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State of Biogas Production in the Slovak Republic

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Abstract

Anaerobic processes have been used in environmental technologies for nearly 150 years. The present paper deals with the use of anaerobic technologies in the Slovak Republic. The introduction briefly describes the past use of anaerobic processes in the world and in Slovakia. The conditions of anaerobic wastewater treatment and stabilization of sewage sludge in biogas plants and biogas production in landfills are discussed. Anaerobic sludge stabilization with biogas production can be found at 52 wastewater treatment plants (WWTPs), of which 22 have cogeneration units with the electrical output of 5.14 MW installed. Only one anaerobic industrial WWTP has a cogeneration installed, with the electrical output of 0.32 kW. Total installed electrical power of 111 biogas plants is 103 MW and the total installed electrical power of ten landfills is 2.24 MW. In the conclusion, further possibilities of the development of anaerobic technologies in Slovakia are presented.

Keywords: Anaerobic digestion of sewage sludge; Biogas; Biogas plants; Biogas potential in Slovakia; Landfill gas

Introduction

Biogas production has shown significant growth in Slovakia recently, mainly due to the growing number of biogas plants. Biogas plants, though, are not the only anaerobic technology for biogas production, also anaerobic sludge stabilization in wastewater treatment plants (WWTPs), anaerobic-aerobic treatment of industrial wastewater, biogas used as energy source in landfills are some of them. Anaerobic processes have been applied in environmental technologies since the beginning of 19th century; the first recorded research of anaerobic organic materials processing was coincidental when examining positive features of raw and stabilized manure. Humphry Davy, a chemist and inventor, used these processes to collect gas containing 30 % of methane in manure stabilization in 1808 [1]. The first anaerobic processes application in environmental technologies dates back to the second half of the 19th century when Louis H Mouras designed an anaerobic reactor for the separation and fermentation of undissolved portion of sewage water in Vesoul (in an article in the Cosmos Journal in 1881, 20 years of experience were mentioned) [2].

Anaerobic processes were used only to stabilize wastewater sludge within environmental technologies until the middle of the 20th century. Then, anaerobic technologies have started to be applied also in wastewater treatment, originally in suspended biomass reactors and later also in high-rate anaerobic reactors [3-6]. In Slovakia, anaerobic technologies were first applied in WWTPs in form of Imhoff tanks. The first anaerobic reactor for wastewater sludge stabilization was built in the second half of 1950s in WWTP Bratislava-Rača [7]; the technology gradually became the most commonly used anaerobic technology in Slovakia. The first anaerobic WWTP was officially established in the sugar refinery in Rimavská Sobota, central Slovakia [8]. And anaerobic-aerobic WWTPs were built also in other sugar refineries all over the country. Unfortunately, only two have been preserved until today. Gradually, also other industries, like food and paper processing, followed and built anaerobic WWTPs, e.g. anaerobic-aerobic WWTP with UASB reactors in Old-Herold in Trenčín, anaerobic IC reactors in Topvar, Topoľčany and Kappa, Štúrovo, which do not exist anymore. Biogas plants and biogas utilization as energy source in landfills has been a growing sector in the last decades.

Anaerobic Wastewater Treatment and Anaerobic Digestion of Sewage Sludge

Anaerobic sludge stabilization belongs to the oldest anaerobic processes applications in environmental technologies, as it was already mentioned above. There are 52 WWTPs with anaerobic sludge stabilization in Slovakia, 22 of which include a cogeneration unit (Combined Heat and Power – CHP) (Table 1), with overall installed power capacity of 5137 kW. Annual biogas production at WWTPs is approximately 21 mil. m^3, which corresponds to an approx. 5 MW power capacity [9]. It is therefore obvious that the capacity of installed CHPs is higher than the corresponding biogas production at WWTPs. There is a potential to increase the power capacity of CHPs at municipal WWTPs and process biodegradable waste in free capacities of the existing stabilization tanks. When comparing the designed WWTP capacity with actual figures in Table 1, it is obvious that free capacity is available. Moreover, this approach to biodegradable municipal waste recovery also results from the valid Waste Management Plan of the Slovak Republic.

WWTP	WWTP capacity		Power capacity of CHP [kW]	WWTP	WWTP capacity		Power capacity of CHP [kW]
	Projected [PE]	Real [%]			Projected [PE]	Real [%]	
BA-ÚČOV	1092000	35,5	1600	Martin	68900	66,0	140
Nitra	270000	40,0	480	Humenné	96700	84,0	120
BA-Petrž	486600	31,9	341	Pov. Bystr.	45000	32,3	72
Levice	217300	45,1	310	Senica	80204	23,8	64
Košice	391700	102,0	300	Sereď	35000	85,5	45
Žilina	746204	24,4	300	BA-DNV	26150	100,6	45
B. Bystrica	190000	39,6	257	Komárno	31950	109,7	40
Prešov	113778	61,1	180	Šaľa	30000	36,5	35
Lučenec	64700	32,5	163	Dol. Kubín	23000	82,6	22
Poprad	143206	93,1	142	Námestovo	46000	39,1	22
Zvolen	80500	91,4	142	Trnava	211700	70,7	317

PE: Population Equivalent

Table 1: Municipal WWTPs with a CHP in Slovakia.

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The first anaerobic-aerobic WWTP commenced its operation in 1991 in Rimavská Sobota sugar refinery with the daily capacity of 2000 t of sugar beet; a two-stage anaerobic-aerobic system. The anaerobic reactor was a 19.5 m high cylindrically shaped stirred tank with the diameter of 16 m and the overall volume of 3000 m^3. The aerobic stage comprised two rectangular activated sludge tanks of 2x950 m^3 with surface aeration connected in series. The designed wastewater flow in the biological WWTP was 1800 m^3/d, with COD of 7,000 mg/l (organic loading rate of 4.2 kg/m^3.d – COD). In average, approx. 95000 m^3 of biogas was produced in one run in an anaerobic reactor (1760 m^3/d) used for heat generation in a sugar refinery heating plant. This WWTP is not in operation anymore, neither is the sugar refinery plant in Rimavská Sobota. Sugar refineries and their WWTPs in Šurany and Trnava followed the same pattern. Two sugar refineries – in Sereď and Trenčianska Teplá – are still in operation, both with anaerobic-aerobic WWTPs operating on the same principles as the one in Rimavská Sobota. The sugar refinery in Sereď processes approx. 4000 t of sugar beet a day, while 490600 m^3 of biogas are produced in one run (4055 m^3/d). The sugar refinery in Trenčianska Teplá processes approx. 6000 t of sugar beet a day, though only 200000 – 300000 m^3 of biogas are produced in one run.

Other existing anaerobic reactors worth mentioning are the IC reactors in Enviral in Leopoldov (distillery), Harmanec (paper mill) and Hurbanovo (brewery); in Table 2 also two other IC reactors are listed, though these are not in operation anymore, unfortunately, neither are the plants.

Electricity is produced from biogas only in the Hurbanovo brewery, where two CHPs with the power capacity of 2x160 kW are installed.

Smaller anaerobic reactors for wastewater treatment worth mentioning are the hybrid reactor in the cheese producing plant PD Slovenská Ľupča (farm), and the UASB reactor in Frucona, Obišovce (fruit and wegetable processing).

Biogas Production at Biogas Plants

Despite the long experience with biogas plants in the former Czechoslovakia, dating back to the early 1970s (biogas plant in Třeboň (Czech Republic) for pig manure processing), only five biogas plants were operated in Slovakia in 2009 (Table 3) due to various legislative, economic and also social obstacles. A boom of biogas plants development has started in 2009 after the introduction of Act 309/2009 concerning the support of renewable energy sources and highly effective combined production, which guaranteed the electricity purchase price for 15 years and the preferential connection of energy production facility to the regional distribution grid, access to the grid, transport, distribution and supply of energy; the key factors of the increased effort to build biogas plants.

By the end June 2015, 111 biogas plants were operated in Slovakia with the installed power capacity of 103 MW; though the situation in connecting new biogas plants to the grid is unclear, since the end of 2013. In december 2013, the distribution corporations Západoslovenská distribučná, a.s., ZSE-D, Stredoslovenská distribučná, a.s., SSE-D, and Východoslovenská distribučná, a.s., VSE-D, decided not to accept nor process any further applications for connecting new energy generating facilities to the grid arguing with the necessity to analyze the impact of those already connected and scheduled for connection on the safety and operability of the grid. Though the applications´ suspension included all types of energy generating facilities, it is obvious that it almost solely concerns energy generation from renewable resources despite the Act 309/2009 which is still in effect supporting the connection and the commitment of the Slovak Republic to replace 14% of the overall energy consumption with renewable resources by 2020, as stipulated in the Directive 2009/28/EC of the European Parliament and of the European Council on the promotion of the use of energy from renewable resources.

In the development strategy for energy generation from small renewable resources, the Slovak Government declared its support to building small energy sources with the power capacity of up to 10 kW consumed only by the operator for his own purposes not supplying (or free of charge) energy to the grid. The current situation also proves the attitude of the state administration to renewable energy support, sanctioning many producers of energy from renewable resources, including biogas plant operators, for not reporting support provided according to the Act 309/2009, including the estimated volume of the energy supplied to the Network Industries Regulatory Office and the regional distribution grid operators by August 15th 2014. This reporting

Installation	Volume of IC reactor [m^3]	Biogas production [Nm^3/d]	Biogas utilization
SHP Harmanec (paper industry)	315	520-750	Boilers – heating for production needs
Enviral Leopoldov (distillery)	301	2200-3000	Boilers – heating for production needs
Heineken Hurbanovo (brewery)	1004	4600-6100	CHP – sale of electricity, heating of wastewater
*Kappa Štúrovo (cellulose and paper industry)	2470	16125	Boilers – heating for production needs
*Topvar Topoľčany (brewery)	250	1440	Boilers – heating of wastewater and industrial buildings

* Operation discontinued

Table 2: IC reactors in Slovakia.

Biogas plant	Main substrates	Power capacity of CHP [kW]	Operation from year
AGROS s.r.o. Bátka	Pig manure, until 2000 also poultry manure	6x128	1995
PPD Brezov	Cattle manure	50	1998
VPP SPU, s.r.o. Kolíňany	Different substrates, mainly animal manure	22	2001
PD Kapušany	Animal manure, maize silage	120	2005
STIFI Hurbanovo	Maize silage	300+330	2005+2009

Table 3: Biogas plants in Slovakia at the beginning of 2009.

obligation has been stipulated in the law since it came in effect, though the sanction, i.e. supplier of energy from renewable resources is entitled by the law to be paid for the green energy supplied to the grid or to be granted a bonus when consuming this energy, was incorporated only on October 22nd 2013 by the Act 382/2013, and is effective since January 1st 2014. It should be noted that most of the sanctioned energy producers had contracts with the grid operators for 15 years and that the estimated volume of supplied energy declared in the reporting obligation is not mandatory.

The content of the substrate represents another problem for biogas plants in Slovakia as the majority uses maize silage as the main substrate; more than one quarter of maize silage produced in Slovakia is used in biogas plants. Despite the fact that the numbers of cattle do not prove the increasing need to produce maize silage, it is obvious that using maize silage as the key substrate for biogas production is not sustainable and neither is the general production of first generation biofuels. Changes in the substrate composition for biogas plants are further discussed below.

Biogas Production at Landfills

According to the Ordinances 283/2001 and 310/2013 on executing certain provisions of the Waste Act as amended, issued by the Slovak Ministry of the Environment, biogas produced at landfills, i.e., landfill gas, needs to be collected in all landfills accepting biodegradable waste. Collected landfill gas has to be processed and used for energy generation; or flared if it cannot be used for energy generation. According to the Environmental Report of 2013, there are 95 landfills for other than hazardous waste in Slovakia; these are mainly municipal waste landfills. Landfill gas is collected and used for energy generation only at ten landfills - Luštek pri Dubnici nad Váhom (2 x 150 kW_{el}), Banská Bystrica (200 kW), Zvolenská Slatina (150 kW), Nový Tekov (200 kW), Žakovce (150 kW), Považský Chlmec (349 kW), Zohor (320 kW), Brezno 150 kW), Livinské Opatovce (150 kW) and Kostolné (270 kW), with the overall installed power capacity of 2239 kW.

Thus, landfill gas is collected and reused from approximately 10% of landfills for other than hazardous waste. There is no information available on landfill gas disposal from municipal landfills, though many of these do not collect and combust landfill gas. According to the latest Waste Act amendment, municipalities are obliged to separate biodegradable waste, plastic, glass, metals and paper, starting from 2013. Biodegradable waste disposal methods should be changed from incineration and landfilling to different reuse methods, mainly to composting and anaerobic processing. Energy potential of biogas production from biodegradable municipal waste is further discussed below.

Potential Development of Biogas Technologies in Slovakia

Potential development of biogas technologies in Slovakia can proceed in the following areas:

- Increasing biogas production in free capacities available in anaerobic stabilization tanks within municipal WWTPs by processing external biodegradable substrates.
- Processing of industrial wastewater rich in biodegradable organic substances in high-rate anaerobic reactors.
- Strategy change from biogas plants for electricity generation to processing facilities for waste and by-products from agriculture, which also concerns the change of substrate composition in biogas plants and the effort to effectively utilize the energy of biogas – utilization of heat from cogeneration units, biomethane production.
- Anaerobic treatment of biodegradable municipal waste.
- Anaerobic treatment of biodegradable industrial waste.

Increasing biogas production in free capacitates available in anaerobic stabilization tanks within municipal WWTPs is feasible, and in fact it has been applied in many WWTPs, while many others are being prepared for this option. Biogas production is limited by the volume of sludge in sludge stabilization and the energy generation potential of about 5 MW, however, external substrates processing would enhance it significantly; considering this option, operators should remember that the offer of substrates that can be dosed into stabilization tanks directly without any pre-treatment is limited. Mechanical pre-treatment of waste and its hygienization should be considered, as the necessary minimum. Clean water as the key objective in a WWTP is another limitation of external substrates processing, as nitrogen and phosphorus have to be removed during the wastewater treatment process. Processing of external substrates can also significantly increase the energy self-sufficiency of WWTPs.

There are several industrial plants in Slovakia producing wastewater rich in organic biodegradable carbon, and, due to various reasons, they discharge wastewater to municipal sewers; anaerobic pre-treatment is feasible directly within the plant benefitting thus the plant, environment and municipal sewer. However, the existing situation is convenient for the plant and the water company.

It is obvious that almost all biogas plants were originally established as facilities for energy generation and sale. Subsidized prices of energy generated from biogas combustion, however, have significantly deformed the business environment. In this industrial sector, the investor calculates the return of the investment from sale of less than a half of the production (electricity) and a part of the production (heat) is lost in heat exchangers for waste heat. Favorable energy prices - and one should also agree with arguments used by farmers that, often, they were not able to effectively sell their crops - lead to building larger biogas plants, while majority of these is processing maize silage at capacity ranging around 1 MW. There are many other wastes in agriculture and farming, though, and by-products from animal and crop farming that could significantly improve the economy of biogas plants on the input side; among others these are animal excrements available in volumes exceeding 10 mil tons per year, or various types of straw amounting around 1 mil ton per year. Straw has not been traditionally used in biogas production; however, some fully operational plants producing bio-ethanol from straw can be found in the world. It is a challenge for the R&D sector to prepare conditions for using this material for biogas production in Slovakia. Biogas production is environmentally more favorable than direct combustion of straw. Besides providing fine fuel, also nutrients and organic materials are returned to the soil in form of digestate. Processing of waste with agricultural and farming byproducts will lead to smaller biogas plants with the power capacity of up to 250 kW, utilizing a large portion of generated energy and heat for their own activitiesand processes. However, building smaller biogas plants contradicts the increasing biomethane generation, as this process is not efficient in small biogas plants. Larger biogas plants with the power capacity equal or exceeding 1 MW represent a more effective solution for biomethane production and its introduction into the natural gas distribution network if the producer cannot utilize the heat by combusting biogas in cogeneration units. If heat can be fully used, cogeneration is in fact a more efficient method of biogas utilization than bio-methane production.

The potential of anaerobic processing of biodegradable municipal waste can be estimated to be approx. 15 MW [10] this method of municipal waste processing cannot be avoided. The recent growth in biogas plants generation shows that building of 30 biogas plants with a 500 kW power is not a technical problem. The largest problem seems to be the logistics in municipal waste collection. Slovakia is facing problems with efficient recycling and collection of plastics and paper which can be stored on site, which would prolong their collection intervals; this approach cannot be applied in case of biodegradable waste. Moreover, it is obvious that the technology for anaerobic processing of biodegradable municipal waste is more complicated, while investment costs to waste pre-treatment technologies are comparable, or higher than those for a biogas plant. As it has already been stated above, a part of these wastes can be processed in WWTP stabilization tanks.

Industry, in particular food processing, agro-industries, and pharmaceutical industry, generates a large volume of waste that can be processed by anaerobic treatment. Considering the processed raw materials and production in these industries, these materials are often rich in nitrogen, sulfur (wastes from slaughterhouses, meat and bone meal, waste biomass from drugs and amino acids production, wastes from distilleries, rapeseed meal from biodiesel production…). High content of nitrogen and sulfur influences the anaerobic processes and nitrogen removal from sludge water and sulfur from biogas, which is a challenge for the R&D sector in Slovakia to enable processing of these wastes.

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