Biogas Stations in Slovakia – Current State

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Abstract — **The paper focuses on the use of biomass in the conditions of the Slovak Republic. The importance and position of biomass within renewable energy sources is highlighted in the introduction. Documents such as laws, studies, and strategies which have been developed with the aim to increase the share of renewable energy sources within the energy mix are listed here. The issue of biogas and its possible sources in the Slovak Republic was also solved. An important part of the paper is the presentation of the current statistical data concerning to the number of biogas stations and also information about the material used for gasification purposes in SR. A separate part of the contribution consists of the field research results focused on selected biogas stations in western Slovakia. We provide basic technical specifications, biomass suppliers and statistical data about heat and electricity production for each station. Selected stations were located in villages: Smolinské, Malý Cetín, Ružindol, Chynorany and Kolíňany.**

Keywords — renewable energy sources, biomass, fermentation, gasification, anaerobic digestion, waste recovery.

I. Introduction

The current way of using energy greatly affects the environment and shows a growing threat of negative climate change, urban smog and acid rain. The Act on the Promotion of Renewable Energy Production was incorporated into the Slovak Republic legislation in 2009 (Act No. 309/2009 Coll.). Its adoption results in rapid increase of the number of biogas plants, an increase of the share of energy produced from agricultural biogas of the total energy production of the country as well as the total energy produced from renewable sources. Enhanced share of renewable energy sources on total energy production is one of the aims of the European Union policy. All these circumstances are incentives to develop biogas power generation. The effect of renewable energy sources (RES) on the environment is lower as well as their contribution to the reduction of emissions, greenhouse gases and pollutants is important [1]. Biomass has the greatest technical potential among all renewable energy sources in Slovakia. Biomass includes biodegradable fractions of products, waste, residues from agriculture (plant and animal) and forestry, as well as decomposable fractions of industrial and municipal waste. Each such source has different properties in terms of heat, ash content and moisture content. Biomass is considered to be a long-term stable source of energy with less dependence on seasonal climate variability. Biomass energy can be converted into electricity, heat, or gaseous and liquid biofuels using various chemical, thermal and biological processes [2].

Biogas is formed by thermochemical and biochemical transformations of biomass. It is obtained from agricultural biomass, biodegradable municipal waste and sludge from sewage treatment plants [3]. It can be used for the production of heat and electricity [4]. The main source of biomass is waste from the wood-processing industry [5]. The second important source of biomass is livestock production, where manure from cattle, pigs and poultry breeds is produced. Another source is municipal and agricultural waste, which can be used to produce biogas. Purpose-built biomass sources as example fast-growing woody plants and crops are another important source of biomass [6].

II. Biogas Stations

Biogas stations are the plants where the conversion of biomass into biogas and digestate is upcoming. Produced biogas contains about 50–75 % of methane, which is the fuel for the energy production. Digestate contains only nutrients and humus, which are no longer decomposable and therefore do not create odour.

The biogas plants, on the basis of the material being processed, can be divided into three groups: agricultural, waste and biogas stations for sewage treatment plants [7].

The simplest use of biogas is its simple burning and the conversion of energy contained therein into heat. Otherwise biogas is used as a fuel for an internal combustion engine in which mechanical energy is produced and following converted into electricity using the generator, and heat is produced in cogeneration [8, 9].

The biogas power stations (BS) consist of several objects. The first object is the inlet tank where the input material is mixed, homogenized and regularly dosed to the main part of the biogas plant, to the fermenter [10]. In the fermentation tank in the absence of air, the material is heated to the operating temperature, mixed and wetted. This process is called anaerobic digestion. The ideal temperature for the anaerobic process depends on the type of bacteria. Biogas is discharged from the fermenter into a storage tank for the future treatment [11]. Cogeneration is a process where biogas is used to drive an internal combustion engine driving a generator for electricity generation. Waste heat from exhaust gas and engine can be used for heating [11].

III. History and Present State of Biogas Production in Slovakia

Although the experience with biogas production in the former Czechoslovakia is relatively long, in Slovakia the first biogas plant was established in 1996 in Bátka

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(AGROS s.r.o.). Only five biogas stations were in operation till the year 2009, while two of them were focused on processing of cultivated targeted crops and three of them were targeted on livestock manure recovery. The production of primary energy from biogas compared to the other European countries was considerably lagging behind due to the short period of biogas plant utilization in Slovakia and similar situation was expected over the coming years [12].

A fundamental milestone in the use of RES was the adoption of Directive 2009/28/EC of the European Parliament and the Council, which committed member states of the EU to set national targets for the implementation of RES in line with the common objective of the Union.

The first milestone for 2020 is to achieve 20 % share of RES in the Union gross final consumption. There was an obligation, for the Slovak Republic, to increase the use of RES for final energy consumption to 14 % in 2020. The significant growth in the construction of biogas stations in Slovakia has been observed after the adoption of Act no. 309/2009 Coll. on the promotion of renewable energy sources and combined production of electricity and heat, together with the Decree of the Office for Regulation of Network Industries (URSO) 221/2013 Coll. The declarations guaranteed the mandatory purchase of electricity by distribution companies with a fixed purchase price for 15 years.

The new energy policy of the Slovak Republic has stimulated the investments into the renewable energy sources. According the URSO statistics, 111 biogas stations with a total output of 103 MW were established in Slovakia by the end of July 2015. The power plant with the highest output - 7.03 MW opened its operation in 2012 in the village Badín near Banská Bystrica. Electricity is produced by processing the compost as a certified biofuel. The installed capacity of the remaining 70 biogas stations ranges from 0.9 to 1.0 MW. Most of these stations are focused to the production of electricity from maize silage.

The data show that the most robust year-on-year increase in the number of biogas stations – up to 41, occurred in 2013, while none was put into operation in 2014. It was related with the decision of the Energy Distribution Companies on December 2013 about a flat-rate suspension of reception of applications for the connection of installations for the production of electricity to distribution grids with outputs greater than 1 MW.

By the start of the year 2017, new price regulation (URSO 221/2013) in the electricity sector came into force. The proposed concept for biogas stations meant a stepping-up of the purchase price of electricity according to their power to four groups. The most common type, i.e. a biogas plant above 0.75 MW, has been included in the lowest price category. The change in legislation has, on the one hand led to uncertainty in the developer's intentions and suspended the construction of new projects, on the other hand, provided platform for discussion and re-evaluation of the future direction with regard to bioenergetics in Slovakia.

According to the European Biomass Association (AEBIOM) approach, the production of silage bioenergy cannot be considered as a sustainable option. Focusing on agriculture and animal husbandry, which have a large amount of processed waste, the stations smaller than 250 kW are recommended. Their installed power will normally cover its own consumption and partial supply of electricity and heat into the distribution system. In addition, the final digestate is considered to be a valuable organic fertilizer with a further added value. Larger biogas stations with a capacity exceeding 1 MW appear to be an efficient solution for biomethane production or combined heat and power production by combustion of biogas in cogeneration units.

The potential for recovery of waste is underlined when the Act no. 79/2015 Coll. on waste entered into force, which obliges municipalities and cities as well as catering facilities to separate biodegradable waste. Last but not least, public awareness needs to be deepened. It is necessary to inform that the smell and noise is minimizing when modern technology is applied. As a suitable example is the biogas station “Biogas Wien”, which has been supplying heat for Vienna city since 2007, and biomethane from kitchen waste process from 2015. Similar activities should also receive support in Slovakia.

The biogas manufacturers’ efforts should be oriented to locating places where the biogas stations can also be used to supply heat. The overall efficiency of the process utilization could reach a value exceeding 80 % if the entire biogas plant building process were to be redirected to modern combined production and well-chosen aggregate size. Compared to the present value of around 40 %, such a situation would represent a real increase with beneficial effects on the environment as well as the share of imported gas used for heating.

IV. Biogas Stations in Slovakia

The state support and increased RES market activated the investments into biogas stations by 2013 when 41 new BS were installed. But this process stopped in the next year 2014. 111 biogas plants with a total output of 103 MW and a planned annual production of 810 526 MWh of electricity was connected into electric grid in Slovakia till the year 2015. The progress in following years was very slow and according to the Office for Regulation of Network Industries (ÚRSO), 117 biogas stations were in operation in the year 2017 [13].

The highest output power reaches biogas station (BS) which is operated by KOMPALA a.s., located in Badín, with a capacity of 7.030 MW. The second in terms of power is BS operated by Alternative Energy, s.r.o. in Bošany (2.830 MW). Following are AT GEMER s.r.o. (Dubnik locality), Biogas Rozhanovce, s.r.o. (Rozhanovce locality) and Agricultural co-operative in Plavnica (Plavnica locality) with the power of 1 MW. The vast majority of biogas plants in Slovakia, more than 70, have installed power ranging from 0.9–1.0 MW. Most of them are focused on the production of electricity from maize silage.

New price regulation of ÚRSO No. 221/2013 in the electricity sector came into force in the year 2014. The proposed concept for biogas stations was based on the installed power and prices were scaled into the four groups. The most common type, a biogas plant above 0.75 MW, has been included in the lowest price category. The subsidies for electricity generation in BS have increased. For the illustration, more than 5.5 million EUR in extra payments were received in 2015 by BIOENERGY

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TOPOĽČANY s.r.o. and BIOENERGY BARDEJOV s.r.o. [14].

More details about the number, location and operational characteristics of selected biogas stations in Slovak Republic can be found in our previous work [15].

V. Production of Biomass in Slovakia

Overview of the used biomass for biogas production in Slovakia for the year 2017 is listed in Tab. I. The accompanying negative phenomenon is that the cultivation of corn silage for BS occupies arable land in the area of approx. 50 000 ha. Another negative phenomenon is the fact that the cost of production, and therefore the selling price of corn silage, has risen toward 40 EUR per ton in comparison to 25 EUR per ton in 2010, which is already at the economic efficiency limit.

TABLE I.
Production of Biomass in Slovakia

Type of biomass	**Annual production (t)**	**Annual production (t) at 70 % utilization of excrements**
excrements of farm animals [1)]	10 450 467 [4)]	**7 315 327**
corn silage from the area of 50 000 ha [2)]	1 500 000	**1 500 000**
grass hay from the area of 110 000 ha [3)]	935 000	**935 000**
together	12 885 467	**9 750 327**

[1)] livestock excrements: manure, liquid manure and dung water – cattle, pigs and poultry together;

[2)] maize silage of 50 000 hectares: the area is an additional area for the production of biogas and above the needs of silage for fattening in livestock production;

[3)] grass herring of 110 000 ha: the area constitutes an additional area for the production of grassland (arable grassland) for the production of biogas beyond the need for grassland for fattening in livestock production;

[4)] production 10 450 467 t: it is the total annual production. It is a potential production usable for biomass production, supposing that no part of this production is used for fertilization in plant production. According to the available data of the ÚKSUP – Central Agricultural Control and Testing Institute in Bratislava valid for the season 2014/2015, the consumption of organic fertilizers in SR on agricultural land was 4 952 317 t (3.02 t per 1 ha pp), which makes 47.3 % of the annual excrement production. While into the organic fertilizer category, excluding livestock excrements, is balanced also agricultural crops, composts and other organic fertilizers integrated into the soil, it is possible to estimate the percentage of livestock excreta used for fertilization in crop production to about 30 % of total annual production. Therefore the available annual production of livestock excrements for biogas production would be 7 315 327 t.

Another important source of waste biomass in agriculture is the production of biomass on unused agricultural land, whose area in Slovakia is approximately 500 000 ha (77 000 ha of arable land and about 350 000 ha are the area of permanent grasslands). The rest is the area of other agricultural land. From this area, we would be able to produce biomass for appr. 130 to 150 low-power biogas plants.

VI. Selected Examples of Biogas Stations

In this chapter we present the selected results of our field research aimed on mapping the existing state of installed BS with focus on technical and electrical parameters as well as specifications of the technical design of the technology.

A. Biogas Station Smolinské

This station is located in the Smolinské village in Senica district as a part of Smolinské Agricultural Cooperative. The operation of the biogas plant was launched in 2011, with the cost of building around 2.6 million EUR (40 % of the fund for the construction was received from the state). The output of the biogas plant is 0.995 MW. Only the electricity is generated in the case of this station. Produced electricity is supplied for Slovenské elektrárne. The input raw materials are different, especially corn silage, grain, cuttings, grass, potatoes or bread. Raw materials come from their own production, but also from nearby municipalities such as Gbely, Plavecké Podhradie and bread from Senica city. The annual consumption of the input material is 14 000 tons. During the year the biogas plant produces approximately 4800 MWh.

Fig. 1. Biomass dispenser.

Fig. 2. Biomass dispenser with scroll magnetization as a function of applied field.

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The residual solid waste which comes from the fermentation process is used as a fertilizer for an agricultural cooperative. The biogas constantly encounters problems associated with accelerated amortization, especially due to the sand in the silage, as well as the failure of the equipment. In the future, no further expansion of production is planned. Individual parts of the biogas station are presented in Figs. 1 and 2.

The homogenized and mixed material is step by step dispensed from the dispenzer into the fermenter – horizontal arrangment (Fig. 3).

Fig. 3. Fermenter.

Fig. 4. Cogeneration unit.

Produced biogas is transferred from the fermenter to a tank and modified for combustion.

Fig. 5. Transformer station.

Electricity production takes place in the cogeneration unit (Fig. 4) and then is fed to the grid by the transformer station (Fig. 5). The residual solid waste resulting from fermentation is transferred from the fermenter to the storage tank (Fig. 6) where it is disposed for fertilization purposes.

Fig. 6. Storage tank with digestate.

B. Biogas Station in Malý Cetín

The biogas plant in Malý Cetín was launched in July 2010. It is located in the outskirts of Malý Cetín in Nitra district. The biogas plant belongs to Bioplyn Cetín Company.

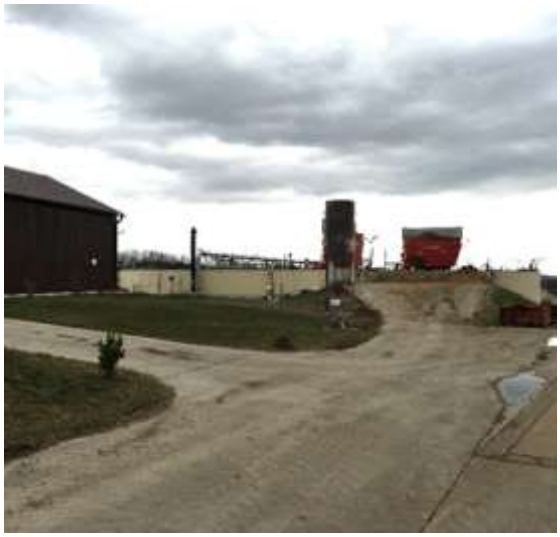

Fig. 7. View of biogas station.

The cost of the building was 3.8 million EUR financed from private resources. The output of the biogas plant is 0.995 MW. Further expansion is not planned. The feedstock uses phytomas, in particular corn silage supplied by AGILE s.r.o. and sugar-pulp delivered from Slovenské cukrovary, s.r.o. Sered. Milk whey which is also used for biogas production is delivered from the AGRO TAMI, a.s. Nitra. Total annual biomass consumption ranges from 16 000 to 18 000 tons. The electricity produced from the biogas is distributed to the grid. About 8 200 MWh of electricity is produced annually. The residual mass is used as a fertilizer for AGILE s.r.o. Figures 7snd 8 show a biogas plant with a biomass dispenser, a horizontal fermenter and a transformation station that serves to transport electrical energy to the grid.

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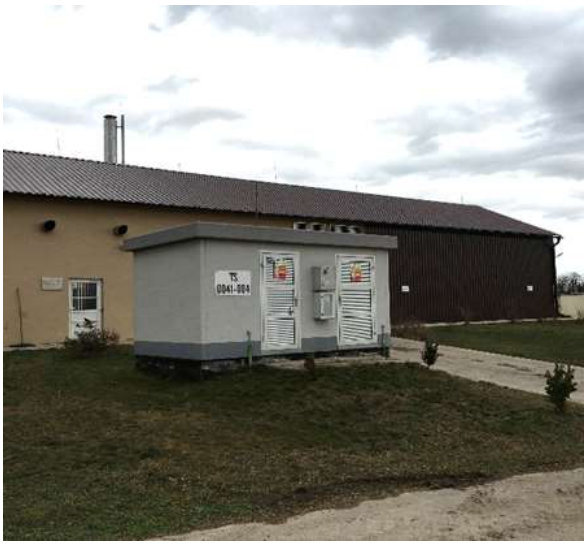

Fig. 8. Transformation station (BS Malý Cetín).

C. Biogas Station in Ružindol

The biogas plant which belongs to RUPOS s.r.o. is located in the village Ružindol, in Trnava district. The construction of the biogas plant started in June 2010 and has operated from June 2011. Investments for its construction were mainly supported from the European Agricultural Fund for Rural Development. Total costs amounted to 3.9 million EUR. The power output of the biogas plant reaches 0.998 MW. The biogas plant uses predominantly biomass maize and hay silage as input, which are supplied by RUPOS s.r.o. The maize silage is mainly fed (17 725 tons yearly), followed by manure consumption (2 217 tons), excrements from breeding dairy cows (1 310 tons) and finally beet pulp with a consumption of 428 tons.

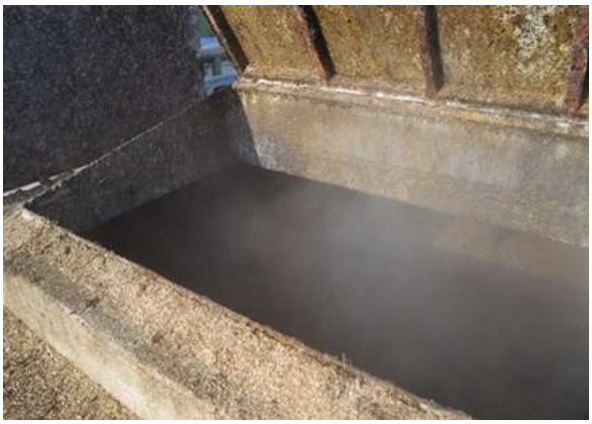

Fig. 9. Homogenization tank.

The biogas plant focuses on the production of electricity for Západoslovenská energetika and for the production of heat for its own consumption. The total annual consumption of biogas is 3 904 016 m^3, while 8 046 MWh of electricity is produced. The company also deals with the production of pellets offered for sale.

Fig. 10. Fermentors in BS Ružindol.

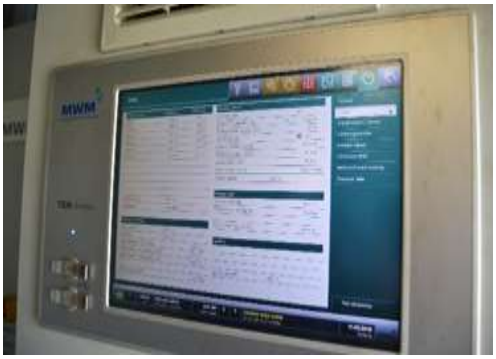

Fig. 11. Control panel.

Fig. 12. Cogeneration unit.

Figure 9 shows a homogenization tank where the inlet substrate is homogenized and diluted so that the dry matter content is less than 10 %. The biogas plant has three vertical fermenters (Fig. 10) where the biomass is heated to 45 °C. The company does not plan to expand production further, only measures related to increasing labour productivity and reducing production costs are planned. The biogas plant is at the stage of development, so the company is mainly concerned with the design deficiencies and the biogas plant itself. The control of the individual parts of the biogas plant is set on control panels (Fig. 11). Electricity generation takes place in the cogeneration unit (Fig. 12).

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D. Biogas Station in Chynorany

The station was founded by BioChyn s.r.o. The start of operation was in 2010. The biogas plant is located in the area of an agricultural cooperative in the outskirts of Chynorany, in the district of Partizánske. It is a biogas plant with anaerobic fermentation technology for the processing of biomass with the output of 0.995 MW. The construction costs of the station amounted to 5.5 million EUR. Sugar leaves, hay, maize silage (Fig. 14), but also rarely used poppy plant is used for the production of energy. Manure and animal urine and organic waste from the slaughterhouse represents about 15 % of consumption.

Fig. 13. Silage troughs.

Most of this biomass comes from the production of the Chynorany agricultural cooperative but also from other contractors, for example, the poppy plant biomass is supplied by the Zentiva pharmaceutical company. The consumption of biomass during the year is not stable. The smallest consumption was in July 2015 with 1 400 tons. There are three silage troughs in the biogas plant area where the biomass is squeezed and stored for a long time before it is moved to the dispenser.

Fig. 14. Corn silage.

From the dispenser, the biomass is transferred to the fermenter at regular intervals, where anaerobic fermentation takes place under continuous stirring (Fig. 15) at 53 °C. The digest which is stored in two collecting tanks is used as a fertilizer for the needs of an agricultural cooperative. The obtained biogas is used in the cogeneration unit to produce electricity and heat. An average of 8 300 to 8 400 MWh of electricity is produced annually, which is supplied to the power distribution company Západoslovenská energetika. The produced heat uses a biogas plant for its own consumption. The company does not plan to expand production in the future.

Fig. 15. A mixer intended for mixing of biomass in a fermenter.

E. Biogas Station in Kolíňany

This biogas station belongs to the Slovak University of Agriculture in Nitra. The station is located in the north-eastern part of the village of Kolíňany, in the Nitra district. The biogas plant serves for the operational verification of laboratory research from the area of energy production from biomass, but also for providing services in the field of practical teaching, development, research and realization of professional practices of SPU students in Nitra. The operation of the biogas plant was launched in 2001. Barnyard manure and hay as an input biomass is obtained from its own source. The installed capacity of the biogas plant is 0.025 MW. The generated electricity and heat are used only for their own consumption. The biomass is dispensed from the hopper (Figs. 17and 18) into the main part of the biogas plant into a 100 m^3 horizontal fermenter where the biogas is produced.

Fig. 16. Hopper.

The biogas produced in the fermenter is concentrated in a gas house (Fig. 17) and from here is fed through a gas line to a low-pressure gas balloon (Fig. 18). Biogas is burned in a cogeneration unit where the electricity is produced.

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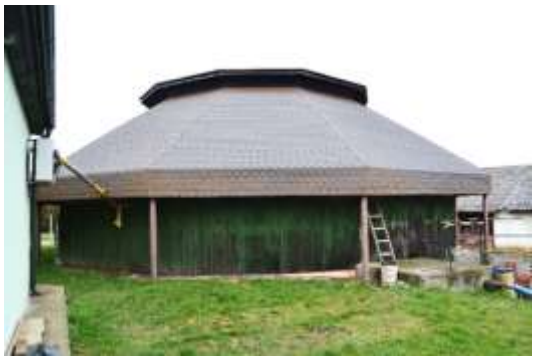

Fig. 17. Biogas house.

Fig. 18. Detail picture of gass line.

VII. Conclusion

Biogas production in Slovakia does not have a long history. The goal of this paper was to make a comprehensive overview of the basic technical and legislative aspects of the biogas utilization. The main benefits of the work are actual information about installed biogas stations as well as statistical data about raw materials used for biomass production. The legislative, technical and economic aspects of the implementation of this technology are considered. At the end of the paper the results of field research focused to technical details of selected installed biogas stations was presented.

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