THE INVESTIGATION OF BIOGAS POTENTIAL IN THE VIDZEME REGION

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Abstract
The potential of biogas and available energy have been calculated alone all of Latvia in general until now. The specific character of each region of Latvia was not excluded. In this article more successful biogas plants sites in Vidzeme region have been inspected, where biogas is combusted in cogeneration plants producing electricity and heat simultaneously. The biogas potential is also calculated in Vidzeme region, 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 and food processing industry waste. The majority of the total biogas potential makes around 304 million m^3 of biogas per year in Vidzeme region and is derived from the unused AAL area – 225 million m^3 of biogas per year. On average, the biogas potential in each district of the Vidzeme region makes around 12 million m^3 of biogas per year. The calculated amount of electricity that could be produced using biogas is around 700 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, sun, 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, which can be obtained in the conditions of Latvia, has to be examined. 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 potential of biogas has been studied throughout Latvia, to ignore counties and raw material types.

The Vidzeme region is characterized with the fact that the average of the unused agricultural lands as a proportion of the total agricultural land is quite remarkable 15%. In this case, a significant potential of biogas in Pieriga region will can be obtained using the culture of intensively growing energy crops, such as eastern galega, canary seed, perennial lupine or tall fescue. In addition, to this potential source of biogas food processing plant wastes and cattle manure may also be added.

Till the end of autumn 2011 five biogas cogeneration plants were operating in Vidzeme region:

- Kalsnava bioethanol factory "Biofuels Ltd" (2 MW) in Madona district;
- waste deposit area, "Daibe" (0.35 MW) in Pargaujas district;
- farm Zemturi (0.7 MW) in Valmiera district;
- Bioenergy 08 Ltd in Madona district;
- CONATUS BioEnergy Ltd in Erglu district.

In the near future it is expected that biogas cogeneration plants will start work: BB Biogas Ltd (2 MW) in Belava municipality of the Gulbene district and Agro 3 Ltd (1.5 MW) in Litene municipality.

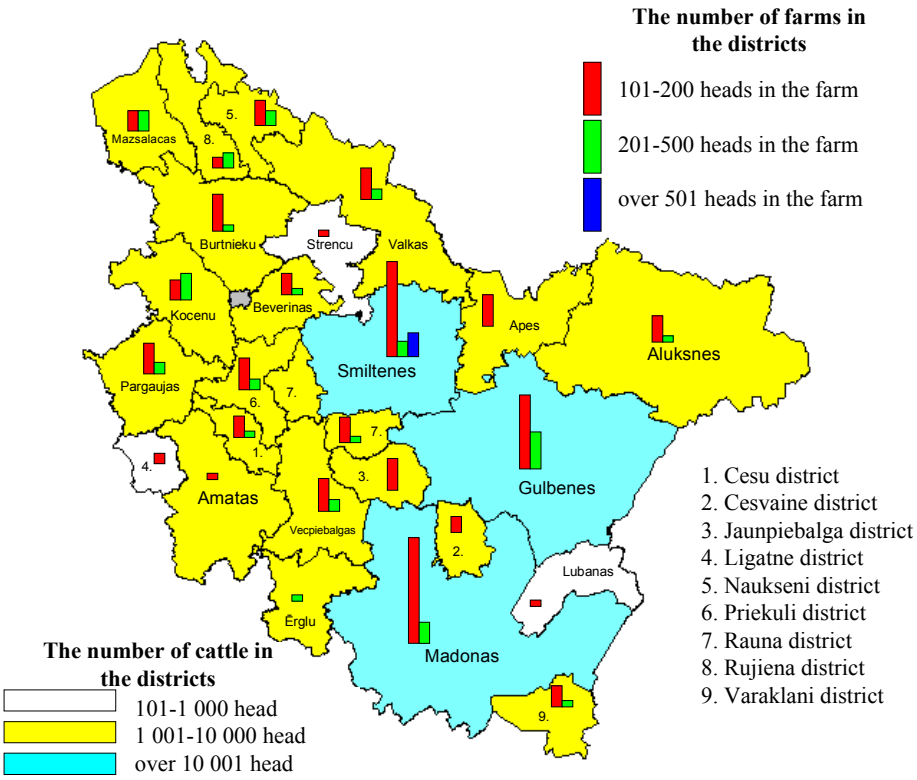
Materials and Methods

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

The domestic animal housings occupied by more than 101 cattle, 1 001 pig and 15 001 chicken were taken into account.

The number of cattle in the districts of the Vidzeme region is mostly balanced 3 500 cattle on average in a district. The majority of cattle is in Madona district – 12 670 cattle, in Smiltene district – 10 655 cattle and in Gulbene district – 9 977 cattle.

Considering the cattle farms, where there are more than 101 cattle, the most such farms are in Smiltene district 27 (19 farms with 101-200 cattle, 3 farms with 201-500 cattle, and five farms with more than 501 cattle), then Madona district follows with 25 farms (20, 5, 0) and Gulbene district with 24 farms (16, 8, 0). Overall, in Vidzeme region there are 138 farms with up to 200 heads in a herd, 45 farms with up to 500 heads in a herd, and 5 farms where there are more than 501 head in a herd (*Database about the number of domestic animals and farms, 2011.)*. Figure 1 shows the concentration of cattle and the number of cattle farms in the districts.



Source: Database about the number of domestic animals and farms, 2011.

Figure 1. **Number of cattle and farms in the districts of the Vidzeme region**

Table 1

Animal manures and wastes production and parameters

Biomass type	Manure or waste produced from one animal, t year^{-1}	Dry matter, %	Organic dry matter, %	Biogas produced, m^3 t_{ODM}^{-1}
Cow manure	16.80	14	86	300
Pig manure	1.64	15	86	500
Chicken manure	0.06	22	80	500
Unused AAL	9.00		70	540
Sewage sludge	0.015*			400

** - organic matter from one person*

Table 2 summarized the largest food producers from which the gathered waste biogas is potentially obtainable.

The unused AAL area to sows with culture of 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 – the amount of obtainable biogas from the energy crops culture, m^3;

L – unused AAL area, ha;

M_{os} – the obtainable amount of organic solids from the unit of unused AAL area, t ha^{-1} (M_{os} - 8 t ha^{-1});

k_d – the 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 t_{ODM}^{-1}.

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

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

where

V_B – the 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 – the amount of organic dry matter in sludge produced by a person per year, kg $year^{-1}$ (m_i = 15 kg $year^{-1}$);

v_b – biogas yield from a ton of organic dry matter in the anaerobic process, $m^3\ t_{ODM}^{-1}$;

k_i – the rate of organic matter of biomass conversion,

K_i – 0.7.

Results and Discussion

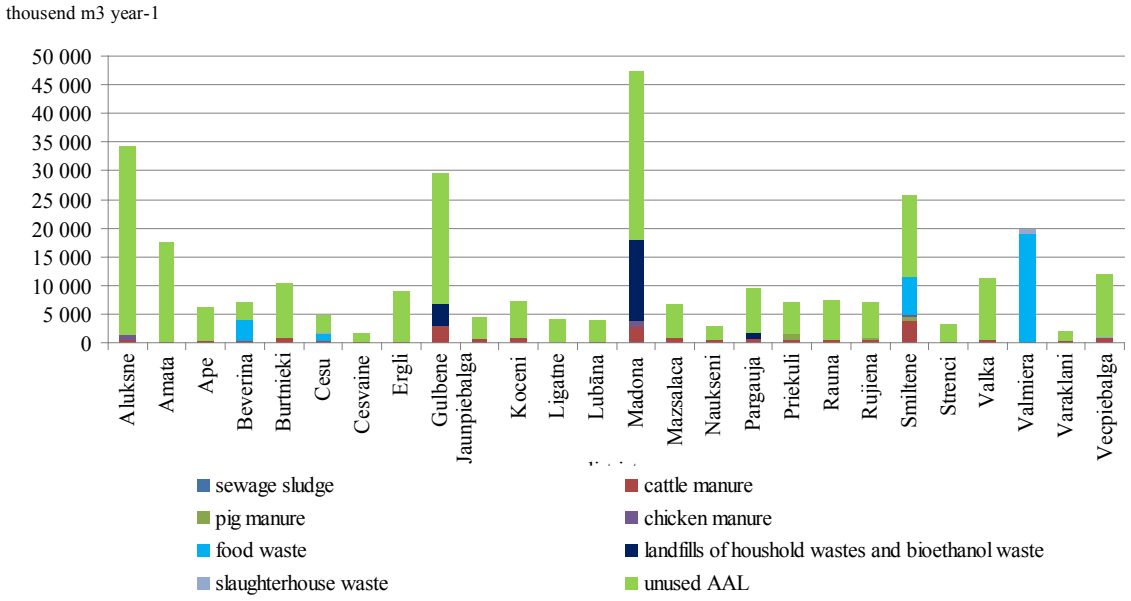
In the work process, considering all potential of raw materials for the biogas production each district can conclude that most of biogas can be obtained in Madona district - 47.4 million m^3 per year. The poultry farm holding company Madona and bioethanol factory Biodegviela Ltd are in Madona district, and there are also quite a lot of cattle farms with more than 101 cattle in a herd. Then following Aluksne district (34.4 million m^3 of biogas per year), with a relatively large unused AAL area (*Database about the unused AAL area, 2010*), Gulbene district (29.5 million m^3 of biogas per year) and Smiltene district (25.7 million m^3 of biogas per year). In Smiltene

Table 2

Food processing industry wastes production and parameters

Company	Biomass type	Waste produced, t $year^{-1}$	Dry matter, %	Biogas produced, $m^3\ t_{ODM}^{-1}$
Cesvaines piens	waste water sludge	56.00	0.80	400
	whey	1428.00	0.03	650
Cesu alus	brewer's grain	6500.00	0.25	750
Lazdonas piensaimnieks	waste water sludge	2.00	0.80	400
	whey	3600.00	0.03	650
Piebalgas alus	brewer's grain	148.00	0.25	750
Rankas piens	waste water sludge	10.00	0.80	400
	whey	2000.00	0.03	650
Smiltenes piens	waste water, m^3	43725.00	0.38	400
	whey	6000.00	0.03	650
Straupes PKS	waste water sludge	10.00	0.80	400
	whey	3130.00	0.03	650
Valmieras maiznieks	waste water, m^3	840.00	0.38	400
Valmieras piens	waste water, m^3	124000.00	0.38	400
Valmiermuižas alus	brewer's grain	10.00	0.25	750
Trikatas siers	whey	3762.00	0.03	650
	waste water, m^3	21900.00	0.38	400
MADONA	slaughterhouse	18.00	0.16	625
Sprīdītis	slaughterhouse	51.54	0.16	625
Gaizeni	slaughterhouse	8.75	0.16	625
AIBI	heavy-duty slaughterhouse	2400.00	0.16	625
RUKS	meat processing plant	840.00	0.16	625
Trials	slaughterhouse	8000.00	0.16	625
Kunturi	slaughterhouse	38.40	0.16	625

Source: Database about the pollution license, 2011.



Source: made by the author

Figure 2. **The potential of biogas by districts**

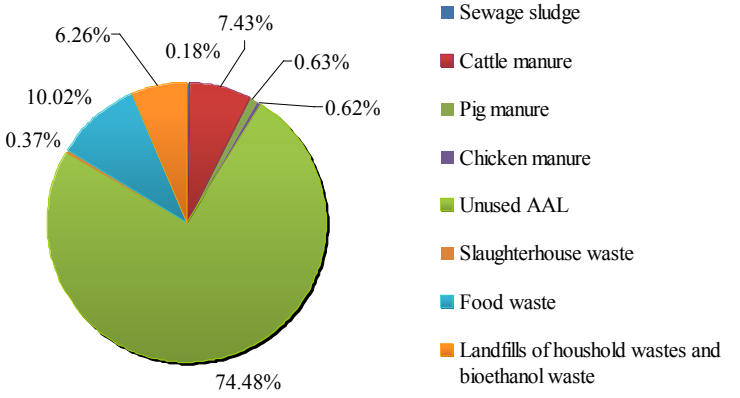


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Figure 3. **The division of the percentage of the potential of biogas depending on the type of raw materials**

district, animal husbandry and milk processing (Smiltene piens Ltd) are highly developed, there are a lot of cattle farms with more than 100 cattle in a herd, and the pig breeding complex Spriditis Ltd Figure 2 shows the potential of biogas as a whole by district.

The total potential of biogas in Vidzeme region is 304.7 million m^3 of biogas per year. The most of biogas, considering the raw material, can be obtained from unused AAL, where the cultures of intensively growing energy crops (for example, galega - over 225 million m^3 of biogas per year in Vidzeme region) are sown. In percentage this represents 74.5% of the biogas potential of the estimated quantity. Considering the heat capacity it can also be concluded that 1.33 TWh of energy can be gained from the cultures of intensively growing energy crops per year, and the summary of heat capacity of biogas is 1.8 TWh of energy per year (Table 3.).

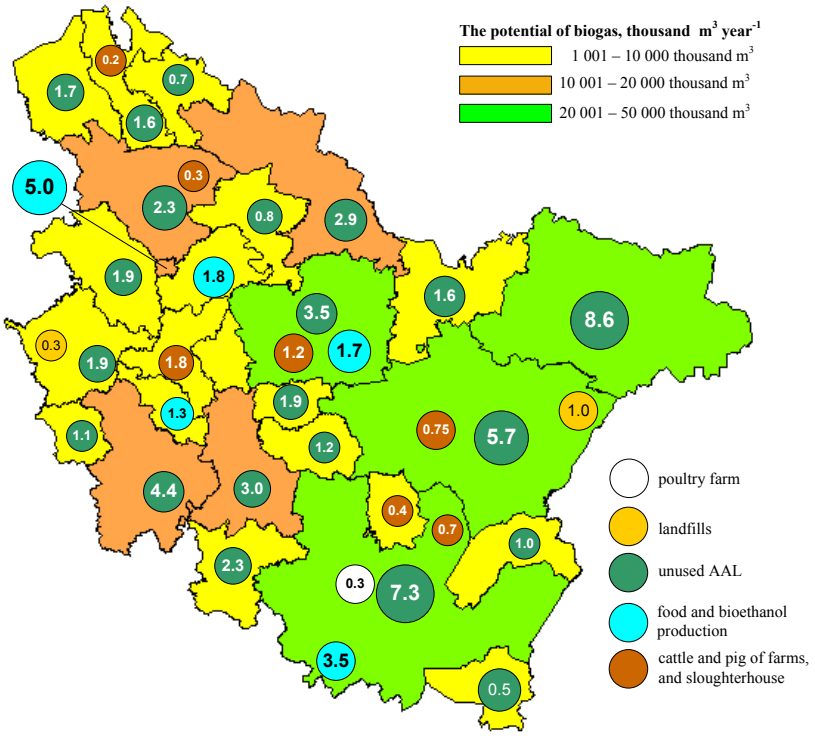
The calculation of energy output from a cubic meter of biogas is 5.0-7.5 kWh of heat capacity can be obtained, depending on the proportion of methane (1 m^3 methane gives about 10 kWh), or an average of 6 kWh m^{-3} or 21.6 MJ m^{-3}. It would produce electricity energy, have been burning 1 m^3 of biogas, 1.5-3 kWh_{el} m^{-3}, or an average 2.2 kWh_{el} m^{-3}. It would produce heat energy of 3-4.5 kWh_{tr} m^{-3}, or an average 4 kWh_{tr} m^{-3}. (*A. Kalnins, 2009.*).

In the work process, after obtaining the potential results of biogas and possible heat capacity of biogas, we can calculate the potential of electrical power of the

Table 3

The summary potential of biomass, biogas and heat capacity of biogas dependence from the types of raw materials

Biomass type	Biomass, t year^{-1}	Potential of biogas, thaus.m^3 year^{-1}	Heat capacity of biogas, kWh m^{-3}	Summary heat capacity of biogas, MWh
Sewage sludge	1 613.16	547.46	6.2	3 394.26
Cattle manure	627 181.50	22 653.80	5.5	124 595.88
Pig manure	29 565.00	1 906.94	6.0	11 441.66
Chicken manure	21 497.74	1 891.80	6.5	12 296.71
Unused AAL	670 251.20	226 966.32	5.9	1 339 101.29
Slaughterhouse waste	11 318.29	1 135.67	5.5	6 246.18
Food waste	-	30 548.22	5.8	189 073.11
Landfills of household wastes and bioethanol waste		19 072.50	5.5	109 415.00
Summary	1 361 426.89	304 722.71		1 795 564.08



Source: made by the author

Figure 4. **Biogas cogeneration plant potentially installed electrical power MW by districts and types of raw materials**

biogas cogeneration plants in each district. Figure 4 shows the results of the calculation.

Conclusions

The total potential of biogas in Vidzeme region is 304.7 million m^3 of biogas per year. The most of biogas, considering the raw material, can be obtained from unused AAL, where sows the cultures of intensively growing energy crops, for example, galega - over 225 million m^3 of biogas per year in Vidzeme region. In percentage this represents 74.5% of the biogas potential of the estimated quantity.

In the work process was concluded that the most biogas can get Madona district – 47.4 million m^3 per year. Because there are many cattle farms, where

more than 101 cattle, bioethanol plant "Biodegviela Ltd" with biogas cogeneration plant capacity 2 MW, as well as the poultry farm "Madona" with 228 thousand chickens. The fellow Aluksne district – 34.4 million m^3 of biogas per year, where is the most unused AAL area – about 11 thousand hectares, Gulbene and Smiltene districts – respectively 29.5 and 25.7 million m^3 of biogas per year.

The summary heat capacity of biogas which can be obtained in the Vidzeme`s region is 1.8 TWh, respectively, the amount of electricity which can be produced in a biogas cogeneration plants during a year is 0.7 TWh_{el} and the amount of heat energy 1.1 TWh_{th}.

The largest electrical power of biogas cogeneration plant can be installed in Madona district – 12 MW, The follow Aluksne district with 8.6 MW and Gulbene district – 7.5 MW

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