THE INVESTIGATION OF BIOGAS POTENTIAL IN THE PIERIGA 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 many successful biogas plants sites in Pieriga region have been inspected, where biogas is combusted in cogeneration plants producing electricity and heat simultaneously. The biogas potential was also calculated in Pieriga 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 341 million m^3 of biogas per year in Pieriga region and is derived from the unused AAL area – 216.6 million m^3 of biogas per year. On average, the biogas potential in each the district of Pieriga region makes around 12 million m^3 of biogas per year. The calculated amount of electricity that could be produced by using biogas is around 750 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 Pieriga 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 26%. 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 Pieriga region:

- waste water treatment plant "Daugavgriva" (2 MW) in Riga;
- waste deposit area "Getlini" (5 MW) in Stopini district;
- Katvaru municipality housekeeping Jaundzelves (0.5 MW) in Limbazu district;
- Sidgunda bio Ltd. (1.6 MW) in Malpis district;
- Bioservis Ltd. (2 MW) in Limbazu district.

In the near future it is expected that two biogas cogeneration plants will start work: Energo Listene Ltd. (1 MW) in Listene municipality of the Tukuma district and Baltic Pork Ltd.. in Sigulda district.

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 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 Pieriga region is mostly balanced: 1 800 cattle on average in a district. The majority of cattle is in Tukuma district – 10 543 cattle, in Ogre district – 6 661 cattle, and in Limbazi district – 6 205 cattle.

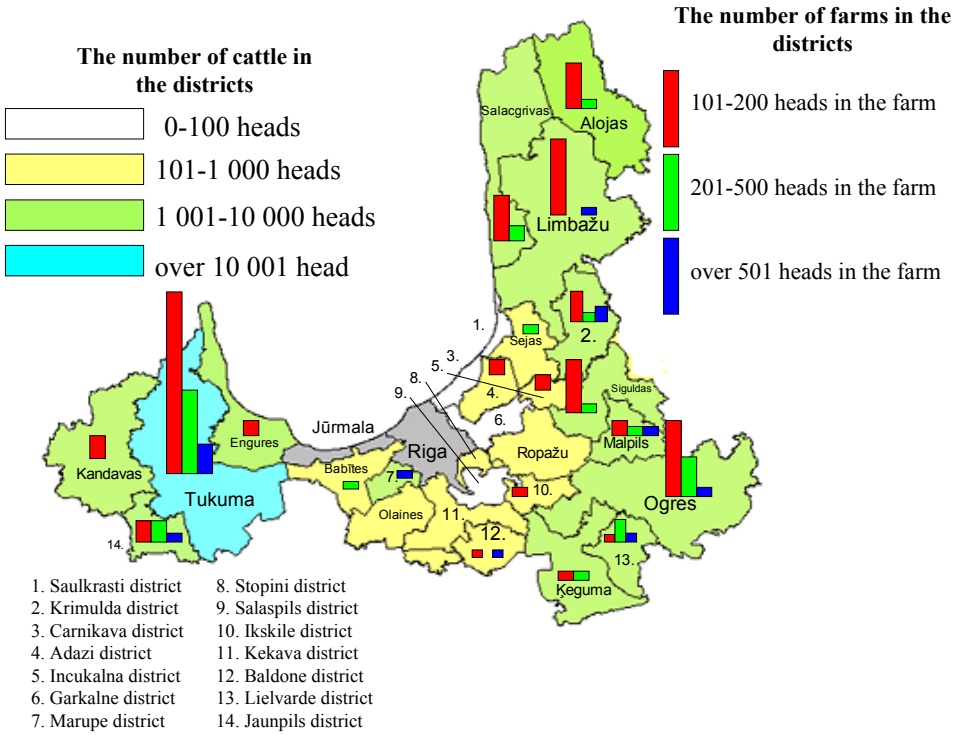
Considering the cattle farms where there are more than 101 cattle, the most such farms are in Tukuma district 29 (19 farms with 101-200 cattle, 7 farms with 201-500 cattle, and three farms with more than 501 cattle), then Limbazi district follows with 14 farms (13, 1, 0) and Ogre district with 13 farms (8, 4, 1). Overall, in Pieriga region there are 78 farms with up to 200 heads in a herd, 27 farms with up to 500 heads in a herd, and 11 farms where there are more than 501 head in

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
Waste water	0.015*			400

** - organic matter from one person*



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

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

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.

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$_{ODM}^{-1}$.

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}
Kekava **	slaughterhouse	658.0	0.16	625
Baltic Pork **	slaughterhouse	70.0	0.16	625
Ulbroka ***	slaughterhouse	10.5	0.16	625
Marno *	slaughterhouse	60.0	0.16	625
MVA *	slaughterhouse	62.8	0.16	625
Rīgas Miesnieks *	slaughterhouse	60.0	0.16	625
Forevers *	slaughterhouse	450.0	0.16	625
Adazu cipsi ****	potato parings	560.00	0.21	610
Aldaris *	brewer's grain	11 521.00	0.25	750
Alojas Sterkelsen ****	potato alburnum	2 660.56	0.24	610
	whey	8 535.60	0.05	650
Limbazu piens *	waste water, m^3	58 690.00	0.38	400
	whey	44.80	0.03	650
Rīgas piensaimnieks *	waste water, m^3	378 562.40	0.38	400
Tukuma piens ****	waste water, m^3	33 580.00	0.38	400
	whey	3 036.00	0.03	650
Jaunpils pienotava ****	whey	3 795.00	0.03	650

Source: Database about the pollution license, 2011.

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

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

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_{VSd}^{-1};
- k_i – the rate of organic matter of biomass conversion,
- K_i – 0.7.

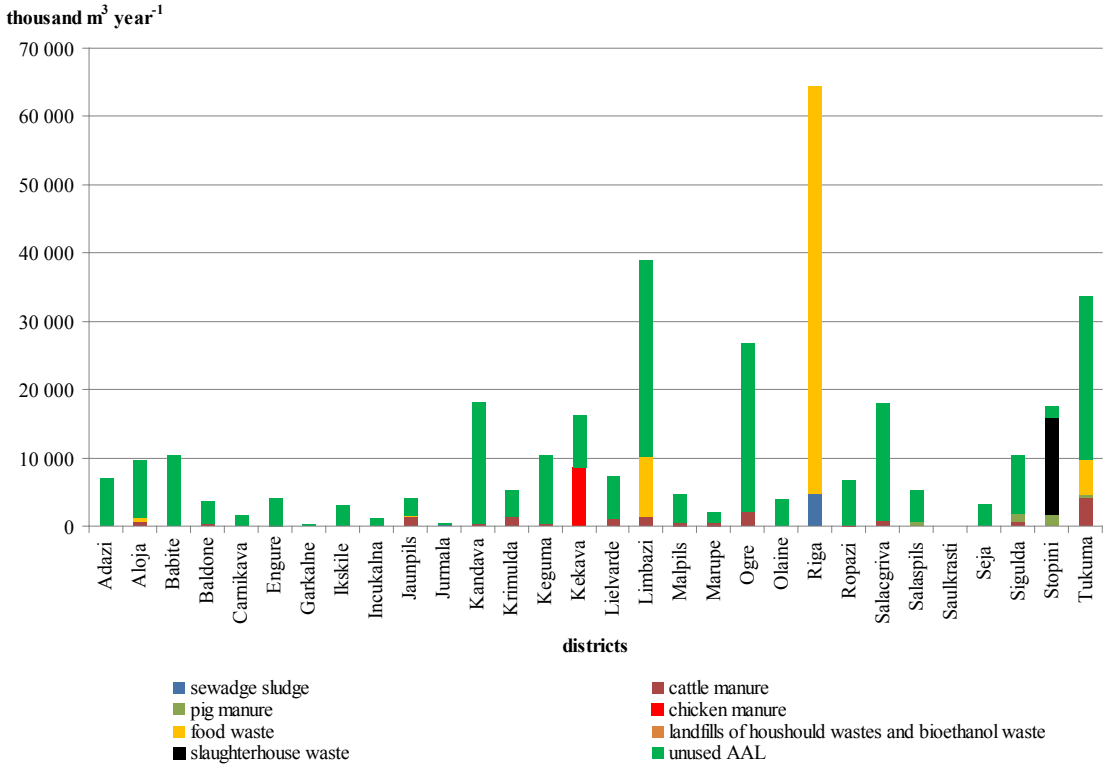
Results and Discussion

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 Riga – 64.5 million m^3 per year. This is explained by the development of food industry, the largest gain of biogas can to be in "Riga piensaimnieks Ltd.". The following is Limbazi district – 52.6 million m^3 of biogas per year there is the milk processing plant "Limbazu piens Ltd.", Tukuma district - 48 million m^3 of biogas per year. Highly developed animal husbandry and milk processing (Tukums piens Ltd.) is in Tukuma district, as well as there are quite a lot of cattle farms with more than 101 cattle in a herd and the pig-breeding complex "Nica 1 Ltd.". Figure 2 shows the potential of biogas on the whole by districts.

The total potential of biogas in Pieriga region is 341.1 million m^3 of biogas per year. The most of biogas, considering the raw material, can be obtained from unused AAL, where cultures of intensively growing energy crops (for example, galega - over 216 million m3 of biogas per year in Pieriga region) are sown. In percentage this represents 63.5% of the biogas potential of the estimated quantity. Considering the heat capacity it can also be concluded that 1.3 TWh of energy can be gained from the culture of intensively growing energy crops per year, and the summary of heat capacity of biogas is 2.0 TWh of energy per year (see: 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 m³ 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.*).

After obtaining the potential of biogas and heat capacity of biogas can be calculated the potential of electrical power of the biogas cogeneration plants in each district. Figure 4 shows the results of the calculation.



Source: made by the author

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

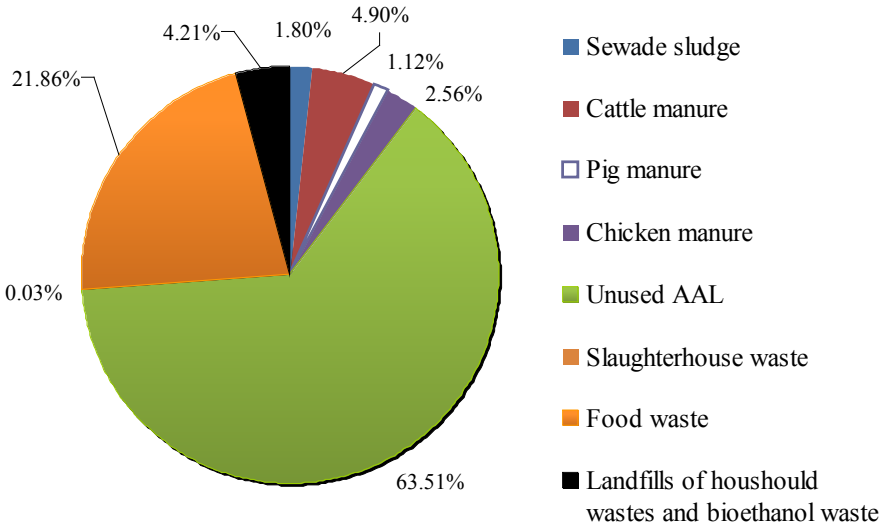


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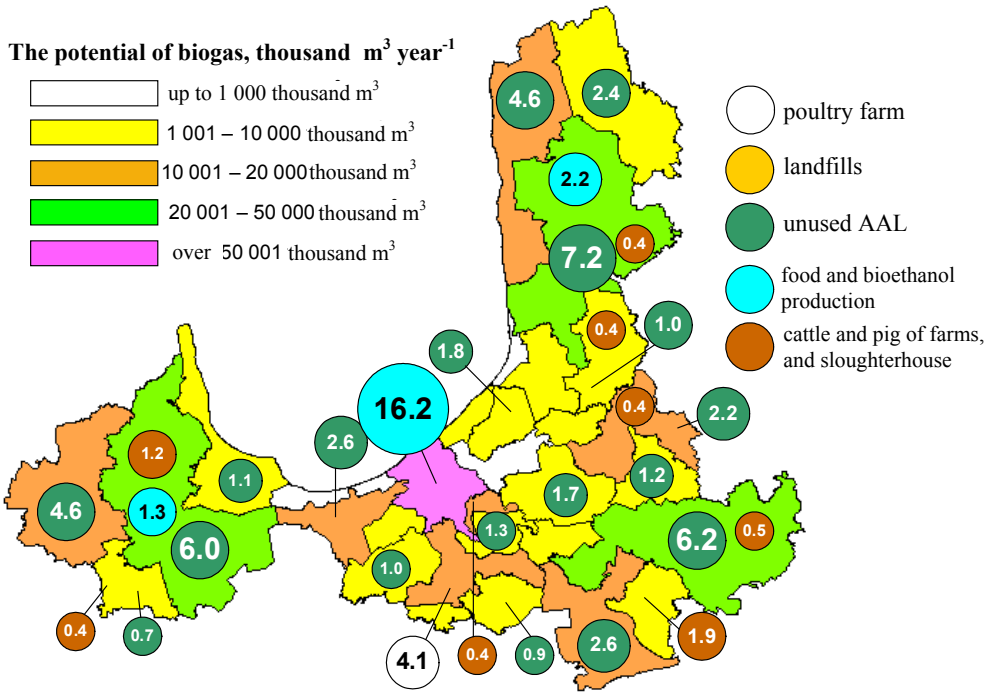
Figure 3. **The division of the percentage of the potential of biogas depending on the type of raw materials**

Table 3

The summary potential of biomass, biogas, and heat capacity of biogas depending on the type of raw materials

Biomass type	Biomass, t year^{-1}	Potential of biogas, thousand m^3 year^{-1}	Heat capacity of biogas, kWh m^{-3}	Summary heat capacity of biogas, MWh
Sewage sludge	14 219.30	6 142.74	6.2	38 084.96
Cattle manure	462 990.00	16 723.20	5.5	91 977.59
Pig manure	59 227.25	3 821.19	6.0	22 927.14
Chicken manure	17 494.45	8 746.92	6.5	56 854.98
Unused AAL	573 156.00	216 652.97	5.9	1 278 252.51
Slaughterhouse waste	1 371.30	92.13	5.5	506.72
Food waste		74 590.64	5.8	460 817.43
Landfills of household wastes and bioethanol waste		14 374.74	5.0	71 873.70
Summary	1 128 458.30	341 144.52		2 021 295.03

Source: made by the author



Source: made by the author

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

Conclusions

The total potential of biogas in Pieriga region is 341.1 million m^3 of biogas per year. The most of biogas, considering the raw material, can be obtained from unused AAL, where to sows the culture of intensively growing energy crops, for example, galega - over 216 million m^3 of biogas per year in Pieriga region. In percentage this represents 63.5% of the biogas potential of the estimated quantity.

In the work process was concluded that the most biogas can obtained in Riga – 64.5 million m^3 of biogas per year, because there are explained by the development of food industry, the largest gain of biogas can to be in "Riga piensaimnieks Ltd." – 57.5 million m^3 per year. The fellow Limbazi

district – 39 million m^3 of biogas per year - there is the milk processing plant ”Limbazu piens Ltd.”, and Tukuma district – 33.8 million m^3 of biogas per year. Highly developed animal husbandry and milk processing (Tukums piens Ltd.) is in Tukuma district, as well as there are quite a lot of cattle farms, with more than 101 cattle in a herd, and the pig-breeding complex “Nica 1 Ltd.”.

The summary heat capacity of biogas, which can be obtained in the Pieriga`s region is 2 TWh, respectively, the amount of electricity which can be produced in a biogas cogeneration plants is during a year 0.78 TWh_{el} and the amount of heat energy 1.22 TWh_{th}.

The largest electrical power of biogas cogeneration plant can be installed in Riga – 16.2 MW. The follow Limbazi district with 9.8 MW and Tukuma district – 8.5 MW.

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