68	4,76	4,6
TOTAL	1		**148**		**90,16**	**89,55**

Tab. 4. Biogas and methane yield (m^3) for scenario 1

Figure 4 shows that the maximum yield of biogas and methane is produced by poultry manure which appears in the input substrate in maximum percentage. Less yield of biogas and methane is from maize silage, while the smallest yield of biogas is from waste fats which represent only 5% of the total input substrate.

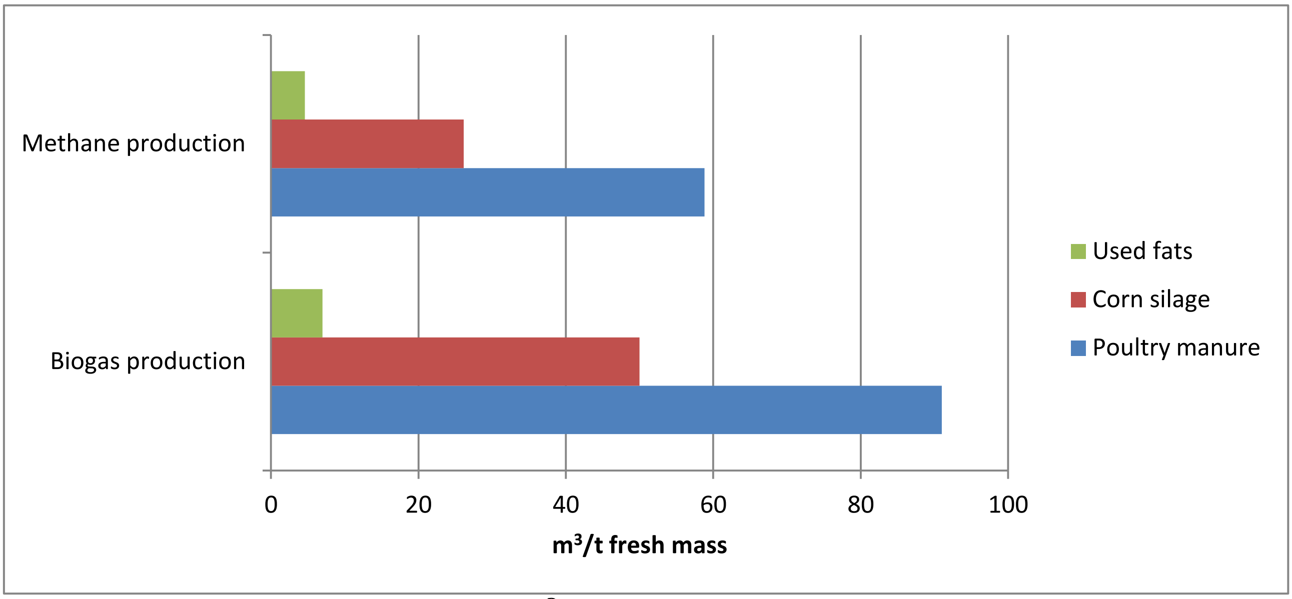

Fig. 4. Biogas and methane yield (m^3/t fresh mass) for scenario 1

3.2 Results of scenario 2

Table 5 shows the calculations for the biogas and methane yield for scenario 2 with one ton of the total input substrate. The maximum yield of biogas and methane is produced by poultry manure, which appears also in the maximum percentage in the input substrate, namely 91m^3 of biogas and 59,15m^3 of methane. With 15% share of maize silage in the input substrate a yield of 30m^3 of biogas and 15,75m^3 of methane is obtained; the lowest yield of biogas is obtained from used fats. Biogas yield from used fats is 21m^3 and methane yield 14,28m^3. Total biogas yield for scenario 2 is 142 m^3/t fresh mass while total methane yield is 89.18 m^3 per ton of input substrate mixture.

Substrate	Quantity of the substrate (t)	Biogas yield (m^3/t of fresh mass)	Biogas yield (m^3/ fresh mass)	Methane content (%)	Methane yield (m^3)	Methane yield (m^3/t dry organic matter)
Poultry manure	0,7	130	91	65	59,15	58,8
Corn silage	0,15	200	30	52,5	15,75	15,7
Used fats	0,15	140	21	68	14,28	13,77
TOTAL	1		**142**		**89,18**	**88,27**

Tab. 5. Biogas and methane yield (m^3) for scenario 2

Figure 5 shows that the maximum yield of biogas and methane is produced by poultry manure, which appears in the input substrate in maximum percentage. Less yield of biogas and methane is from maize silage, while the smallest yield of biogas is from used fats.

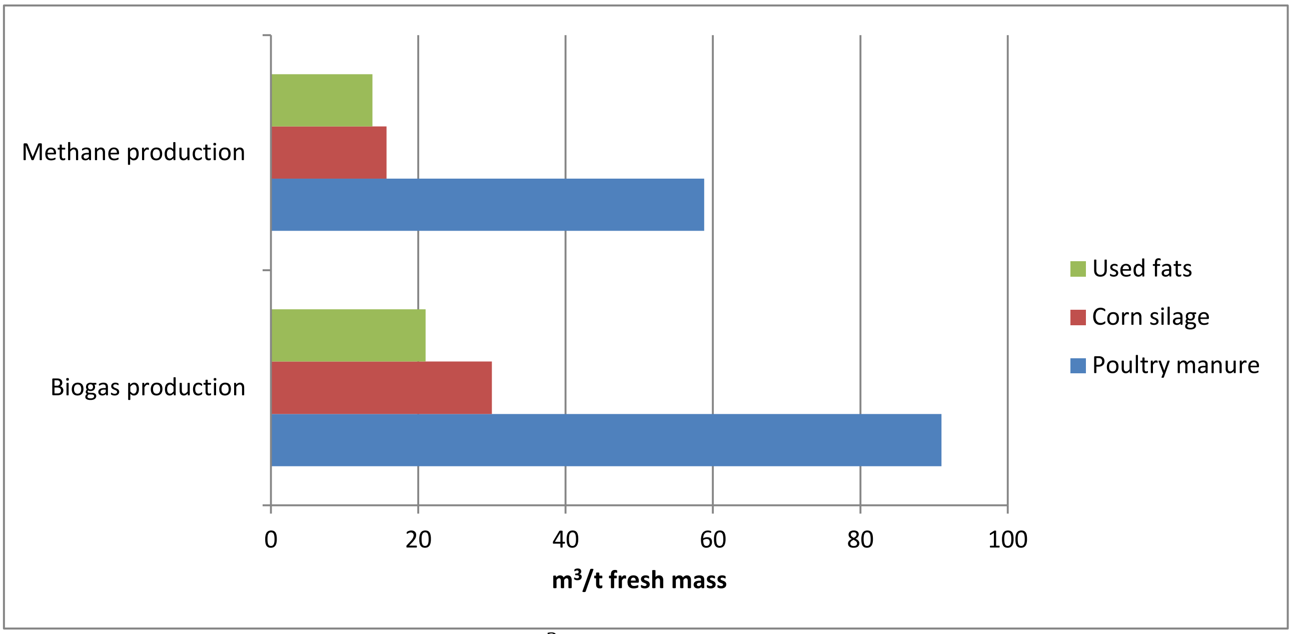

Fig. 5. Biogas and methane yield (m^3/t fresh mass) for scenario 2

3.3 Results of scenario 3

Table 6 shows the calculations for the biogas and methane yield for scenario 3 with one ton of the total input substrate.The maximum yield of biogas and methane is produced by poultry manure which appears also in the maximum percentage in the input substrate, namely 104m^3 of biogas and 67,6m^3 of methane. 10% share of maize silage in the input substrate gives a yield of 20m^3 of biogas and 10,5m^3 of methane.

The lowest yield of biogas is obtained from used fats, namely 14m^3 of biogas and 9,52m^3 of methane. Total biogas yield for scenario 3 is 138 m^3/t fresh mass while total methane yield is 87.62 m^3 at one ton of input substrate mixture.

Substrate	Quantity of the substrate (t)	Biogas yield (m^3/t of fresh mass)	Biogas yield (m^3/ fresh mass)	Methane content (%)	Methane yield (m^3)	Methane yield (m^3/t dry organic matter)
Poultry manure	0,8	130	104	65	67,6	67,2
Corn silage	0,10	200	20	52,5	10,5	10,46
Used fats	0,10	140	14	68	9,52	9,18
TOTAL	1		**138**		**87,62**	**86,84**

Tab. 6. Biogas and methane yield (m^3) for scenario 3

Figure 6 shows that the maximum yield of biogas and methane is produced by poultry manure which appears in the input substrate in maximum percentage. Less yield of biogas and methane is from maize silage, while the smallest yield of biogas is from used fats.

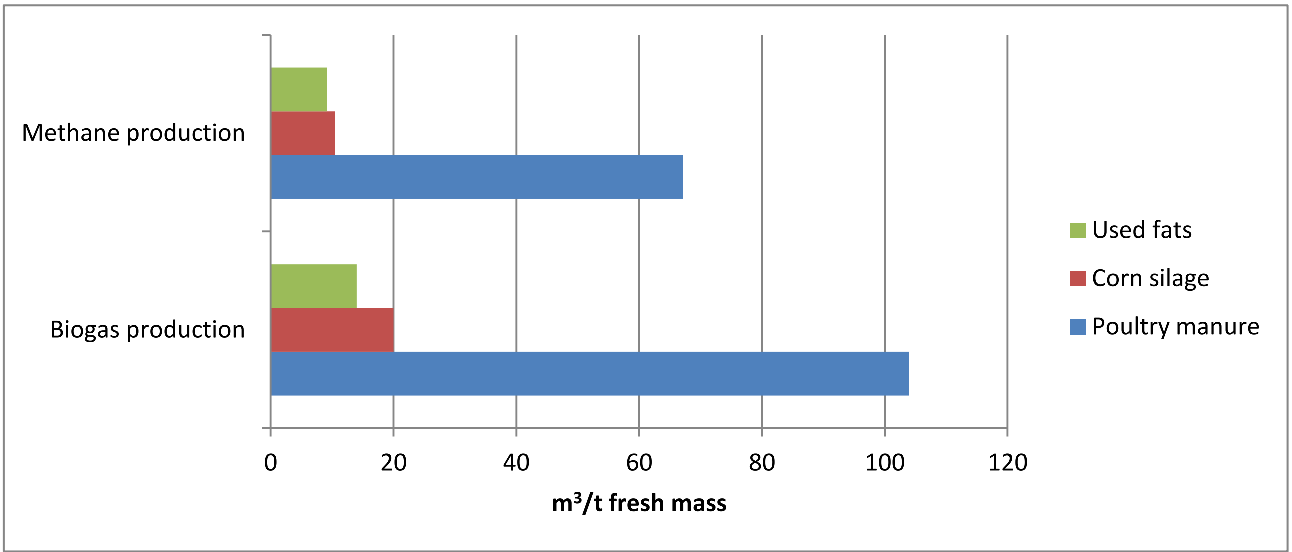

Fig. 6. Biogas and methane yield (m^3/t fresh mass) for scenario 3

4. Conclusion

In this study, the potential for reducing the amount of maize silage in the input substrate in the production of biogas in the biogas plant Drazenci has been compared and calculated. Three different scenarios for the production of biogas with reduced content of maize silage in the input substrate have been compared. Statements are theoretical in nature and are based on calculations. In analyzing the data, it has been found that there are opportunities to reduce maize silage in the input substrate. According to the results it can be confirmed that biogas plant Drazenci can maintain the same level of biogas production while reducing input substrate maize silage. Input substrate maize silage can be replaced by used fats. It can be concluded that the use of maize silage has a major impact on the production of biogas and that used fats significantly affect the yield of biogas and increase the methane content.

The maximum possible yield of biogas and methane was calculated for scenario 1with the largest percentage of maize silage in the input substrate. Maize silage as energy plant is on the top of the biogas yield. Maize silage has a 200 m^3 biogas yield per ton of fresh mass, compared with poultry manure that reaches the biogas yield of 130 m^3 per tonne of fresh mass. The use of poultry manure for biogas plant Drazenci represents a minimal cost, because they have enough of this substrate. The most favourable option for the biogas plant Drazenci is replacing the whole of maize silage by used fats which also give a very high yield of biogas and methane. This scenario would also be the best for the biogas plant Drazenci, as far as they have available enough used fats, but unfortunately they do not.

Future research will focus on increasing the yield of biogas from waste materials (fats) and reduce the use of materials that are primarily used for food production (maize, cereals,, ...).

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