SPECIFIED EVALUATION OF MANURE RESOURCES FOR PRODUCTION OF BIOGAS IN PLANNING REGION LATGALE

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Abstract
Evaluation of manure production from different livestock is important for business planning in bioenergy sector. According to proposed legislation, share of animal sourced byproducts, including manure, can be limitative for application on state aid for new biogas plant building and for feed-in tariff calculation for purchase of electricity produced in biogas plants. For calculation purposes, livestock was divided into 11 different groups, and animals in every group have approximately same manure output per head in a year. Manure resources from dairy cow were calculated with consideration of average milk yield within every parish or municipality in Latgale planning region. Biogas potential obtainable from livestock manure was 11.2 million m^3, including 77.6% from cattle 17.4% from pigs, 4.5% from poultry and 0.5% from horses in planning region Latgale in 2011.
Key words: biomass waste, livestock manure, anaerobic digestion.

Introduction

Political strategy is aimed to enact the provisions of Directive 2009/28/EC in Latvia by development of production of renewable energy, including energy production from biomass. Renewable energy share in gross energy consumption should to increase from 32.5% in year 2005 up to 40% in year 2020. The development scenario anticipates that in the electricity sector the share of GFEC increases from 44.9% in 2005 to 59.8% in 2020, in the corresponding period in the heating and cooling sector the share increases from 42.7% to 53.4%, and in the transport sector the share increases from 0.9% to 10% (Ministry of Economics, 2011). Manure is the largest and cheapest resource for biogas production in planning region Latgale. Anaerobic treatment of manure reduces emissions of methane and other harmful substances into environment to great extent. Careful evaluation of manure resources for biogas production can contribute to estimation of digesters volume and capacity of cogeneration units. Specified evaluation of available resources is needed also for successful application for obtaining of EU and state's financial support for building of biogas cogeneration plant and for obtaining of financial support from potential investors. Cabinet Regulations prescribes, that for application for aid for biogas plants building (40% of eligible expenses) owner should have at least 30% of feedstock for biogas plant animal by-products and derived products not intended for human consumption. Special 'waste' component is proposed to include in feed-in tariff for purchase of electricity produced from waste biomass according to draft Renewable Energy Law. Properly calculated resources are necessary for stable round year running of biogas cogeneration plant to fulfill the obligations on selling of electricity to system operator or heat to consumers. Data on biomass resources, including manure, are important also for energy strategy planning at municipal, regional and state level.

Materials and Methods

Investigation is based on assumption that in the immediate future economically viable anaerobic digestion plants can be constructed at farms having livestock more than 100 livestock units. Livestock population data characterized by subgroup were collected. The farms having at least 100 cattle (horses), 1000 pigs (oats, goats) or 5000 poultry were incalculated in every municipality as potential manure supplier for biogas plants in planning region Latgale. Predominant method for cattle manure handling is the solid litter manure collection and storage system in planning region Latgale traditionally. Manure output from livestock and poultry in municipality (region) in a year was calculated as follows:

$$M = \sum_{n=1}^{i} N_i \cdot m_i \,, \qquad (1)$$

where:

- M – livestock (animals and poultry) manure produced in municipality (region), t.
- n – Number of specified groups of livestock population in municipality (region),
- N_i – average number of livestock (animals and/or poultry) present year-round within i^{th} group of livestock,
- m_i – manure produced per one head in a year in the i^{th} group of livestock, t,

Average manure production per one dairy cow is dependent on cow's milk yield and calculates help by regression equation obtained from data on normative

manure output for dairy cows, (Priekulis J. et al., 2008):

$$m_l = 0.0024 \cdot Y_d + 0.447, \quad (2)$$

where:

m_l – average manure production per dairy cow in municipality in a year, t yr^{-1},

Y_d – average milk yield per dairy cow in municipality in a year, kg yr^{-1}.

Biogas production from manure potential was calculated as the sum of biogas volumes obtainable from manure produced by all groups of animals in parish (municipality, region):

$$V_B = \sum_{n=1}^{i} N_i \cdot m_i \cdot k_{DMi} \cdot k_{OMi} \cdot v_{Bi}, \quad (3)$$

where,

V_B – biogas volume, potentially obtainable from manure biomass in parish (municipality, region) in a year, m3,

k_{DMi} – dry matter content in manure produced by ith group of animals in parish (municipality, region),

k_{OMi} – organic matter content in dry matter of manure produced by ith group of animals in parish (municipality, region),

v_{OMi} – specific biogas output from manure organic matter for ith group of animals in parish (municipality, region), m^3 t^{-1}.

Energy of biogas obtainable from manure biomass in municipality (region) was calculated as follows:

$$E_B = \sum_{n=1}^{i} N_i \cdot m_i \cdot k_{DMi} \cdot k_{OMi} \cdot v_{Bi} \cdot e_{Bi}, \quad (4)$$

where,

E_B – energy potential obtainable from biogas produced from manure, kWh,

e_{Bi} – specific heat energy content of biogas obtained from manure produced by ith group of animals (poultry), kWh m^{-3}.

Electric power of cogeneration unit(s) utilizing biogas from manure in parish (municipality, region) was calculated as follows:

$$P_e = \frac{E_B}{k_e \cdot T_C}, \quad (5)$$

where,

P_e – rated electric power of cogeneration units will be installed in parish (municipality, region), kW,

k_e – coefficient of electric efficiency of cogeneration unit, $k_e = 0.4$,

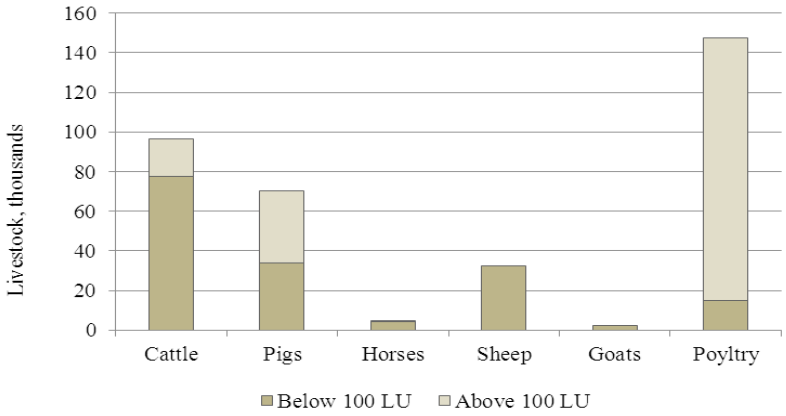
T_C – number of hours in a year while cogeneration units operate at a rated capacity, $T_C = 8000$ h.

Number of animals (poultry) in farms having more than 100 livestock units and average milk production from dairy cows were obtained from databases of State agency Agricultural Data Centre (LDC). General data on number of animals, e.g. average number of animals in herds, total number of animals in planning regions were obtained from databases of Central Statistical Bureau (CSB). Some specified data on animals, e.g. actual number of pigs in piggeries were obtained help by interviews. Data on manure characteristics were derived both from experimental data, as well as from literature, including normative documents and scientific publications.

Results and Discussion

Investigated total number of cattle, pigs, horses, sheep and goats was 206.7 thousand located in 22.8 thousands barns in Latgale planning region. Number of poultry was 147.6 thousands, situated in 795 barns in Latgale. There were 76 cattle farms, 7 piggeries, 1 horse stable and 1 poultry farm having livestock above 100 livestock units (LU) in planning region Latgale. There were investigated 55 cattle herds with number of animals in range 100-300 heads, 19 herds with number of animals in range of 300-500 heads and 4 herds with number of animals more than 500 heads in region Latgale in year 2011. Average size of cattle herd was 155, 382 or 802 heads within range of 100-300, 300-500 or above than 500 cattle per herd respectively. Distribution of number of animals in herds in respect of the accepted threshold value of 100 livestock units in planning region Latgale is shown in Fig.1. Around 20% of cattle, 2% of horse, 52% of pigs and 91 % of poultry are included in large herds (more than 100 LU) suitable for biogas plants building nearby those farms. Pigsties with more than 1000 animals were accounted in 7 farms in planning region Latgale, including three pigsties located in Rēzeknes municipality and in each single pigsty located in Aglonas, Dagdas, Daugavpils and Ludzas municipality. No one sheep or goats herd above 100 LU exists in planning region Latgale in a year 2011.

Aiming to improve accuracy of manure resources evaluation, all the suitable animals (cattle, pigs, horses and poultry) was divided in eleven groups according to its manure production capability per one head. The number of livestock within specified groups in planning region Latgale, coefficients for dry matter, organic matter, biogas production and heat energy content of biogas are presented in



Source: State Agency Agricultural Data Centre

Figure 2. **Number of animals in herds below and above 100 LU in planning region Latgale**

Table 1

Groups of livestock, number of livestock, energy content of biogas, manure and biogas characteristics

Group number	Group characteristics	Number of heads in group in Latgale	Manure production per head, t yr^{-1}	Manure in Latgale, t	Dry matter content	Organic matter content in dry matter	Biogas output from manure, m^3 t^{-1}	Heat energy of biogas, kWh m^{-3}
i		N	mi	M	k_{DM}	k_{OM}	v_B	e_B
1	Dairy cows	8407	0.0024 Y_D + 0.447	100400	0.18*	0.86**	300	5.8
2	Calves (0-6 month)	3367	2.6*	8750	0.18*	0.86**	300	5.8
3	Heifers (6-12 month)	1338	8	10700	0.18*	0.86**	300	5.8
4	Young cattle 12 – 24 month	3525	11.1	39130	0.18*	0.86**	300	5.8
5	Cattle (more than 24 month, except dairy cows)	2372	12*	28460	0.18*	0.86**	300	5.8
6	Horses	100	8*	800	0.3*	0.86**	300	5.8
7	Piglets	10409	0.4*	4164	0.07**	0.86**	500	6
8	Sows	2392	2.5*	5980	0.08**	0.86**	500	6
9	Gilts and boars	1243	2.5	3108	0.09**	0.86**	500	6
10	Fattening pigs	22507	2*	45104	0.06**	0.86**	500	6
11	Poultry	132600	0.022*	2917	0.45	0.75	510	6

*Sources: *(Priekulis at al., 2008), **(Дубровский at al., 1988)*

Table 1. For purpose of this investigation, prevailing manure handling technology was litter manure collection for cattle, horses or poultry, and slurry collection for pig manure in planning region Latgale.

Manure production by animals in different groups, manure characteristics, specific biogas output from organic matter of manure and specific energy content of biogas from different groups of animals from farms with more than 100 LU in planning region Latgale are presented in Table 1.

Average values of manure production m_i per 1 head in a year for all groups of livestock, except dairy cows, are given in Table 1. Average manure production m_i per dairy cow in a year was calculated according to equation (2) for all parishes and

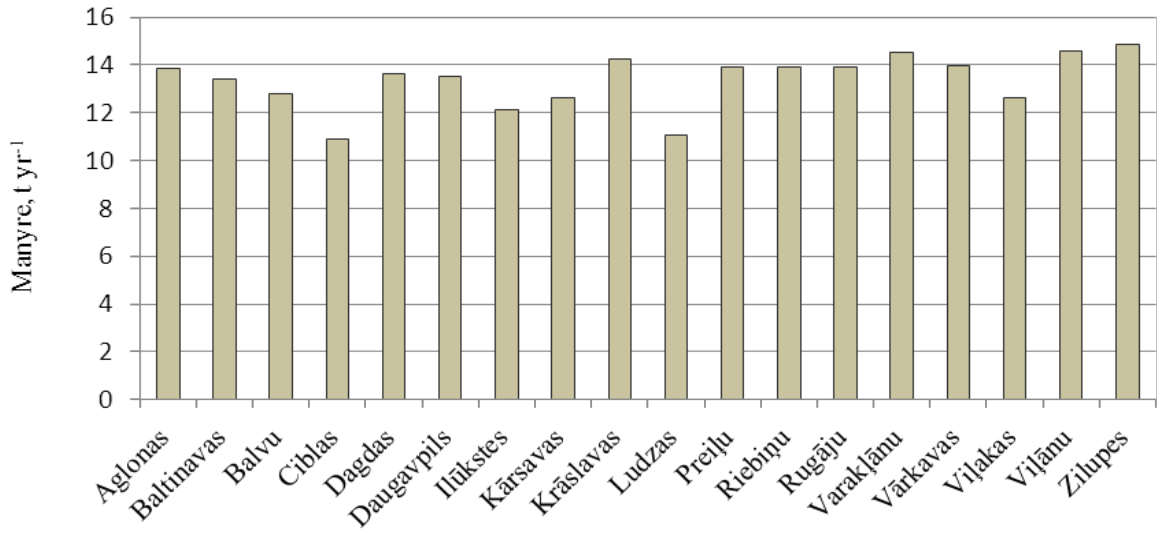


Figure 2. **Average manure production per one dairy cow in a year in municipalities of Latgale**

Table 2

Manure dry matter, biogas, energy and power of cogeneration units in municipalities in Latgale

Municipality	Dry matter	Biogas	Biogas	Biogas energy	Electric energy	Electric power of cogeneration unit
	t	Thous. m^3	%	MWh	MWh	MW
Aglonas	1550	502	4.5	2964	1186	0.148
Balvu	969	250	2.2	1450	580	0.072
Ciblas	231	60	0.5	346	138	0.017
Dagdas	2331	750	6.7	4426	1770	0.221
Daugavpils	4983	1606	14.3	9491	3796	0.475
Ilūkstes	2744	708	6.3	4106	1642	0.205
Krāslavas	1459	376	3.4	2183	873	0.109
Līvānu	2291	591	5.3	3429	1371	0.171
Ludzas	918	350	3.1	2086	835	0.104
Preiļu	891	230	2.0	1333	533	0.067
Rēzeknes	7920	2302	20.5	13479	5391	0.674
Riebiņu	3554	915	8.2	5309	2124	0.265
Rugāju	1335	344	3.1	1997	799	0.100
Vārkavas	2677	691	6.2	4006	1602	0.200
Viļānu	5972	1541	13.7	8936	3574	0.447
Sum	**39823**	**11216**	100	**65542**	**26217**	**3.277**

municipalities in planning region Latgale. Evident differences between municipalities were obtained in manure production per one dairy cow in a result of different levels of milk yields, Fig.2.

Manure, biogas, energy and constant electric power of cogeneration units for 11 groups of animals were calculated help by formula (1-5) in every parish, municipality, and in whole region Latgale, see Table 1. Summary manure dry matter, biogas, energy and constant electric power of cogeneration units within municipalities in Latgale are presented in Table 2.

Biogas production potential is strongly varying between municipalities. Highest biogas potential have municipality Rēzekne, as there were located many large cattle and pig farms, Fig. 3.

Biogas potential from cattle, pigs, horses and poultry manure in planning region Latgale, calculated help by equation (3), is presented in Fig. 4.

The share of biogas potential obtainable from manure is largest for cattle manure 77.6%, followed by

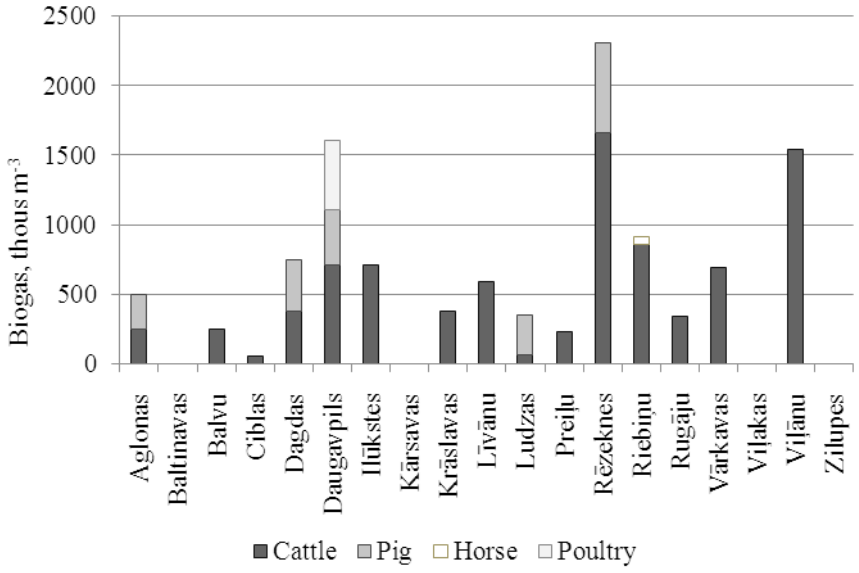


Figure 3. **Biogas production potential from livestock manure in municipalities of Latgale**

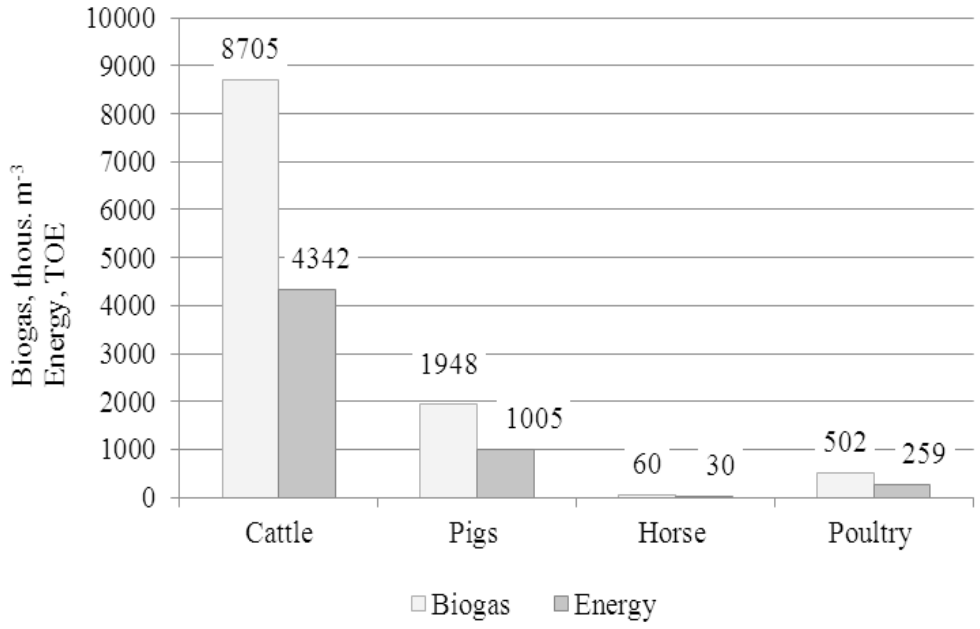


Figure 4. **Biogas and energy potential from utilizing of different manure in planning region Latgale**

pigs 17.4%, poultry 4.5% and horses 0.5% in planning region Latgale in 2012.

Summary constant electric power of cogeneration units in 25 most prospective parishes in Latgale are presented in Fig. 5.

The most perspective was the building of biogas plant in parish Viļāni, as there was located large dairy farm. The electric power of recently commissioned cogeneration unit is 0.95 MW, or 2.7 times larger to compare to biogas potential obtainable solely from manure in parish Viļāni. Rest of the needed feedstock for this cogeneration plant is provided by plant biomass, e.g. cereals, perennial grasses, maize, other energy crops or biomass from unused agricultural areas.

Economically feasible biogas production from manure is possible in 47 parishes from 151 in planning region Latgale. It is reccomended to include in feedstock, apart of manure, the different local biomass, e.g. maize, perennial grasses and legumes, straw, reed, waste biomass from food industry, biodegragable part of municipal wastes, aiming to increase economical viability for potential biogas projects and to provide stable round year running of biogas cogeneration plants.

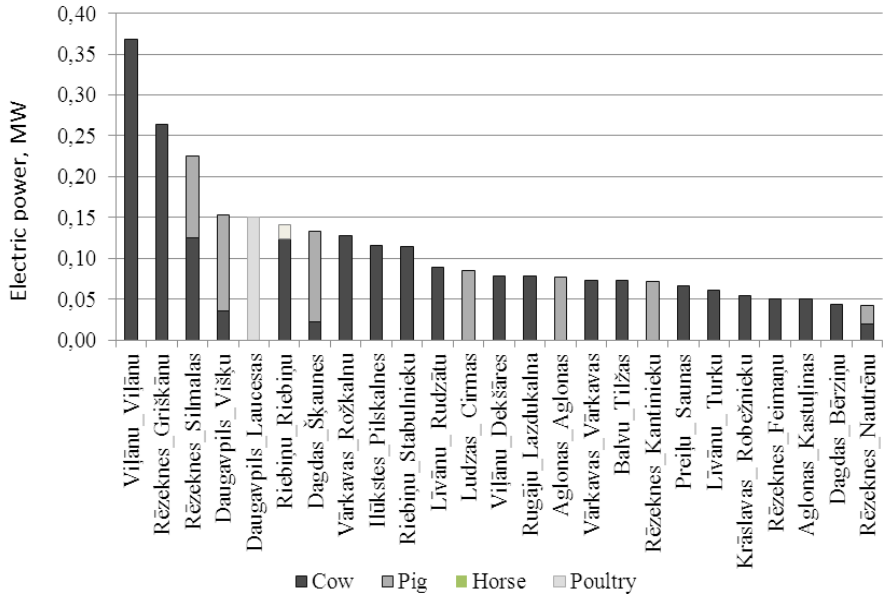


Figure 5. **Electric power of installable cogeneration units in most prospective parishes for utilizing of biogas produced from different manure in planning region Latgale**

Conclusions

Biogas potential obtainable from livestock manure was 11.2 million m^3, including 77.6% from cattle 17.4% from pigs, 4.5% from poultry and 0.5% from horses in planning region Latgale.

Manure dry matter available for economically justified biogas production was 39823 t in planning region Latgale in 2011.

Largest biogas potential of 2.3 million m^3 was obtainable in municipality Rēzekne, where located 20.5% of biogas potential from manure in planning region Latgale.

Electric power obtainable from biogas production from manure was varying from 0.008 MW in parish Skrudalienas, municipality Daugavpils to 0.37 MW in parish Viļāni, municipality Viļāni in planning region Latgale.

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