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AN INTEGRATED APPROACH FOR LANDFILLED WASTE REDUCTION THROUGH ITS EFFECTIVE UTILIZATION TO ENERGY GENERATION

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Key words: *waste energy, biogas, pyrolysis, syngas, waste treatment*
Abstract: *Present work is considers an integrated approach based on modern technologies (excluding direct incineration), for reducing of the landfilled municipal waste disposed and obtaining energy from them for the region of Rousse. The advantages of the presented technologies are considered. The calorific value of the received energy carriers, and the expected quantity of gas are estimated to a single unit of input waste. The technological schemes of the installations are presented. The possibilities for application of the received energy sources have been analysed. In conclusion, the quantity reduction of the landfilled waste is computed.*

INTRODUCTION

Current trends in waste management are characterized by the search of an approach to minimize the landfilled waste and its maximum utilization. The main goal is zero waste. All applicable waste treatment technologies aim to extract to the great extend the invested resources form the waste - both physical and energy – while the resulting product is marketable.

The solution of this problem depends on the morphological composition of the waste and its condition. For part of the waste, this issue is easily solved by separating the recyclable components. But this is a small part of the waste that is in good condition. For the rest, which includes biodegradable waste and those that are not suitable for recycling like plastics, paper, wood, leather waste textiles etc. the main option is their energy utilization.

The energy potential of a certain component depends on its carbon content. [1]

The effective technologies for efficient energy recovery of waste are as follows:

- Biogas production

- Direct incineration of the waste or Refuse-derived fuel (RDF)

-Syngas production through pyrolysis

Biogas production. Biogas is produced when the waste is treated in an anaerobic environment with absence of oxygen. When using anaerobic installation for biodegradable waste, the biogas process is limited to a few weeks cycle [2]. This is due to the fact that technologically the conditions are suitable for the biogas generation from biodegradable waste (there is no mixing of these wastes with others). When appropriate temperature conditions exist, typically the process is mesophilic (temperature 37° C).

Direct incineration is an oxidation process that results in thermal destruction of waste, and the energy rejected by the process is used to produce heat and power energy [3]. Direct incineration of MSW is the most widely used method in the world for treating municipal waste for energy purposes. It has been developing for decades and has a wealth of experience in its realization.

Pyrolysis is a process of thermal destruction without oxygen, carried out at temperatures of 800-1000 °C resulting to pyrolysis gas or syngas [4].

In all three processes an energy carrier is generated, which is use for electric and thermal energy generation, usually via cogeneration.

The main advantage of the process of gasification of the waste, compared to its direct incineration, is the possibility of obtaining a higher quantity of electrical power per unit of heat power energy.

From an energy point of view, waste is a local energy source. Bulgaria has poor energy resources and waste energy utilization will reduce the import of fuels and hence the dependence on external energy supplies.

At technologies for energy utilization of waste, the volume of the landfilled waste is significantly reduced. At the same time the waste product is not biologically active and has lower requirements for landfilling, ie. it is not necessarily to be stored in a sanitary landfill for municipal waste.

An alternative technology for the disposal of biodegradable waste is composting. The process is aerobic in which a final stabilized product is obtained. Using this technology there is no recovery to the energy input. Previous experience shows that the commercialization of compost cannot pay back the investment in waste management systems. The main issue is a decrease of the f landfilled waste.

In waste incineration, investment for installations is high. The technology requires the availability of a perennial heat consumer. Purification facilities are expensive with significant incidental costs. Hazardous waste is also generated. All this makes this technology hard to realize for poorly populated residential systems.

Currently, a complex solution of the waste problems in Bulgaria is designed mainly for the city of Sofia. For the other Regional Waste Management Associations, the main approach is separation of recyclable components and landfilling, but this is in sharp contrast with the current trends in reducing the landfilled waste.

The present study is based on specific data from the Regional Waste Management Association (RWMA) Rousse - it is chosen as a typical example of such associations established in Bulgaria.[5,6]

POSSIBLE TECHNOLOGICAL SOLUTIONS FOR ENERGY GAIN FROM THE WASTE IN ROUSSE RWMA

An integrated approach for decrease of the landfilled waste by generation of energy in RWMA Rousse requires the use of several technologies that give environmental benefits depending on the used component of the waste for energy production.

According to the waste management programs in the municipalities of RWMA Rousse, separate collection of biodegradable waste is foreseen. The most effective solution for waste utilization is the production of biogas in an anaerobic installation and subsequent production of compost from the output fermentation fraction, after which it will be offered to the market.

On Figure 1 the technological scheme of the anaerobic installation for biogas is shown.

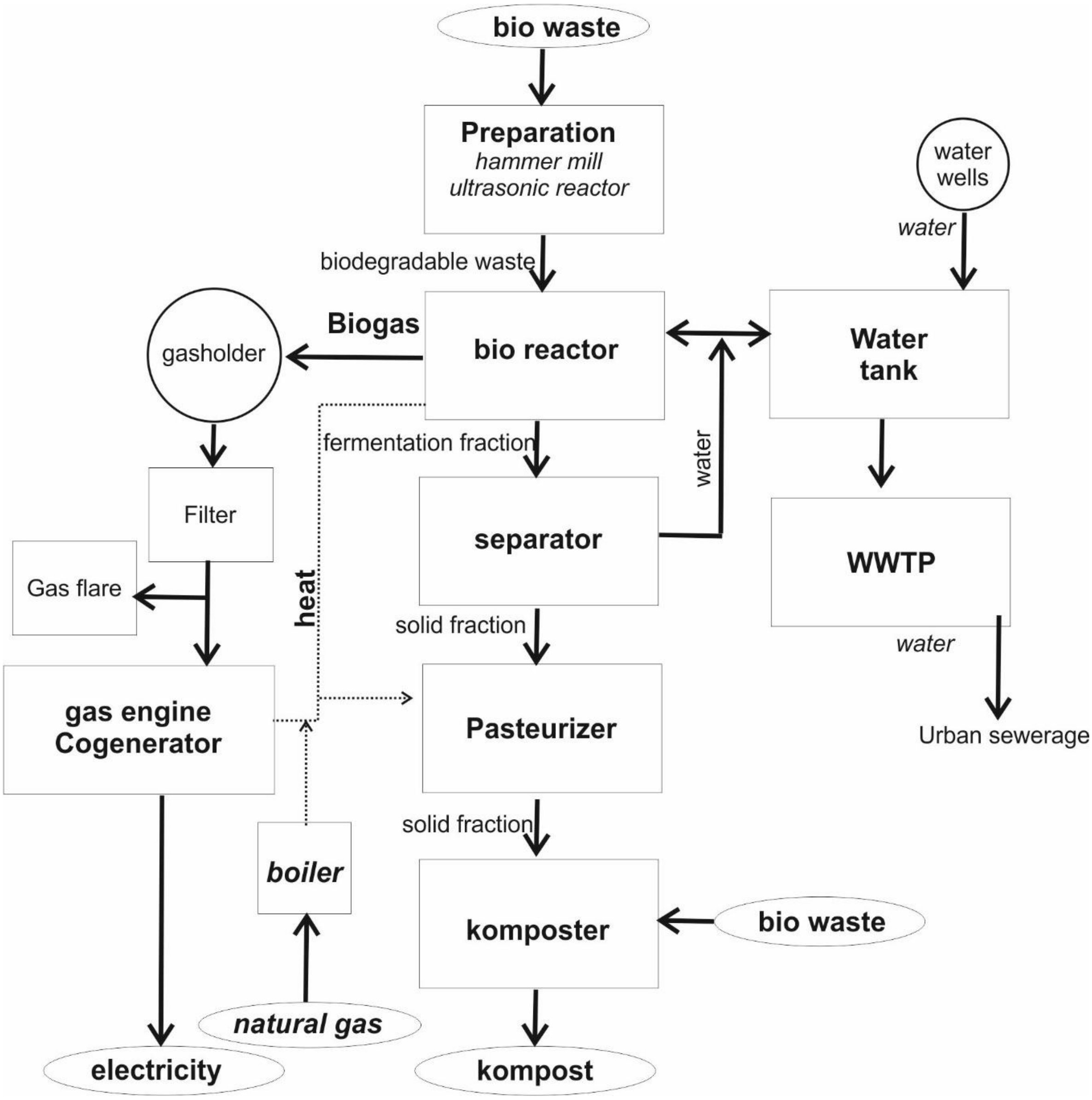

Figure 1 Technological scheme of the installation for anaerobic digestion of biodegradable solid municipal waste collected separately in Rousse

Apart of the separately collected biodegradable waste the remaining amount is significant. One of the modern technologies for its energy utilization is through vacuum gasification [7].

Figure 2 is presents a technological scheme of a vacuum gasification installation.

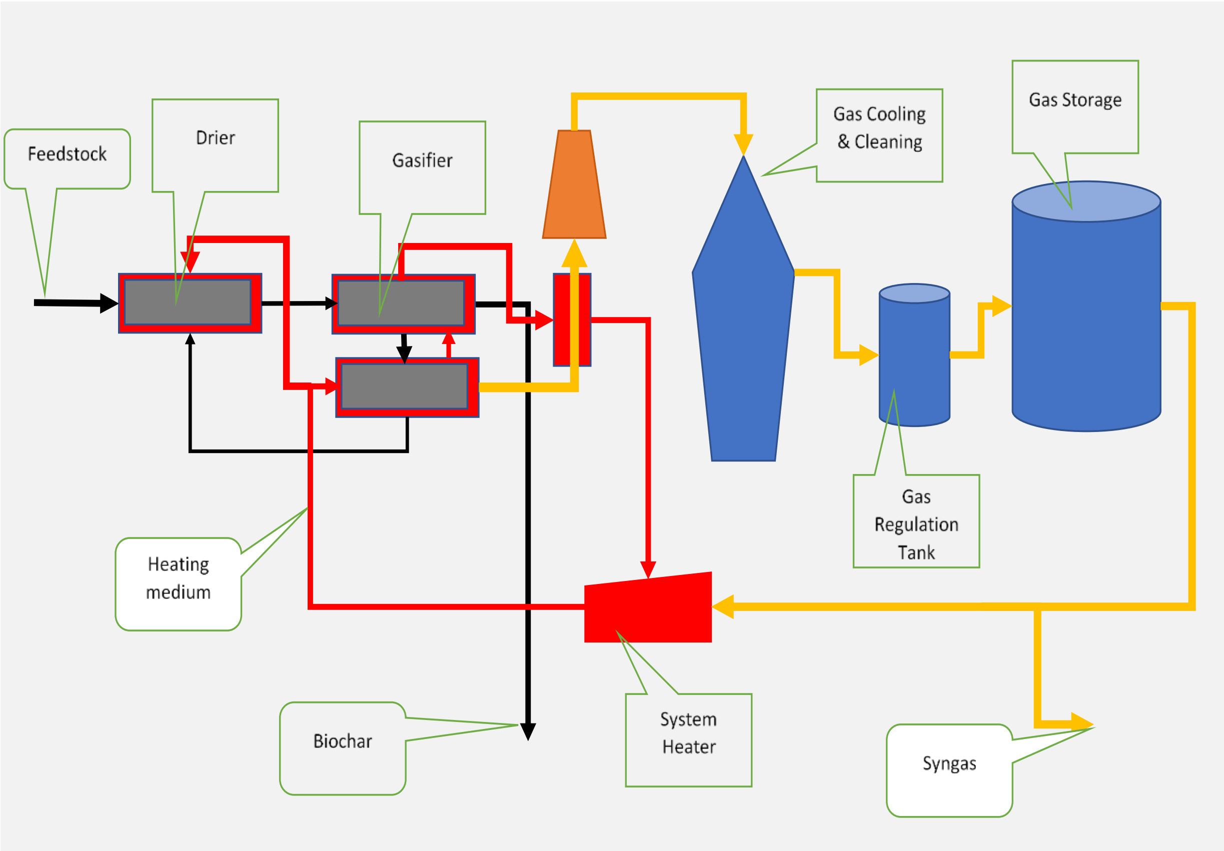

Figure 2 Technological scheme of waste vacuum gasification installation

The advantages of the vacuum gasification installation compared to conventional incinerators are as follows:

- The syngas received is relatively clean from an environmental point of view and can be used in installations where expensive methods of exhaust gas cleaning are not required.
- The investment in vacuum gasification installations is up to 40% lower than the incinerators, at the same capacity of the raw material. The lower price is due to the "light" gas cleaner and the compact size due to the absence of a huge air flow that is needed for combustion in incineration installations.

Vacuum gasification technology has the following features:

The technological process uses two-stage gasification with a high degree of conversion of hydrocarbon compounds in gaseous fuel - synthesis gas. The residual waste product after gasification is up to 20%, which is not active and can be landfilled. Temperatures at which gasification is performed ensure the absence of hazardous components in the residual waste fraction. Exhaust gases emitted into the atmosphere do not contain furan, dioxins and other harmful gases, and all harmful components such as heavy metals and others found in the solid fraction are in a bound and harmless form.

Regarding the generated energy career from the anaerobic installation - biogas and vacuum gasification – syngas, both products allow their easy use as a primary energy carrier.

ENERGY CAPABILITY OF THE BIOGAS AND SYNGAS PRODUCED

The calorific value of these fuels is determined by the content of hydrogen, methane and other combustible components.[8]

Based on the literature data and observations of such installations, the composition of the combustible components of these gases are presented in Table 1.

Table 1 - Mean composition of biogas and syngas

Chemical formula	Units	**Biogas**	**Syngas**
CH_4	%	**55**	**25**
H_2	%	0	**38**
CO	%	0	**17**
Ethilene	%	0	**4**

The rest components up to 100% are ballast gases with respect to the combustion process.

Based on the percentage of the respective component and the lower heating value, the calorific value of these gases is determined for:

- Biogas - 5.3 kW / m^3N.
- Syngas - 5.2 kW / m^3N

The most common and effective way to recover these gases is by using them to produce electrical power in cogenerator with OTO engine and then there is a maximum yield of electrical power. Typically, waste treatment installations are built far from heat consumers and therefore are more difficult to implement. In these cases, the received heat power energy is mainly used for the needs of the technological process.

On Fig. 3 the thermal efficiency of the installations is shown depending on the power of the motor

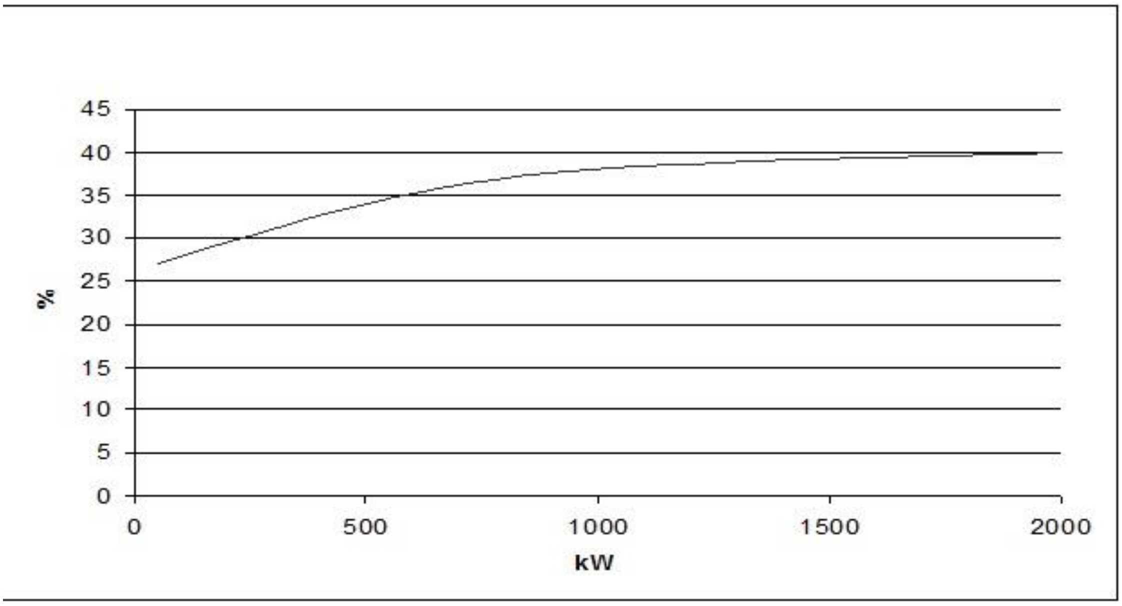

Figure 3 Thermal efficiency of the generators with Oto engine

So it is perfectly feasible to expect the efficiency to be in the range of 35-40%.

The amount of gas generated is determined by the mass balance as follows:

- - Biogas - 150 kg / 1000 kg of waste;
- - Syngas - 722 kg / 1000 kg of waste

INSTALLATIONS WASTE INPUT

All calculations are based on final data for 2016 and estimated data for 2023 - because then the corresponding installations could be developed.

Currently, the annual amount of landfilled waste is about 78 000 tonnes on the territory of RWMA Rousse.[6]

Table 2 presents the amount of biodegradable waste that is generated and those that can be used in a biogas installation.

Table 2 – Amount of biodegradable waste 2023 total and eligible as feedstock for the anaerobic installation, excluding the recycled ones

RWMA-Rousse		Generated-total amount	Collected separately and submitted to an anaerobic biogas plant
Food waste	/y	**15857**	**5708**
Gardening	/y	**15575**	**8308**
Woody	/y	**1488**	**787**
Paper and cardboard	/y	**6937**	**1387**
Total	**/y**	**39857**	**16190**

The total amount of landfill waste after taking into account the input to the biogas installation is about 62,000 t / y.

There are materials in the composition of the waste that cannot be energetically utilized - these are inert materials and glass. Based on the data from the morphological analyses for the individual municipalities, their amounts are calculated and it is concluded that theoretically about 40000 t / y. can be fed to a vacuum gasification installation. It is realistic a vacuum gasification installation for about 16-20 thousand tons / y to be developed, which corresponds to 40-50% of the theoretically calculated.

Conclusions

RWMA Rousse has the potential of waste, from which it is possible to generate energy in different modern technologies. Part of the biodegradable waste that can be collected separately will be used in an anaerobic installation for biogas production, and some of the waste will be used as an input raw material in a vacuum gasification installation. From this integrated approach for energy utilization will reduce the landfilled waste with about 35-40%.

The resulting biogas and syngas are in sufficient amount to be used as fuel in boiler installations or cogeneration plants based on Otto's cycle.

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ИНТЕГРИРАН ПОДХОД ЗА НАМАЛЯВАНЕ НА ОТПАДЪЦИТЕ ЧРЕЗ ЕФЕКТИВНОТО ИЗПОЛЗВАНЕ ЗА ГЕНЕРИРАНЕ НА ЕНЕРГИЯ

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Ключови думи: *енергия от отпадъци, биогаз, пиролиза, сингаз, третиране на отпадъци*

Резюме: *Настоящата работа разглежда интегриран подход, основан на съвременни технологии (с изключение на директно изгаряне), за намаляване на депонираните битови отпадъци и получаване на енергия от тях за района на Русе. Разгледани са предимствата на представените технологии. Калоричността на получените енергийни носители и очакваното количество газ се изчисляват на база единица входни отпадъци. Представени са технологичните схеми на инсталациите. Анализирани са възможностите за прилагане на получените енергийни източници. В заключение се изчислява количеството на депонираните отпадъци.*