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The analysis of biodegradable waste as renewable resource for alternative energy production in Estonia

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The process of anaerobic digestion is well known for digestion of wastewater and sludge, but now it has been widely implemented for production of renewable energy worldwide. Biogas from anaerobic digestion process is one of the most perspective alternative energy sources.

Directive EU for renewable energy targets has been determined to 25% in 2020 for Estonia. Presently (2010) in Estonia the share of renewable energy rose to approximately 21%.

The annual of municipal solids waste (MSW) generated in Estonia accounts for 0.5 million tons or, taking into account the urban population (1.344 million inhabitants), 372 kg per capita. Up to 56% of total municipal solids waste generated in Estonia is easily biodegradable and can be used for biogas production.

The volumes and qualities of different types of biodegradable fraction of municipal waste, industrial waste and waste of landscaping, agricultural waste and sewage sludge generated in Estonia during the period from 2002 to 2011 were analysed and their energy potential was estimated.

The obtained data demonstrates that the main sources for biogas production are sewage sludge and animal manure. Also wastes of food industry, biodegradable municipal waste, and herbaceous biomass and agriculture products may be used. Special attention is paid to agricultural products and waste.

The minimum energy potential from waste in Estonia may be estimated as 306.69 GWh per year, but this is only 3% from total energy production in Estonia. For the achievement of the recommended level of using renewable energy in Estonia in 2020, other natural sources of energy such as solar, wind, rain, etc. will be used.

Key words: anaerobic digestion, biodegradable wastes, biogas, manure, renewable energy, waste

INTRODUCTION

The two key issues on the today's agenda are reduction of the amount of wastes and search for the sources of renewable energy. The process of anaerobic digestion (AD) of biodegradable waste that has high energy potential can be a possible solution for these problems.

A significant part of wastewater treatment plants is related with biological processes using activated sludge at some Baltic countries (Vaboliene et al., 2007; Zub et al., 2008; Dauknys et al., 2009). Anaerobic digestion is a well-known method for stabilisation of sludge from wastewater treatment plants (WWTP). The overall anaerobic digestion of organic fraction of excess sludge can be roughly broken into four metabolic stages: hydrolysis, acidogenesis, acetogenesis and methanogenesis. In well-balanced anaerobic decomposition, all products of the previous metabolic stage are converted into the next one resulting in a nearly complete conversion of the anaerobically biodegradable

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organic material into the end products – methane, carbon dioxide, hydrogen sulphide and ammonia. The remaining hardly biodegradable part of waste is stabilized and can be used as fertiliser or soil conditioner comparable with aerobic compost (Kalyuzhnyi et al., 2000). High degradation of organic matter and the additional amount of gas may reduce the cost of sludge treatment and generate additional energy.

To improve the characteristics of waste and to increase the biogas production co-digestion is used. Co-digestion is a simultaneous digestion of homogeneous mixture of two or more substrates. Usually a major amount of main basic substrate (e. g. manure or sewage sludge) is mixed and digested together with minor amounts of a single or a variety of additional substrates. Co-digestion offers several ecological, technological and economical benefits:

- Digester operational advantages, e. g. better nutrient balance (optimal nutrient ratio of TOC: N: P should be around 300:5:1), improved substrate handling, improved fluid dynamics.
- Improved overall process economics, e. g. higher biogas yield (40–200%) and additional income from gate fees paid for the waste materials digested.
- Most of chemical energy of the substrate is turned into biogas, less spent solids are to be processed and applied as fertilizer or soil conditioner (Braun and Wellinger, 2002).

As substrate for co-digestion can be used the following: residual sludge, garbage waste, paper mill residues, slaughter house waste, animal manure, sawdust, energy crops (corn, oats, lawn grass, clover), food industry waste (from distilleries, breweries, yeast production, confectionery by-products), pharmaceutical wastes, etc. (Braun and Wellinger, 2002; Kaparaju et al., 2002).

Today, most European countries are strongly dependent on fossil energy imports from regions rich in fossil fuel sources such as Russia and the Middle East. Developing and implementing renewable energy systems such as biogas from anaerobic digestion process, based on national and regional biomass resources, will increase security of national energy supply and diminish dependency on imported fuels. Directive of EU for renewable energy targets has been determined to 25, 40 and 23% in 2020, respectively for Estonia, Latvia and Lithuania (Directive…, 2009). The sunlight, wind, rain, tides, waves and geothermal heat are renewable energy. The share of renewable in electricity generation is around 19%, with 16.1% of global electricity coming from hydroelectricity and 3.3% from new renewable (REN21, 2011). The main contributors of new renewable energy are municipal solid waste (MSW), sewage sludge from wastewater treatment plants, manufacturing waste and landfill gas. The biomass used for electricity generation varies by region. Forest by-products, such as wood residues, are common in the United States. Agricultural waste is common in Mauritius (sugar cane residue) and Southeast Asia (rice husks). Animal husbandry residues, such as poultry litter, are common in the UK (Urban and Mitchell, 2011).

Presently the anaerobic co-digestion process is widely implemented for production of renewable energy worldwide. The production of methane via anaerobic digestion of the waste would benefit the society by providing clean fuel from renewable feedstock. Reducing the application of fossil fuel for energy production will reduce environmental impact, including global climate warming and pollution. Limitation of carbon dioxide and other emissions through emission regulations, carbon taxes, and subsidies on biomass energy is making anaerobic digestion a more attractive and competitive technology for waste management.

During the 1990s the anaerobic digestion process for treatment of a mixture of primary and secondary sludge of Tallinn wastewater treatment plant was studied at TUT and anaerobic reactors were recommended for construction (Blonskaja et al., 1996). The anaerobic digesters were constructed in Tallinn wastewater treatment plant (WWTP) in the 2000s and anaerobic mesophilic (30–35 °C) treatment process was used. The biogas produced was used for heating digesters and other internal needs of the WWTP. The investigation of scientists and engineers of TTÜ had shown that the thermophilic (53–55 °C) process should be used as a method of pre-treatment of sludge before the anaerobic digestion process (Menert et al., 2001, 2008). The choice of this type of operation regime was made due to the better hygienic quality of digested sludge in that range.

Besides sludge treatment, the anaerobic treatment process was investigated for the treatment of wastewater of food industry, such as cheese industry, yeast industry (Zub et al., 2008; Blonskaja et al., 2009; Koplimaa et al., 2010), distillery wastes and vegetable oils (Blonskaja and Vaalu, 2006). The results of this investigation showed that during the anaerobic digestion process the wastewaters of food industry are easily degradable and the process of biogas production is successful.

Currently, this process has been widely implemented for production of renewable energy from different types of waste worldwide.

The first biogas stations in Estonia were built in 1987:

1. Biogas station in Pärnu using pig manure operated in 1987–1997. Producer of 6 210 m^3 of biogas per day, operation ended with the closing of the pig farm.

2. Biogas station in Linnamäe using pig manure operated in 1987–1995 (Danish technology). Operation concluded when corrosion damaged the digester (Baltic biogas…, 2012).

Currently in **Latvia** there are 12 active biogas plants and half of them are based on livestock manure or other agricultural wastes of energy crops, and only one is more than one year old. Presently, the total energy production from biogas is 7.7 MW per year. Ltd. "Riga's üdents" wastewater treatment facility "Daugavgriva" produces 2.096 MW from anaerobic sludge digestion. Sanitary landfills produce energy from landfill gas: "Getlini" (Riga district) – 5.24 MW of energy, "Kivites" in Liepaja region – 450 kW and "Dalbe" (Valmiera region) – about 1 MW of energy from landfill gas (Bendere, 2011). There are currently 48 biogas plants approved for investment support from the Rural Development Programme all in different stages of the planning phase (Foged and Johnson, 2010).

In **Lithuania** it was considered to be best to demand the use of anaerobic digestion as a best available technique for livestock farms, and simultaneously to introduce excise taxation on natural gas in order to generate funds for increased support to renewable energy production, as for instance higher guaranteed feed in tariffs for electricity from biogas plant, which presently costs 0.30 LTL per kWh. There is a great interest in the Danish organization and technologies for combustion of household waste and use of the heat in the district heating systems. Household waste is a completely unutilized energy resource in Lithuania (despite from a few landfill gas stations). Forest based biomass makes up the largest proportion of the Lithuanian renewable energy production basis. The plan is to use biomass only for heat in smaller villages, while in larger cities for cogeneration of heat and electricity, and to reach a 70% share of biomass in heating by 2020 (Foged and Johnson, 2010).

In **Estonia** in 2005 about 18% was covered by renewable energy, mainly biomass which is a major resource in the country. Legislation is not encouraging farmers to build biogas plants in Estonia. It is possible to apply for support under the Rural Development Programme but the potential support amount is only sufficient to cover 10–20% of the investment costs. As a result, no biogas plants have been built in Estonia since 2007 (Foged and Johnson, 2010).

Presently (2010) in Estonia the share of renewable energy has risen to approximately 21%, of which 19% is heat and 2% is electricity. The data of Estonian Institute of Economic Research shows that 13.13 mln m^3 of biogas was produced in Estonia in 2010 that was less than in 2009. 71% (9.32 mln m^3) of biogas was produced from landfills, 22.5% (2.96 mln m^3) of biogas was from sewage sludge and 6.5% (0.8 mln m^3) was from swine slurry. During the two last years the greatest portion of the produced biogas was burned (Table 1).

Biogas production is carried out at Tallinn, Narva and Kuressaare Water Treatment Plants, Salutaguse Pärmitehas AS, and Saare Economics

Table 1. **The biogas production and use in Estonia, mln m³ (Estonian…, 2011)**

Biogas	2007	2008	2009	2010
Biogas production from: sewage sludge	2.64	2.84	2.69	2.96
swine manure	0.57	0.39	0.59	0.85
landfill	9.34	8.62	10.32	9.32
Total biogas consumption in the domestic market	12.55	11.85	13.60	13.13
Biogas for electricity generation	3.67	3.18	2.04	2.75
Biogas for heat generation	4.47	4.12	3.16	3.16
Burned biogas	3.78	3.8	7.78	6.16
Biogas for technological processes	0.62	0.75	0.52	1.05

Ltd. Only one station (Saare Economics Ltd. at Saaremaa) is based on livestock manure and other agricultural waste. The slurry and manure are dry matter and have low-energy potential and therefore the investment per unit of energy production is very big (Mikelsaar, 2008). Landfill gas is collected in Väätsa, Joelähtme, Uikala, Pääsküla and Paikuse landfills. All the listed landfills, except Uikala landfill, produce electricity and heat energy. Some of biogas stations are at different stages of search investment, planning phase and under construction. The operating and planned biogas stations in Estonia are presented in Table 2. Today ten biogas stations are working, seven stations began to operate in 2012 and in the future 12 biogas stations may be built elsewhere. The sludge from WWTP, manure and gas from landfill are used as the main resource for the biogas production.

Today the production and consumption of biogas in Estonia is still very small. At the same time, Estonia has a potential for the development of the biogas sector. Manure, sewage sludge, organic waste, food industry waste and herbaceous biomass may be used as a resource for biogas production in Estonia.

The aim of the study was as follows:

- To analyze the quantity and quality of biodegradable waste generated in Estonia.
- To evaluate the potential of biogas from these types of waste.
- To evaluate the quantity of alternative energy of biodegradability waste.

MATERIALS AND METHODS

The literature review was compiled in order to obtain knowledge about anaerobic co- digestion process for biogas production. The comparison of the situation of biogas production from waste in Lithuania, Latvia and Estonia was one of the objectives. The composition of municipal waste was analysed to estimate the quantity of biodegradable portion of municipal waste generated in Estonia.

The volume and quality of different types of biodegradable fraction of municipal waste, industrial waste and waste of landscaping, agricultural waste and sewage sludge generated in Estonia were analysed and their energy potential was estimated. The data on the amount of waste generated during the period from 2002 to 2011 was received from the Estonian Environment Information Centre, from the official statistics available in internet and from a number of research projects.

In the study the following types of waste were analysed:

- municipal solid waste from 47 cities and 15 counties;

Table 2. **Operating and planned biogas plants in Estonia**

Biogas plant		
Working stations and going biogas (TUT, 2008 , Menert, 2012)	**Built in 2012**	**Possible stations in the future (TUT, 2008, Menert, 2012)**
Tallinn WWTP	Aravere Biogas	Torma Ltd.
Narva WWTP	Tartu Biogas	AS Ekseko
Kuressaare WWTP	Loo Biogas	Tapa WWTP
Saare Economics	Oisu Biogas	Rakvere WWTP
WWTP of Salutaguse Yeast factory	Vinni Biogas	Kimeko Ltd.
Tallinn landfill (Jõelähtme)	Aardlapalu landfill	Puidukaubandus Ltd.
Pääsküla landfill	Tartu WWTP	AS Evemar
Rääma (Paikuse) landfill		AS Revekor
Uikala landfill		Väätsa Agro Ltd.
Väätsa landfill		Soone Farm Ltd.
		AS Tallegg, Biogas Ltd. (Loo)
		Põlva Biogas Ltd.

- biodegradable waste from 121 food industry companies;
- sewage sludge from 21 wastewater treatment plants;
- gardens, parks, pastures and meadows in Estonia;
- manure and energy crops from all 15 counties.

The method of statistical analysis using Mathcad 2001 Professional software was applied for the evaluation of the received data. The maximum, minimum and average values were calculated. The results are presented as average data of each year. Significant differences were removed from the estimation results.

The municipal waste generation is connected with economical activities and the size of population. During the last years the growth rate of the MSW generation decreased due to the slowdown of the economic growth. Today in Estonia there are only 121 food companies. The main types of food industries in Estonia are:

– dairies;
– meat production and processing industry;
– fish processing industry;
– fruit and vegetable industry;
– bakeries;
– alcohol- and non-alcohol production industry;
– ice-cream production industry;
– other food production industries (like chicken egg production, yeast, spices, etc.).

The largest pollution was caused by dairy, brewing and meat industry companies.

The sludge from WWTP is the best organic substrate for biogas production. Activated sludge is a by-product of the wastewater treatment process. Organic matter is easily degradable during the anaerobic digestion process and sludge pretreatment is not necessary. Today in Estonia the anaerobic digestion process for biogas production is used at large wastewater treatment plants.

From parks and streets large amounts of biodegradable organic waste come that can be used as additional feedstock in biogas production.

Special attention was paid to agricultural waste as the volume of this type of waste was very high.

The focus of this article was on the estimation of the biogas potential of biodegradable waste. Calculation of the theoretical amount of biogas was based on the data from scientific publications (Seadi et al., 2008; Normak et al., 2008).

As a result, the general picture of energy potential of biodegradable waste for biogas production in Estonia has been given.

RESULTS AND DISCUSSION

The analysis of biodegradable waste and biogas potential

Estonian national waste management plan 2008–2013 provides that the landfills issue will be finally solved in 2013, but today (2011) ca. 70% of municipal solid waste (MSW) and wastes from many industries are still land filled (Eek, 2011). The generation of municipal solid waste in Estonia during 2002–2010 is presented in Fig. 1.

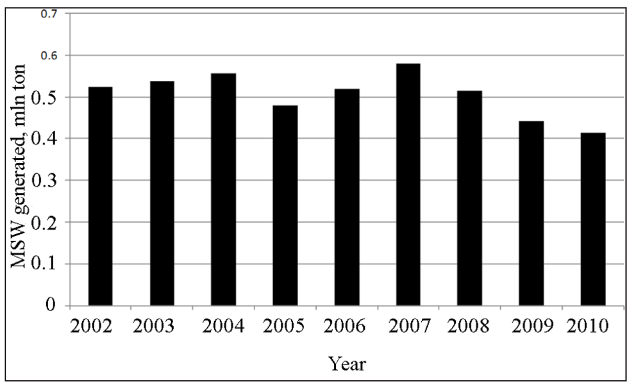

Fig. 1. Municipal solid waste generated in Estonia in 2002–2010 (Source: Estonian Environment Information Centre)

During the periods 2002–2010, average municipal solid waste generations was 507 ths. tons/year. The largest quantity of municipal solid waste (578.804 ths. tons) was generated in 2007. The recession of Estonian economy began in 2008 and consequently the quantity of waste constantly decreased. In 2011 the production of MSW dropped to 417.014 thousand tons.

The analysis of waste produced in 47 cities in Estonia showed that the largest source of pollution is Tallinn, which accounts for 52% (205.447 ths. tons/year) of all MSW generated by Estonian towns.

The annual of MSW generated in Estonia accounts for 0.5 million tons or, taking into account the urban population (1.344 million inhabitants), 372 kg per capita, i. e. less than in the western countries (Kalyuzhnyi et al., 2003). Around 56% of municipal solids wastes are of easily biodegradable food residues or biowastes (SEI, 2008), annual generation of these in Estonia accounts for 0.291 million tons.

The percentage of biodegradable waste in the total amount by weight of municipal waste deposited in a landfill shall be reduced to:

1) 45 by 16 July 2010;
2) 30 by 16 July 2013;
3) 20 by 16 July 2020 (Biolagunevate…, 2006).

Usually municipal solid waste consists of different types of waste. The composition of municipal waste in Estonia of 2007, as an example, is presented in Fig. 2. Paper and kitchen waste make the largest portion. The quantity of other components was considerably smaller.

Biodegradable part of MSW

Industrial waste

Today in Estonia there are 121 food industry companies of which 99 are large companies (Blonskaja and Loigu, 2012). The average amount of waste was estimated as 169.377 ths. tons/year. The largest pollution was caused by dairy (115.735 ths. tons/year), brewery (23.600 ths. tons/year) and meat (20.167 ths. tons/year) industry companies. The quality of wastewater of food industry companies varies and depends on the branch of industry. In food industry wastewater temperature is higher than that of the municipal wastewater. Wastewater of most companies contains high concentrations of nitrogen and phosphorus. However, all wastewater contains large amounts of easily biodegradable organic matter (high concentrations of protein, fat, lactose, etc.), so it can be treated by anaerobic methods. The potential of biogas of industrial waste was estimated to be 30 mln m^3 per year.

Wastewater sludge

The good quality of wastewater effluent at wastewater treatment plants (WWTP) in Tallinn, Haapsalu, Pärnu, Tartu and Kuressaare is a result of the reconstruction of WWTPs and use of a new technology for nitrogen and phosphorus removal, such as anaerobic-aerobic treatment. On the other side, the excess sludge is a serious issue for all wastewater treatment plants in the majority of the countries. The volume of sludge forms 0.5–2% of treated wastewater, however its handling and disposal costs amount up to 50% of the total operating costs of WWTP. Sludge is composed of by-products collected at different stages of the wastewater treatment process. It contains both compounds of agricultural value (including organic matter, nitrogen, phosphorus and potassium, and, to a lesser extent, calcium, sulphur and magnesium), and pollutants which usually consist of heavy metals, organic pollutants

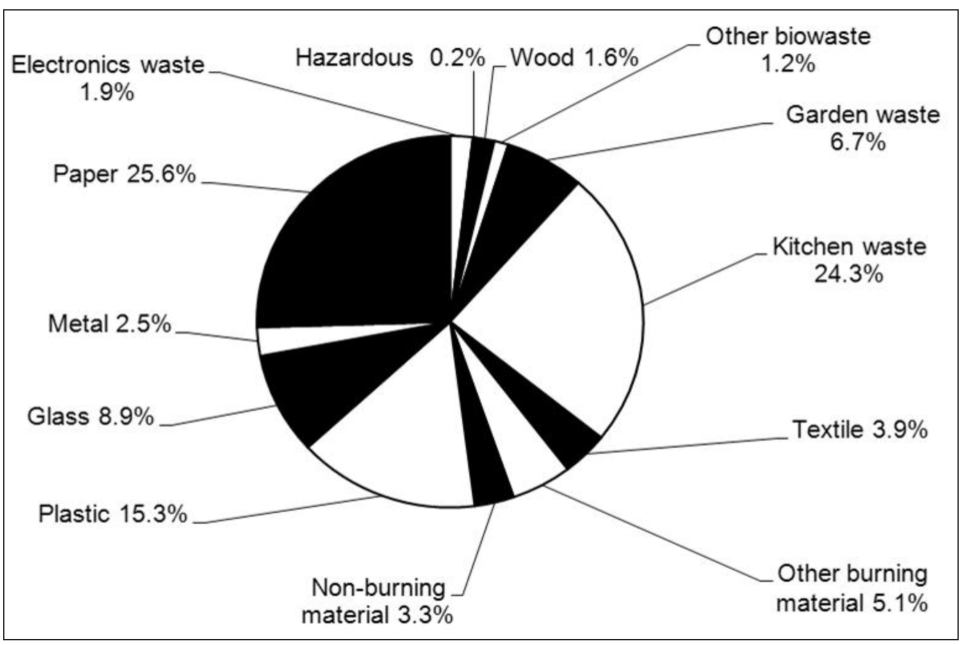

Fig. 2. The composition of municipal waste in Estonia in 2007

and pathogens. Usage of sludge in agriculture is limited by possible high concentrations of heavy metals and pathogens. Although Estonia has gained some success in reconstruction and modernization of WWTPs, achievements in wastewater sludge treatment are still moderate.

The amount of sewage sludge was steadily increasing in 2002–2007 (Blonskaja and Loigu, 2012). The peak value of 99.349 ths. tons was reached in 2007, which was followed by a downward trend. This trend is still ongoing. In 2009, merely 69.117 ths. tons of sludge were generated. The average amount of sewage sludge was estimated as 67.585 ths. tons/year. The practice of disposal of used non-stabilized sludge involves the use of the so-called sludge beds for natural drying or application as fertilizer.

Unfortunately, this is unsustainable and leads to a release of abundant, possibly hazardous, emissions into the environment. At the same time, wastewater sludge is a valuable resource especially with regard to its energetic value. Today, only some large treatment plants in Estonia are using anaerobic digestion process for sludge treatment and biogas production.

In total, the AD treatment of 67.585 ths. tons of sludge generated in Estonia would produce 33 mln m^3 of biogas.

Garden and landscaping waste

From parks and streets come big amounts of biodegradable organic waste which can be used as additional feedstock in biogas production. Garden waste has high nitrogen and humidity content, high density of material and minor lignite content, those properties make garden waste rapidly degradable. Landscaping wastes include plant stems, straws, sawdust, leaves (mainly autumn leaves), pieces of wood and bark which can be characterized as dry, high carbon content and inflexible feedstock. Due to these properties landscaping wastes are slowly degradable. Landscaping wastes need to be crushed prior to anaerobic digestion process, then the landscaping wastes are suitable feedstock for biogas production (Eesti…, 2005). Although too much garden and landscaping waste in the mix reduces the yield of biogas, as a substance called lignin which is found in woody material does not break down without oxygen (Briefing…, 2007). The average amount of waste was estimated as 6.161 ths. tons/year. Methane content of garden waste is about 55–65% and biogas production is around 3 mln m^3 per year.

Agricultural waste

Agricultural wastes such as manure, slurry, silage, harvest by-products (straw, fruit & vegetable wastes, etc.) are used as basic feedstock in biogas production plants. In general, animal manure has relatively high water content, ranging from 75% to 92% (Singh and Steven, 2009) and high content of inorganic nutrients, including N, P, K, ammonia, also consists of minor readily fermentable substrates, because most of the readily degradable substances (especially carbohydrates) have been digested and absorbed by animals. Animal manure also contains a large amount of microbial biomass, including bacteria and methanogens, what makes biogas production easier (Seadi et al., 2008).

The quantities of waste and biogas are presented in Table 3. The potential of biogas was calculated from the literature data (Keskkonda…, 2004; Normak et al., 2008). Based on the available statistics, the estimation of the number of agricultural animals (2.749 mln) shows that in Estonia approximately 7 million tons of animal wastes are produced annually, the anaerobic digestion of which may generate 425 million m^3 of biogas (Table 3). The methane content is about 60%.

The largest amount of agricultural waste was produced in Jõgevamaa, Tartumaa, Saaremaa and Lääne-Virumaa because the bulk of cattle breeding in Estonia concentrates in these counties. The smallest quantity of agricultural waste generation was registered in Raplamaa.

Energy crops

Energy crops are grown specifically for energy production and are suitable for anaerobic digestion. These include grass, maize, rape, sugar beet, silage of rye and defective potatoes, fruits and grain. The crops which are most suitable for biogas production have high biomass yield per hectare (tons of dry mass = dry mass harvested per ha), they have low cultivation costs, high digestibility and appropriate C/N ratio (between 20 and 30) (Mammoli et al., 2011).

Table 3. **The average quantity of wastes and theoretical biogas potential**

Animal and type of waste	Heads million	Dung t/ head/ year	Slurry t/head/ year	Total wastes million t/ year	Moisture %	Dry matter (DM) million t/year	Biogas m³/t DM	Biogas potential mln m³
Cattle without dairy cows	0.149							
– dung		5.3		0.790	75	0.198	200	39.60
– slurry			8.7	1.296	68	0.415	210	87.15
Dairy cows	0.113							
– dung		12		1.356	75	0.339	200	67.80
– slurry			21.0	2.373	68	0.760	210	159.6
Pig	0.360							
– dung		0.7		0.252	75	0.063	300	18.90
– slurry			1.6	0.576	75	0.144	270	38.88
Sheep	0.065	1.5		0.098	85	0.015	300	4.50
Poultry	2.056	0.033		0.068	63	0.025	250	6.25
Horse	0.006	9.0		0.054	85	0.008	300	2.40
Total	2.749			6.863		1.966		425.08

For the calculation of the theoretical biogas production from energy crops the value of 170 m³/t was used (Normak et al., 2008) (Table 4).

The quantity on energy crops mostly depends on weather. During 2004–2010 average energy crops generation was 67.929 ths. tons per year. Overall, the AD treatment of all energy crops generated in Estonia would produce 12 million m³ of biogas.

Herbaceous biomass

Estonia has 283.5 thousand hectares of idle land and natural grassland. Biomass productivity of 7.3 t per ha (wet weight), this would represent unused land available quantity of 2.07 million tons of biomass (Vares, 2008). The possibility of biogas production is 280 mln m³ per year.

Table 4. **Energy crops generation and biogas production (Source: Statistics Estonia)**

Energy crops	Growing area, ths. ha	Total output, ths. tons/year	Biogas mln m³/ year
Corn	1.375	28.076	4.773
Rye	13.212	35.279	5.997
Beet	0.35	4.574	0.778
Total		67.929	11.548
5% of silos			0.577
Total with silos			12.125

The analysis of energy potential

The total theoretical energy potential of investigated raw materials for biogas production is presented in Table 5. Calculation of the theoretical amount of biogas was based on the data from scientific publications (Seadi et al., 2008; Normak et al., 2008). The electricity production was calculated based on the assumption that 1 m³ of biogas yields 1.5 kWh of electricity.

Table 5 shows that Estonia has enough raw materials (4.346.508 ths. tons per year) for building new biogas plants in the future. The average amount of biogas production was estimated as 783.777 mln m³/year. Manure has the greatest energy potential. Herbaceous biomass and organic forms of municipal waste also have great potential of energy.

During 2002–2011 average energy production was 10.867 gigawatt hour (Electricity…, 2012). Average potential of energy from waste was only 3O6.69 GWh, which is only 3% from the total quantity of energy production.

To achieve the recommended level of renewable energy in Estonia by 2020, other natural sources of energy such as solar, wind, rain, etc. must be used.

Table 5. **Minimum energy potential of different types of waste generated in Estonia**

Type of waste	Amount of waste, ths. tons/year	Biogas mln m^3/ year	% *	Economically usable biogas quantity, mln m^3/year	Min energy GWh /year
Biowaste from food industry	169.377	30.319	10	3.032	4.55
Sewage sludge	67.585	33.793	50	16.896	25.34
Garden and park wastes	6.161	3.081	20	0.161	0.92
Total manure	1.966.000	425.080	30	127.524	191.29
Energy crop+silos	67.929	12.125	5	0.606	0.91
Herbaceous biomass	2.069.456	279.376	20	55.875	83.68
Total	4.346.508	783.774		204.094	306.69

* – % of economically usable biogas quantity was recommended by Background…, 2010

CONCLUSIONS

Estonia has enough raw materials for building new biogas plants in the future. The best resources from biodegradable waste for biogas production are manure, herbaceous biomass, biodegradable municipal wastes and sewage sludge. The quality of biodegradable waste is suitable for the anaerobic digestion process. The location of biogas stations will depend on the location of sources of raw materials. Mapping the biodegradable waste generating sources enables to select the best location for biogas plants in the future. In Estonia in 2020 the energy production from renewable resources must reach 25%. Average potential of energy from waste was only 306.69 GWh, which is only 3% from the total quantity of energy production. To achieve the recommended level of renewable energy in Estonia by 2020, other natural sources of energy such as solar, wind, rain, etc. must be additionally used.

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BIOLOGIŠKAI SKAIDOMŲ ATLIEKŲ KAIP ATSINAUJINANČIŲ ŠALTINIŲ ALTERNATYVIOS ENERGIJOS GAMYBAI ESTIJOJE ANALIZĖ

Santrauka

Atliekų kiekio mažinimas ir atsinaujinančių energijos išteklių paieškos yra dvi pagrindinės šiuolaikinės problemos. Anaerobinis biologiškai skaidomų atliekų, kurios turi didelį energijos potencialą, pūdymas yra galimas minėtų problemų sprendimo būdas. Dabar šis metodas yra plačiai naudojamas atsinaujinančios energijos gamybai pasauliniu mastu. Tam, kad būtų pagerintos atliekų savybės ir padidinta biologinių dujų gamyba, taikomas kompleksinis pūdymas. Kompleksinis pūdymas yra tuo pačiu laiku vykdomas gerai išmaišyto mišinio iš dviejų arba daugiau substratų pūdymas. Dažniausiai didelis kiekis pagrindinio substrato (pvz., mėšlo, nuotekų dumblo) yra sumaišomas ir pūdomas kartu su mažesniu kiekiu vieno ar daugiau papildomo substrato(-ų).

Pagrindiniai šio tyrimo tikslai:

– įvertinti organinių atliekų kiekio mažinimo sąvartynuose galimybes;

– išanalizuoti Estijoje sukaupiamų biologiškai skaidomų atliekų kiekį ir kokybę;

– įvertinti biologinių dujų potencialą iš tokio tipo atliekų;

– įvertinti alternatyvios energijos kiekį iš biologiškai skaidomų atliekų.

Metinis buitinių kietųjų atliekų kiekis Estijoje – 0,5 mln. tonų, arba po 372 kg vienam gyventojui (1,344 mln. gyventojų). Šis kiekis nuo 2007 m. nuolat didėja. Iki 56 % bendro buitinių kietųjų atliekų kiekio, sukaupto Estijoje, yra lengvai biologiškai skaidomos ir gali būti naudojamos biodujų gamybai.

Europos Sąjungos direktyvoje nurodyta, kad Estijoje iki 2020 metų 25 % energijos turi būti pagaminta iš atsinaujinančių energijos šaltinių. Dabar (2010) Estijoje atsinaujinanti energija vidutiniškai siekia 21 %, iš kurių 19 % sudaro šiluma ir 2 % elektra.

Estijoje yra pakankamai žaliavos tam, kad būtų pastatytos naujos biodujų gamyklos ir įrenginiai. Mažiausias energetinis potencialas iš biologiškai skaidomų atliekų Estijoje gali būti vertinamas 341,60 GWh / metus. Geriausi ištekliai biodujų gamybai Estijoje yra mėšlas, žalioji biomasė, biologiškai skaidomos buitinės atliekos ir dumblas.

Raktažodžiai: anaerobinis pūdymas, biologiškai skaidomos atliekos, biodujos, atsinaujinančioji energija, atliekos