Mechanics Transport Communications

ISSN 1312-3823 (print)
ISSN 2367-6620 (online)
volume 17, issue 1, 2019
Academic journal **http://www.mtc-aj.com** **article № 1747**

POSSIBILITIES FOR ENERGY PRODUCTION FROM MUNICIPAL WASTE BIOGAS IN ROUSSE REGION

Ivaylo Ganev, Iskra Simova, Tsvetelina Petrova
ivailo.ganev@gmail.com; iskrasimova@gmail.com, tzvetelina.petrova@tu-sofia.bg

Technical University of Sofia, Sofia 1000, 8 Kl. Ohridski Ave, BULGARIA

Key words: *biogas, anaerobic installation, waste energy, biodegradable waste, waste treatment*
Abstract: *Present work deals with analysis of the possibilities for utilization of biodegradable waste at the region of Rousse. The advantages of the utilization of the biodegradable waste are discussed from ecological point of view and in terms of the energy perspectives. Quantitative data from different biodegradable waste generated by the municipalities of interest is analyzed. The quantities of the biodegradable waste to be processed in a biogas installation are calculated. The technological scheme of the biogas installation is presented. Mass balance estimation of the biogas quantities that will be generated by the installation is performed. The biogas parameters are studied and possible utilization technologies are suggested.*

INTRODUCTION

Waste accumulates significant amounts of resources and energy in its "life" cycle. The main issue before landfilling is how to recover the invested resources and energy. This problem is solved for part of the waste by separation of the recyclable components. But there still is a group of components, the biodegradable waste in particular, that cannot be treated this way.
The question is what are the possible solutions that can give a useful product from biodegradable waste? The existing technologies for biodegradable waste utilization are very limited mainly to biogas production. Biogas generation is based on an anaerobic digestion process, i.e. with absence of oxygen. This can be realized as following:

- by landfilling of biodegradable waste at a landfill;
- by developing an anaerobic installation for biodegradable waste that generates biogas.

In the case of landfilling and after that generation of biogas (landfill gas), the processes are much slower because the waste is mixed with no degradable waste and the anaerobic conditions are present after the technical restore of the landfill. The landfill gas generation process lasts decades, which leads to a lower gas flow rate, and hence utilization difficulties. The only advantage of this approach is that no additional investments are needed.
The biogas generation process in anaerobic installations for biodegradable waste is limited to a few weeks cycle. This is a consequence of the technological conditions ensured for the

biogas generation from biodegradable waste (there is no mixing of these waste with others). This lead to controlled quantities and utilization of the gas produced. The most common way of utilization is combined production of electrical and heat power.
From an energy point of view, biogas from both landfills and anaerobic installations is a renewable energy source (RES). In addition to this, biogas is also a local energy source. As Bulgaria is poor of local energy sources possible biogas utilization will reduce fuel import and dependence of external supplies as well, even in minimal scale. There is no doubt that, the generation and use of biogas from waste brings significant benefits. From waste management point of view, the utilization of part of the waste in anaerobic installations significantly reduces the volume of landfills, especially if it is used in addition to the production of biogas the product obtained after the fermentation of the waste is utilized as well.
The environmental impact of biogas technology on biodegradable waste is essential because:
First of all, the landfilled biodegradable waste will be reduced as well as the targets set in the National Waste Management Program (till 2020 the amount of waste must be up to 35% of the total amount of the same waste generated in 1995) will be achieved.
The second is that emissions of free-flowing greenhouse gases will be reduced. The reduction of the landfilled biodegradable waste leads to a reduction in the total amount of landfill gas generated in landfills. Globally, it is found that a large amount of landfill gas generated in landfills cannot be captured. Landfill gas is the major environmental problem caused by the landfill of solid municipal waste.
Despite the obvious benefits of developing an anaerobic installation for the treatment of separately collected biodegradable municipal waste to society, it is very important to determine the exact capacity of the installation and the choice of technology for making investment decisions respectively.
In Bulgaria, the problem of the landfilled bio-waste is solved technologically only for the Sofia region where an installation for their recovery is developed. In the other regions of the country, these problems remain active and still have not studied.
The present study examines the potential biogas production of biodegradable waste from a typical Regional Waste Management System (RWMS) - such as Rousse.

QUANTITATIVE ASSESSMENT OF THE BIODEGRADABLE WASTE FOR RWMS ROUSSE

In table 1 summarizes the municipalities of RWMS Rousse [1,2,3]:

Table 1

Municipality	**Population**	**Portion of landfilled waste**
Rousse	161838	82.09%
Vetovo	11620	1.49%
Ivanovo	8519	5.59%
Slivo Pole	10085	4.11%
Tutrakan	14012	6.72%
RWMS Rousse	206074	100.00%

All calculations are based on the final data for 2016.

At present, on the territory of RMS Rousse, the only operating waste treatment installation is the landfill of RWMS Rousse. The annual amount of landfilled waste is about 78,000 tons [3]. In the analysis below, only biodegradable waste that can be used as feedstock in installations for anaerobic treatment installation for biodegradable municipal waste will be considered. These wastes are:

- Food waste
- Paper
- Gardening

There is also other biodegradable waste which potential for biogas generation at anaerobic digestion is greater but their degradation process is much longer [4] and cannot be directly used in bioreactors (fermenters). These are:

- *Wood*
- *Textile*
- *Leather*

Primary treatment of wood waste is recommended in order to eliminate the slowing effect of cellulose on the biodegradation process, whereby this kind of waste can also be used in bioreactors.

In Table 2 are presented the quantities of biodegradable waste that can be used in an installation for anaerobic treatment by municipalities. The estimated data is for 2023, when such installation can be built and put into service [2,3].

Table 2 Quantities of biodegradable waste by municipalities for 2023 permissible as feedstock for the anaerobic installation without the recycled materials

		Rousse	**Vetovo**	**Ivanovo**	**Slivo pole**	**Tutrakan**	**RWSM**
Food	t/y	12960	325	1048	283	1240	**15857**
Gardening	t/y	10640	662	1709	1659	906	**15575**
Wood	t/y	1143	37	86	142	80	**1488**
Paper and cardboard	t/y	5736	137	409	226	430	**6937**
Total	**t/y**	**30478**	**1162**	**3252**	**2309**	**2656**	**39857**

Only part of the biodegradable waste can be collected separately for their use in a biogas installation for anaerobic treatment. Table 3 presents the estimated amount of biodegradable waste for biogas installation

Table 3 Quantities of biodegradable waste by municipalities as feedstock for the anaerobic installation at 2023

		Rousse	Vetovo	Ivanovo	Slivo pole	Tutrakan	RWSM
Food	t/y	4536	114	367	257	434	**5708**
Gardening	t/y	6142	289	771	714	392	**8308**
Wood	t/y	571	19	43	114	40	**787**
Paper and cardboard	t/y	1147	27	82	45	86	**1387**
Total	**t/y**	**12396**	**449**	**1262**	**1130**	**952**	**16190**

Regarding the season on figure 2 the change of the individual biodegradable waste components are illustrates (for the municipality of Rousse).

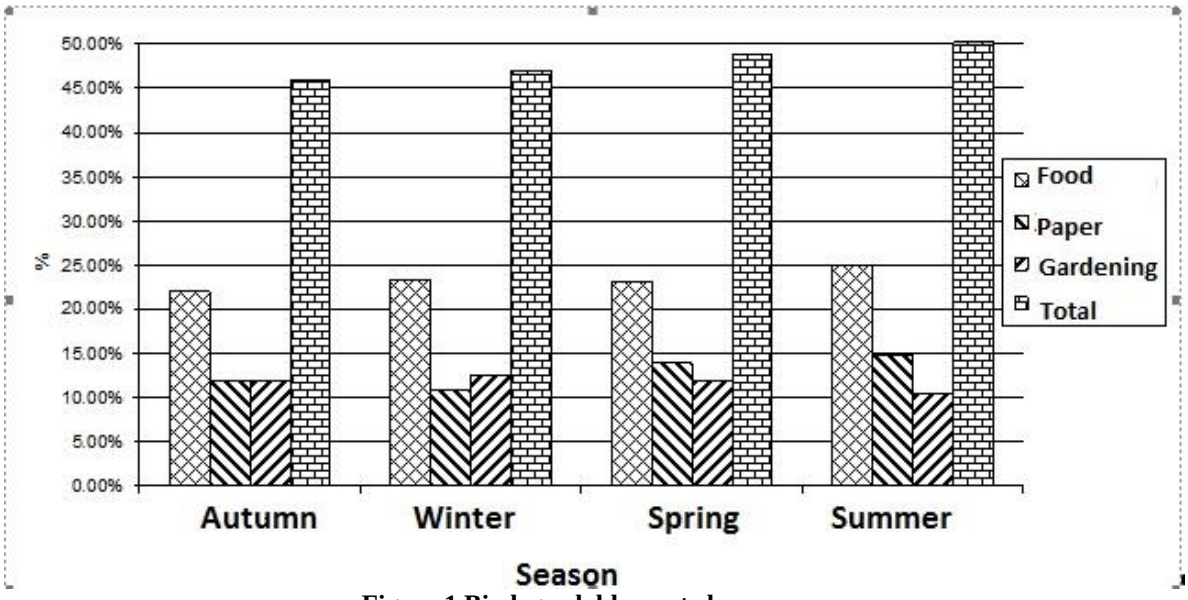

Figure 1 Biodegradable waste by seasons

Based on the biodegradable waste quantities, can be concluded that the amount of biodegradable waste for RWSM Rousse is sufficient for anaerobic installation for biogas to be build.

TECHNOLOGICAL SCHEME OF INSTALLATION FOR ANAEROBIC TREATMENT OF BIODEGRADABLE WASTE AND POSSIBILITIES FOR BIOGAS PRODUCTION

The technological block scheme of the biogas installation is shown on Figure 2.

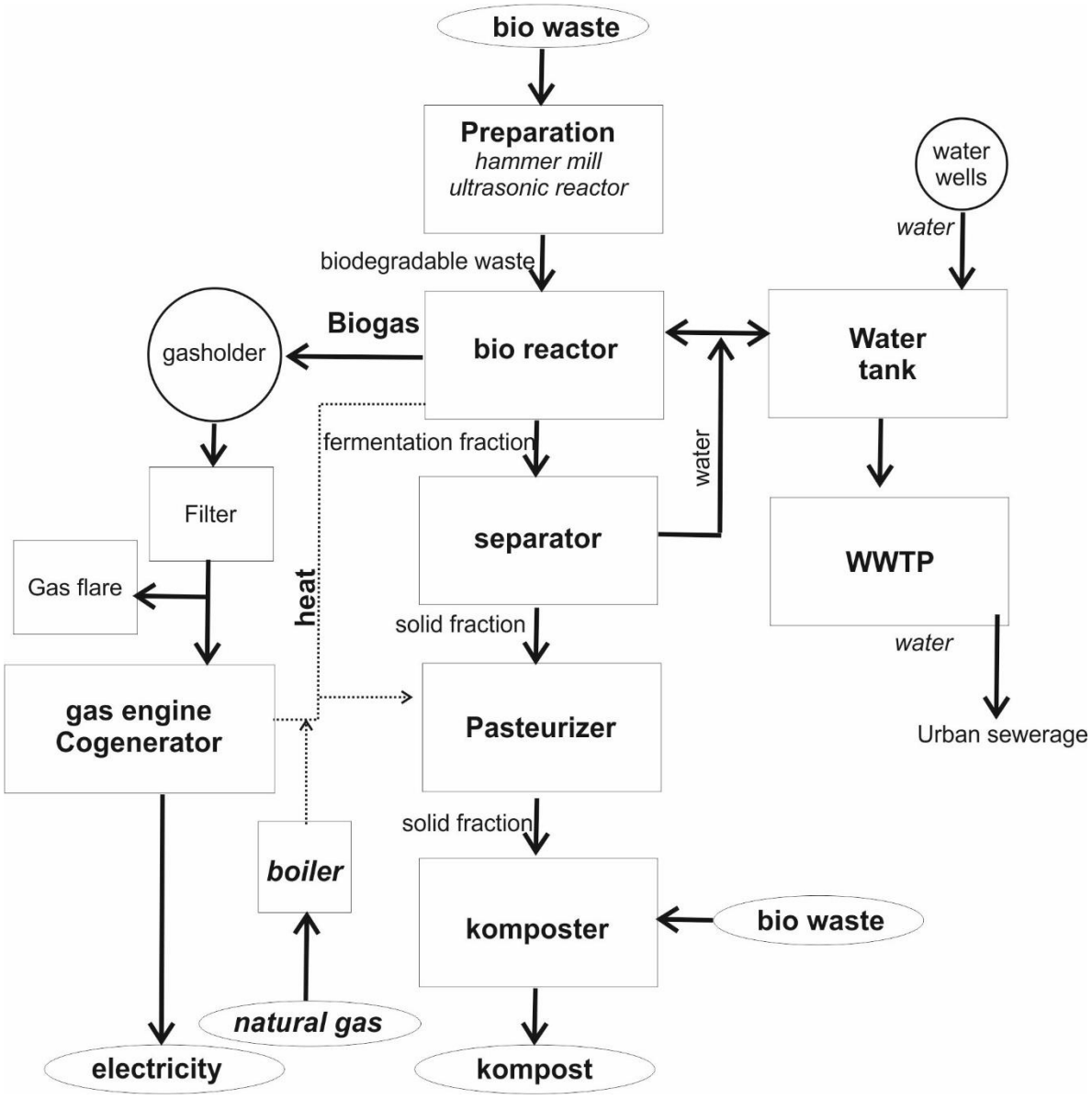

Figure 2 Technological scheme of the installation for anaerobic digestion of biodegradable solid municipal waste collected separately in Rousse

Based on this technological scheme in Table 4 the basic mass flows rates [5,6,7] at the nominal capacity of the installation with an input of 15 000 t /year are presented.

Table 4 Mass balance of the technology for dry continuous fermentation of biodegradable waste with a nominal capacity of 15000 t / y

Biodegradables wastes delivered	**15000**	tons
Bioreactor input including	**19500**	tons
Biodegradables wastes	13500	tons
Green waste, non-treated	3000	tons
Technological water after centrifugation	3000	tons

Output after bioreactor including	**17250**	tons
Solid fraction	4350	tons
Liquid fraction	12900	tons
Biogas	**2250**	tons
Input composting		
Solid fraction	4350	tons
Green waste, non-treated	2250	tons
Technical water for irrigation	9900	tons
Received compost	**4350**	tons
Losses and waste	**3600**	tons
Compost losses	1350	tons
Hazardous waste including		
Pretreatment	1500	tons
Composting	750	tons

On the basis of the estimated amount of biodegradable waste entering the installation calculations are made using the Busswell equation model [6]. The results obtained are used in the received biogas assessment.

ENERGY CAPACITY (CALORIFIC VALUE) OF THE BIOGAS

The calorific value of the biogas is determined by its methane content of. Due to their small amount the other combustible components (including H_2) do not affect the biogas calorific value.

Lower heat of incineration or calorific value for methane is 36 MJ / m3N (8560 kcal / m^3N) or 50 100 kJ / kg or 9.7 kWh / m^3N [8].

Table 5 presents the biogas yield at different quantities of biogas entering the installation

Table 5 Methane obtained at different installation loads

		Biogas received, t/y					
Parameters	**Unit**	**2 500**	**5 000**	**7 500**	**10 000**	**12 500**	**15 000**
CH_4	%	53.89%	53.89%	53.89%	53.89%	53.89%	**53.89%**
CO_2	%	41.75%	41.75%	41.75%	41.75%	41.75%	**41.75%**
NH_3	%	4.29%	4.29%	4.29%	4.29%	4.29%	**4.29%**
H_2S	%	0.07%	0.07%	0.07%	0.07%	0.07%	**0.07%**
CH_4	**Nm^3**	**284 413**	**568 825**	**853 238**	**1 137 651**	**1 422 063**	**1 706 476**

Based on the data from Table 5 the energy indicators of the generated biogas [9] are determined as well as the installed capacities presented in Table 6.

Table 6 Biogas generated and installed generation capacities

Parameters of biogas generated	Value	Unit
Methane at nominal installation load 15000t/y	1 706 476	m^3/y
Biogas energy capacity	16 552 817	kWh/y
Annual usability of the installation	8 760	h
Heat power received	1 890	kWh

Conclusions

RWSM Rousse has the potential of biodegradable waste, some of which can be collected separately and used in an anaerobic installation for biogas generation. Such an installation will meet the objectives to reduce the portion of the generated biodegradable waste.

The biogas generated is in sufficient quantity to be used as a fuel in thermal or cogeneration power plants based on Otto cycle principle. In addition to this, the energy produced is a renewable and a product of domestic energy source that will lead to greenhouse gas emissions reduction as well as decrease of primary energy sources import.

Finally development of an installation for anaerobic digestion for biodegradable municipal waste treatment is highly recommended for RWMS Rousse and other similar regional associations for waste management.

Acknowlegment: The paper is published with the support of the project No BG05M2OP001-2.009-0033 "Promotion of Contemporary Research Through Creation of Scientific and Innovative Environment to Encourage Young Researchers in Technical University - Sofia and The National Railway Infrastructure Company in The Field of Engineering Science and Technology Development" within the Intelligent Growth Science and Education Operational Program co-funded by the European Structural and Investment Funds of the European Union

REFERENCES

[1] http://www.nsi.bg/sites/default/files/files/data/timeseries/Pop_6.1.1_Pop_DR.xls, 2017

[2] http://www.nsi.bg/sites/default/files/files/data/timeseries/Pop_6.2.2_Pop_DR.xlsq 2017

[3] Ecology_3.3, http://www.nsi.bg/sites/default/files/files/data/timeseries/Ecology_3.3.xls, 2017;

[4] Rajaram V., and 2. From Landfill Gas to Energy: Technologies and Challenges, ISBN: 978-0-415-66474-5, CRC Press, 2011

[5] www.moew.government.bg

[6] Biogas from Waste and Renewable Resources, , ISBN 978-3-527-31841-4, 2008;

[7] Prof. Dr.-Ing. Dieter Deublein, Dipl.-Ing. Angelika Steinhauser, Biogas handbook, Teodorita Al Seadi and collective, ISBN 978-87-992962-1-7

[8] Tasheva S., G. Valchev, V. Rasheva,. Emission limit values for emissions from different combustion plants. Sp. "Toplotehnika za bita", no. 2, year XIV, 2009, 41-44

[9] Valchev G., S. Tasheva, V.Rasheva, . Comparative characteristics of a flame-tube steam generator. Scientific Conference with International Participation "Food Science, Techniques and Technologies 2008", October 24-25, 2008, Scientific Works, Vol. LV, Scroll 2, 219-224, ISSN 0477-0250

ВЪЗМОЖНОСТИ ЗА ПРОИЗВОДСТВО НА ЕНЕРГИЯ ОТ ОТПАДЪЧЕН БИОГАЗ В РЕГИОНА НА ОБЩИНА РУСЕ

Ивайло Ганев, Искра Симова, Цветелина Петрова
ivailo.ganev@gmail.com; iskrasimova@gmail.com, tzvetelina.petrova@tu-sofia.bg

Технически университет – София,
София 1000, бул. „Климент Охридски“ 8
БЪЛГАРИЯ

Ключови думи: *биогаз, анаеробна инсталация, отпадъчна енергия, биоразградими отпадъци, третиране на отпадъци*

Резюме: *Настоящата работа се занимава с анализ на възможностите за оползотворяване на биоразградими отпадъци в района на Русе. Предимствата от използването на биоразградимите отпадъци се разглеждат от екологична гледна точка и от гледна точка на енергийните перспективи. Анализират се количествени данни от различни биоразградими отпадъци, генерирани от общините, представляващи интерес. Изчисляват се количествата на биоразградимите отпадъци за преработка в инсталация за биогаз. Представена е технологичната схема на инсталацията за биогаз. Извършва се оценка на масовия баланс на количествата биогаз, които ще се генерират от инсталацията. Изучават се параметрите на биогаза и се предлагат възможни технологии за тяхното използване.*