INVESTIGATION OF BIOGAS POTENTIAL IN STOPINI DISTRICT

Indulis Straume
Latvia University of Agriculture
indulis.straume@llu.lv

Abstract. The potential of biogas and available energy have been calculated alone throughout Latvia in general until now. The specific characteristics of each region of Latvia were not taken into account. In this article there have been more successful biogas plant sites in Stopini district inspected, where biogas is combusted in the cogeneration plant producing electricity and heat simultaneously. The biogas potential is also calculated in Stopini district, where it was produced from domestic animal (cattle, pigs and chicken) manure, as well as the unused agricultural available land (AAL) area, the waste water treatment of biological plants of the largest cities, the largest landfills of solid household waste in the region, food processing industry waste. While calculating the potential of biogas, the majority of the total biogas potential was established, which makes around 341 million m^3 of biogas per year in Stopini district and is derived from the unused AAL area – 6.2 million m^3 of biogas per year. The amount of electricity that could be produced using biogas after the calculation is around 35 GWh per year.

Key words: biogas production, animal manure, unused agricultural available land.

Introduction

The estimated draft law in Latvia on the renewable energy provides that in 2020 the local renewable energy sources, such as, solar, wind, wood and biogas, are allocated a significant proportion (40 %) of primary energy consumed in the energy market in Latvia. Therefore, first, the estimated potential of renewable energy has to be examined, which can be obtained in the conditions of Latvia. Unlike other energy sources, biogas is less dependent on weather conditions and it can be envisaged both in-season, and more distant future, with no special adjustment of the present results. Until now, the biogas potential has been studied all over Latvia, without marking the counties, as well as the resulting potential has been mentioned, without marking the raw material types.

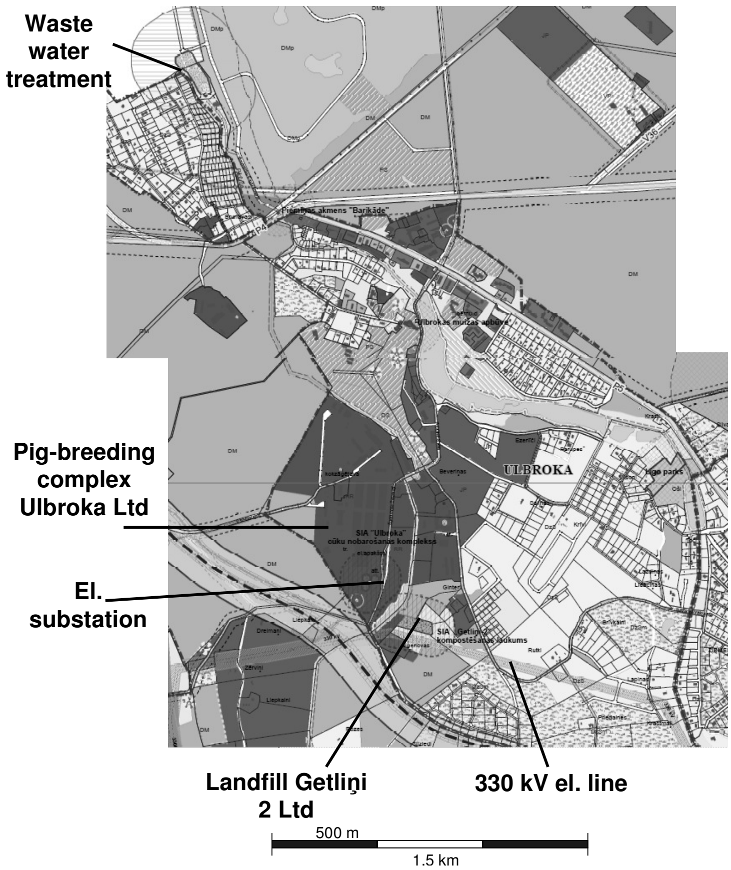

Fig. 1. **Center of Stopini district**

Significant potential of biogas in Stopini district could be obtained by using the energy of crop plants, such as, eastern galega, canary seed, perennial lupine or tall fescue, due to the fact that Stopini district is characterized by the fact that the average of the unused agricultural lands as a proportion of the total agricultural land is quite remarkable 501 ha, or 53 % from total agricultural land area of the district [1]. In addition, to this potential source of biogas food processing plant wastes and cattle manure may also be added.

Materials and Methods

When calculating the potential of biogas the following was taken into account: cattle, pig and poultry manure, food processing industrial waste, waste water treatment biological plants in the largest cities, largest landfills of solid household waste in the region and unused agricultural available land (AAL) area. The technical parameters, which have been considered at the potential of biogas calculation, are given in Table 1.

Table 1

Animal manure and waste produced and parameters

Biomass type	Manure or waste produced, $t \cdot year^{-1}$	Dry matter, %	Organic dry matter, %	Biogas produced, $m^3 \cdot t_{ODM}^{-1}$
Cow manure	16.80	14	86	300
Pig manure	1.64	15	86	500
Poultry manure	0.06	22	80	500
Unused AAL	9.00	–	70	540
Waste water	0.015*	–	–	400

*organic matter from one person

The number of domestic animal (cattle, pigs and chicken) in Stopini district is 115 cattle and 15 840 pigs. The cattle are kept on 15 farms (1 – 5 cattle – 13 farms, 6 – 10 cattle – 3 farms and 21 – 50 cattle – 2 farms). Major parts of pigs are kept in the pig-breeding complex Ulbroka Ltd. [2].

Unused AAL is in comparatively small amount in Stopiņi district (501 ha, or 53 % from the total agricultural land area of the district), out of them:

- 127 hectares overgrown;
- 319 hectares uncultivated;
- 55 hectares building in process.

Mostly this land is not very fertile and not particularly useful in agriculture. In order to improve the soil fertility there is a need to take soil liming and to increase organic nutrients in the soil [3].

The unused AAL area being sown with intensively growing energy crops, for example, galega, the acquired quantity of biogas can be calculated using the following expression:

$$V_B = L \cdot M_{os} \cdot k_d \cdot v_b \qquad (1)$$

where V_B – amount of obtainable biogas from the energy crops, m^3;
L – unused AAL area, ha;
M_{os} – obtainable amount of organic solids from the unit of unused AAL area, $t \cdot ha^{-1}$ ($M_{os} = 9$ t ha^{-1});
k_d – rate of organic matter of biomass conversion, K_d – 0.7;
v_b – biogas yield from a ton of organic dry matter in the anaerobic process, $m^3 \cdot t_{ODM}^{-1}$.

The characteristics of waste water treatment (WWT) in Stopini district are shown in Table 2.

The amount of biogas produced from sewage sludge can be calculated using the expression:

$$V_B = n_i \cdot k_a \cdot m_i \cdot v_b \cdot k_d \qquad (2)$$

where V_B – obtainable amount of biogas from sewage sludge, m^3;
n_i – population in locality;

k_a – coefficient, which indicates the proportion of the population apartments (houses) connected to the biological treatment plants;
m_i – amount of sludge organic dry matter produced by a person per year, $kg \cdot year^{-1}$ (m_i = = 15 $kg \cdot year^{-1}$);
v_b – biogas yield from a ton of organic dry matter in the anaerobic process, $m^3 \cdot t_{VSd}^{-1}$;
k_i – rate of organic matter of biomass conversion, K_i – 0.7.

Table 2

Waste water treatment in Stopini district [3]

Village Ulbroka WWT	**Villages Upesleja un Saulriesi WWT**	**Village Licu WWT**
Biological plants Load – 690 $m^3 \cdot dn^{-1}$ Avarage results of waste water: Susp.m. – 44 $mg \cdot l^{-1}$ BSP5 – 64.8 $mg \cdot l^{-1}$ KSP – 134 $mg \cdot l^{-1}$ Water drained into river Pikurga Building of a new WWT has been started.	Biological plants Load – 570 $m^3 \cdot dn^{-1}$ Avarage results of waste water: Susp.m. – 31 $mg \cdot l^{-1}$ BSP5 – 57.5 $mg \cdot l^{-1}$ KSP – 135 $mg \cdot l^{-1}$ Waste water after tretment is drained into river Maza Jugla. In 2010 building of a new WWT was started.	Biological plants Load – 70 $m^3 \cdot dn^{-1}$ Avarage results of waste water: Susp.m. – 40 $mg \cdot l^{-1}$ BSP5 – 61.8 $mg \cdot l^{-1}$ KSP – 110 $mg \cdot l^{-1}$ Waste water after treatment is drained into a melioration ditch. Building of a new WWT is not planned.

Results and Discussion

The potential of biogas is dependent on two factors in Stopini district. The first factor: if it is planned to sow unused AAL area with some intensively growing energy crops. The second factor: if it is planned to promote pig breeding in Latvia, wherewith the pig breeding complex Ulbroka Ltd not to be liquidated.

As a resalt there are four scenarios in the produce of biogas:

- both economic sectors, unused AAL area to sow and pig breeding not to be liquidated, but promoted;
- production of biogas alone from energy crops;
- production of biogas alone from pig manure;
- both economic sectors are liquidated.

The calculation of the energy output from a cubic meter of biogas is 5.0 – 7.5 kWh of heat capacity can be obtained, depending on the proportion of methane (1 m³ methane gives about 10 kWh), or an average of 6 $kWh \cdot m^{-3}$ or 21.6 $MJ \cdot m^{-3}$. It would produce electricity energy, burning 1 m^3 of biogas, 1.5 – 3 $kWh_{el} \cdot m^{-3}$, or an average 2.2 $kWh_{el} \cdot m^{-3}$. It would produce heat energy of 3 – 4.5 $kWh_{tr} \cdot m^{-3}$, or an average 4 $kWh_{tr} \cdot m^{-3}$ [5].

The first scenario: the potential of biogas is 6.95 million m^3 biogas per year in this case and the summary heat capacity of biogas is 35 GWh. The potential of biogas is shown in Table 3 and Figure 2.

But considering, that unused AAL are barren because they are sabulous, really is the third scenario. In this case the potential of biogas is 4.7 million m^3 biogas per year. The summary heat capacity of biogas is 26.72 GWh in this case

If both economic sectors, as pig breeding and unused AAL area, are not used in the production of biogas, then the potential of biogas is 3 million m^3 biogas per year and the summary heat capacity of biogas 17 GWh in Stopini district.

The electrical and heat power of the cogeneration plant that can be installed in Stopini district in keeping with previously named scenarios, is shown as follows in Table 4.

Table 3

Summary potential of biomass, biogas and heat capacity of biogas dependence on the types of raw materials

Biomass type	Biomass, t year^{-1}	Potential of biogas, mil.m^3 year^{-1}	Heat capacity of biogas, kWh m^{-3}	Summary heat capacity of biogas, GWh
Solid household waste	28 500.0	2.993	5.5	16.46
Unused AAL	4 014.0	1.517	5.9	8.95
Pigs manure	25 246.4	1.628	6.0	9.77
Cattle manure	1 897.5	0.069	5.5	0.38
Sewage sludge	43.2	0.019	6.2	0.12
Summary	59 701.10	6.225	–	35.67

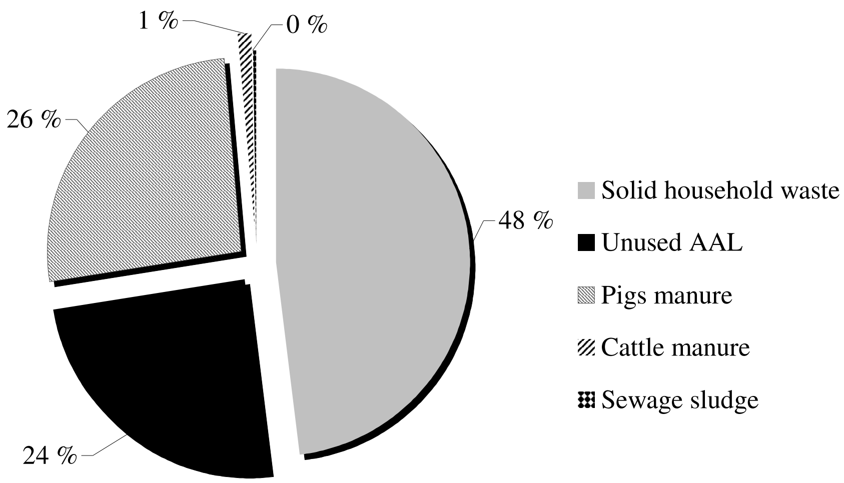

Fig. 2. **Division of the percentage of the potential of biogas depending on the type of raw materials**

Table 4

Cogeneration plant electrical and heat power

Scenarios	Electrical power, MW	Heat power, MW	Electricity energy, GWh·year^{-1}	Heat energy, GWh·year^{-1}
Scenario 1	1.45	2.65	12.12	23.55
Scenarios 2 and 3	1.10	2.01	9.62	17.64
Scenario 4	0.70	1.30	6.12	11.22

To cover the heat load in summer period, the power of cogeneration plant is selected considering the consumers of heat load. Usually one person a day needs 40 litres of hot water, it is 2 kWh, or due allowance for pipeline loses: 3.4 – 4 kWh. The population who live in Ulbroka is 2 878 people and as follows the heat what is consumed for preparation of hot water per day is 11 512 kWh. It will be, calculating to one hour – 960 kW. So we can conclude that at the worst, the necessary heat load will be provided.

Conclusions

1. The total potential of biogas in Stopini district is 6.22 million m^3 of biogas per year. The most of biogas, considering the raw material, can be obtained from soil household waste – over 3 million m^3 of biogas per year in Stopini district. In percentage this represents 48 % of the biogas potential of the estimated quantity. The second major producer of biogas can be the pig breeding complex Ulbroka Ltd – 1.6 million m^3 of biogas per year, which is 26 % of the biogas potential of the estimated quantity.

2. The electrical and heat power of the cogeneration plant that can be installed in Stopini district in keeping with the previously named scenarios is 1.45 MW and 2.65 MW respectively.
3. The summary heat capacity of biogas, which can be obtained in the Stopini district is 35 GWh, respectively, the amount of electricity that can be produced during a year in the biogas cogeneration plant is 12.12 GWh_{el} and the amount of heat energy 23.55 GWh_{th}. But the minimum electrical and heat energy is 6.12 GWh_{el} and 11.22 GWh_{th} respectively.

Acknowledgements

This publication has been prepared within the framework of the ESF Project „Attraction of human resources to the research of the renewable energy sources", contract

No. 2009/0225/1DP/1.1.1.2.0/09/APIA/VIAA/129.

References

1. Database about the unused AAL area. Available at: http://www.lad.gov.lv/lv/citi-pakalpojumi/lauksaimnieciba-izmantojamas-zemes-apsekosana/ 15. May 2011.
2. Database about the number of domestic animals and farms. Available at: http://pub.ldc.gov.lv/pub_stat.php?lang=lv, 25. September 2011.
3. Stopiņu novada teritoriālais plānojums, 2009 (The territorial planning of Stopini district, 2009). Available at: http://www.stopini.lv/public/30728.html 15. December 2011. (in Latvian)
4. Kalniņš A. (2009) Biogāzes ražošanas saimnieciskie un vides ieguvumi (Biogas production in the economic and environmental benefits). Available at: www.erab.lv/Biogazes %20rokasgramata.pdf, 13. January 2011. (in Latvian)
5. Database about the pollution license. Available at: http://www.vpvb.gov.lv/lv/piesarnojums/a-b-atlaujas, 25. October 2011.