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ANIMAL WASTE AS THE SOURCE OF GREEN ENERGY IN THE REPUBLIC OF SERBIA

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Abstract

Intensive livestock production in the Republic of Serbia is accompanied by the generation of a large amount of animal waste. The lack of an organized system for managing this type of waste represents a significant problem when it comes to human health and the environment. The fact that the greater part of animal waste can be turned into a useful resource - green energy - is ignored. By using animal waste as a raw material for obtaining biogas, "green" electrical and thermal energy is obtained. The paper analyzes the current situation of animal waste management in the Republic of Serbia and the possibility of using it for energy purposes. The research results indicate that this waste is used as an energy source in some biogas power plants together with silage and residues of agricultural products. There are currently around 40 bioelectric power plants operating in Serbia, and the possibility of building new ones is much greater, but it is limited by large financial investments in their construction. Using animal waste as an energy source avoids environmental pollution while at the same time achieving benefits for both the investor and the local population-community.

Key words: *Animal waste, green energy, Republic of Serbia.*

Introduction

Limited energy resources and problems associated with the consumption of fossil fuels have forced all countries, especially developed ones, to consider the transition from traditional energy sources to renewable energy sources. Waste of animal origin includes waste generated in slaughterhouses, meat processing plants and facilities for breeding and keeping animals, as well as carcasses of dead animals. In the Republic of Serbia, this type of waste is classified into three categories, and the research conducted in this paper is focused on animal waste generated on farms.

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The increase in the number of animals in livestock production leads to an increase in the amount of waste, which can have harmful effects on the environment if it is not managed properly. Livestock waste contributes to global warming through methane emissions from manure and other sources. If animal waste is used as organic fertilizer or as an alternative source of energy in the form of biogas, it can help reduce global warming. Using livestock waste as an energy source offers numerous advantages, including odorless fuel and reduced soil and air pollution [1]. Unsafely discarded animal remains are dangerous for human health and the environment because they represent a source of infection and the risk of spreading animal diseases that are transmitted to humans, such as rabies, salmonella, anthrax, bird flu and others [2].

Generation of green energy from animal waste

Green energy is electricity obtained from renewable energy sources. Animal waste is a significant source of green energy, and manure is most often used to obtain it.
Anaerobic digestion (AD) is a process that converts manure into methane-rich biogas. It can significantly reduce greenhouse gas (GHG) emissions from manure. Using biogas as a substitute for other fossil fuels, such as coal, in electricity generation eliminates two sources of GHG — manure and coal combustion [3].
Figure 1 shows the process of converting biogas into electrical and thermal energy.

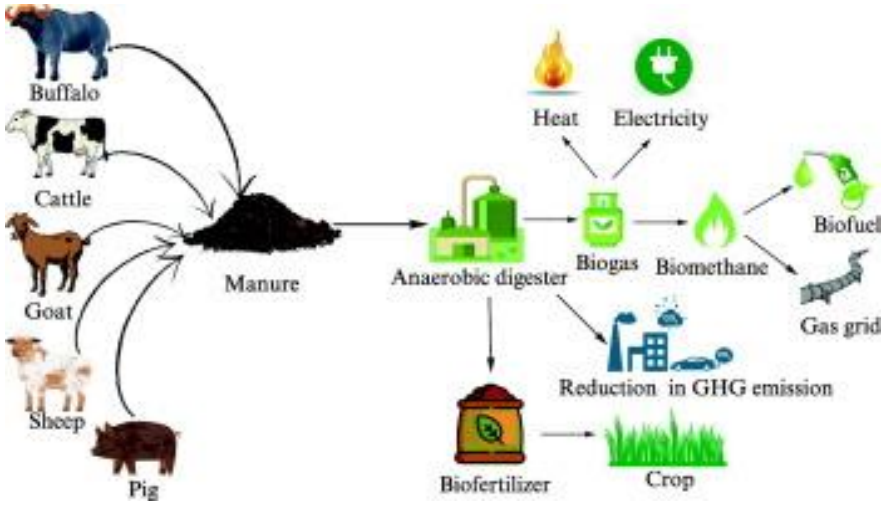

Figure 1: Conversion of biogas into electrical and thermal energy [4]

The production of biogas through the process of anaerobic digestion additionally enables the development of jobs because it requires manpower for the production, assembly and transportation of raw materials, the production of technical equipment as well as the construction, operation and maintenance of biogas plants.
The biogas plant not only produces electricity, but the digested substrate, known as digestate, is a useful soil fertilizer rich in nitrogen, phosphorus, potassium and

micronutrients that can be applied to the soil using the same equipment as liquid fertilizer. It is not only a question of purely energy implications, but also of positive impacts on the use of land, crops, on the local economic system and on the employment of the local population [5].

Although biogas systems cost less than some other technologies, their provision is often still a challenge for low-income households in developing countries, especially in rural areas [4].

Biogas also helps farmers to significantly reduce the negative impacts of their activities on the environment. It enables them to recycle organic nutrients and restore soil fertility, making it a key resource for the present and future of rural areas. Biogas plants allow many farmers to convert their conventional practices into sustainable agriculture, thereby contributing to the development of the bioeconomy. The use of biogas for rural areas has other environmental benefits. Reduces the need to burn wood for domestic use, slowing deforestation and eliminating emissions that would otherwise be produced [5].

Animal waste in the Republic of Serbia

Dealing with animal waste includes collection, classification according to the degree of risk (category), storage and treatment. Waste of animal origin is classified as waste group 02 00 00 according to the Waste Catalog [6]. Dealing with this type of waste is defined by the Rulebook on the method of sorting and dealing with by-products of animal origin, veterinary and sanitary conditions for the construction of facilities for the collection, processing and destruction of by-products of animal origin, the way of conducting official control and self-control, as well as conditions for livestock cemeteries and grave pits [7]. From the aspect of environmental protection, dead animals are also environmental pollutants. Under the influence of atmospheric factors in the external environment, they quickly decompose with the creation of unpleasant-smelling gases (ammonia, hydrogen sulfide, mercaptan) and other decomposition products (fatty acids, aromatic acids) and thus pollute the environment (air, soil, water). Such places become habitats for stray dogs and cats, rodents, vultures and insects [8]. Organized management of animal waste is not fully developed due to insufficient financial support to local governments, and an additional problem is poorly developed awareness of threats to health and the environment, as well as insufficient motivation of agricultural producers. Application of the "polluter pays" principle is difficult to implement.

According to the data of the Republic Institute for Statistics of the Republic of Serbia, in 2023, 177,511.00 tons of waste of animal origin were generated [9]. This data cannot be considered complete because a large part of animal waste ends up in waterways and landfills (Figure 2), which poses a great danger to human health and the environment.

Figure 2: Dead animals at the landfill
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Production of green energy from animal waste in the Republic of Serbia

The research results indicate that animal waste is used as an energy source in some biogas power plants together with silage and residues of agricultural products. There are currently about 40 bioelectric power plants operating in Serbia, and the possibility of building new ones is much greater, but the financial investments for their construction are high.

According to data from 2019, there were 22 biogas plants in operation in Serbia, with a total installed power of 21.21 MW. Most of the plants had a power of about 1 MW, a few in the range of 500 to 650 kW, and only one had a power of 200 kW. In that year, these plants together used about 175,000 t equivalent amount of liquid manure, which was less than 1% of the total potential in Serbia. It is concluded that the current share of properly disposed manure in Serbia is very low, while it is almost completely unused on small farms [10].

One of the first biogas power plants in Serbia realized in the Dairy "Lazar" in Blace. The plant is co-generative, electric power 1 MW, heat power 1060 kW and during the first year of operation (8400 operating hours) 7 400 000 kWh of electricity was produced, of which 6 800 000 kWh was delivered to the electricity distribution network. The technological process is anaerobic in a buried digester, in which biogas (Hd = 5.5 kW/Nm3) and biofertilizer (solid and liquid phase) are produced on the basis of cow manure (30%), whey (40%) and silage (30%). The biogas plant was realized within only 15 months [11].

An example of good practice is the investment of the Turkish company Fortis Energy, which deals with renewable energy projects, in a 3 MW biogas power plant in the village of Dolovo in Vojvodina. The facility's three engines are expected to produce

more than 28 million kWh of electricity annually, which is enough to supply 12,000 households and prevent the emission of 20 million kilograms of CO_2 equivalents from fossil fuels [12].

Agricultural farms in Serbia are fragmented, which represents one of the main problems for the formation of an anaerobic system for the production of green energy that could support and pay for itself [13].

It is necessary to turn to small biogas plants, which include plants on smaller farms that use mainly animal manure as raw material, and the produced biogas is used at the site of the plant for the combined production of electricity and heat. Small biogas plants are not defined in the valid and planned legal and sub-legal documents of the Republic of Serbia, which means that their development and implementation is not supported either. Data on this area in Serbia are not available in the literature [10].

Small biogas plants usually have high specific investment costs. The average investment for a biogas plant with an installed capacity of 75 kW is estimated at €9,000/kW, which is significantly higher compared to a 1,000 kW plant, where the investment is around €3,750/kW. When, in addition to liquid manure, other substrates are used (such as energy plants, chicken manure, fodder residues and harvest residues), additional devices are needed for pretreatment and dosing of the substrate into fermenters, which further increases investment costs [10].

It is estimated that each bioelectric power plant with a capacity of 1 MW can reduce the total emission of greenhouse gases by approximately 7000 cubic meters compared to a thermal power plant using coal [14].

Conclusion

Although significant amounts of animal waste are generated annually in the Republic of Serbia, this waste is not recognized as a resource for obtaining green energy. There are many reasons, but the biggest problem is the inadequate management of this waste in rural areas. An additional difficulty is the lack of information among agricultural producers about the advantages of green energy and the economic profit they could achieve regardless of high initial investments.

By building small biogas plants, farmers could achieve significant socio-economic benefits, while simultaneously contributing to environmental protection. These solutions would provide them with additional income and as a reduction of energy costs on farms. By introducing biogas technologies, farmers become key actors of sustainable development, which can improve their social status and strengthen the local economy.

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