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The Aspects of Research and Education Activities in the Field of Renewable Energy Carriers

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Abstract : Energy politics of Slovakia is focused on sustainable economic growth and competitiveness by the means of sustainable Slovak energetics. The increase share of renewable energy carriers in the production of electricity and heat leads to a reduction in the consumption of fossil fuels and that consequently contributes to the reduction of pollutants and greenhouse gases. The existing regional potentials in the field of electricity and heat production are in the form of renewable energy carriers and the largest contributor is biomass. The development of the use of alternative energy sources aro uses a need for researchand development as well as new qualified professionals. The support from the European Union has enabled to build a work space that combines research and development activities with the processes of education and training and therefore is creating the conditions for the training of the professionals and the promotion of ideas in the field of renewable energy carriers.

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1 Introduction

The use of renewable energy carriers (REC) is based on advanced and environmentally friendly technologies which leads to a reduction in greenhouse gas and pollutant emissions. The Green Report 2018 states that thein crease in the number of built biogas plants (BPS) has been stagnating in there cent period. The most BPS have an installed capacity in the range of 0,9 – 1,0 MW and most of them are focused on the production of electricity from corn silage. The consumption of corn silageinto BPS in Slovakia has, according to expert estimate, reached 1,2 mil. tons per year. The construction of other BPS and thus an other corn consumption on a biogas production could endanger the stocks of bulk feed for animal production. There foreit will be necessary, when building new BPS in Slovakia, to focus on the processing of other forms of biomass, as invasive plants, bio-waste etc. [1, 2]. The strategical aim of the Energy Policy of the Slovak Republic which was approved pursuent to the Slovak Government resolution No 548/2014 is to achieve competitive low-carbon energy which would provide safe, reliable and efficient supply of all energy forms at affordable prices considering consumer protection and sustainable development. It defines key objectives and priorities of energy sector until 2035 with a long-term time horrizon until 2050. The concept of the energy development is focused on the optimization of energy mix from the point of view of energy security. The emphasis is laid on the use of domestic energy sources and low-carbon technology, as renewable sources and nuclear energy. From the point of view of the structure of the used primary energy sources, the Slovak republic has a balanced share of individial energy sources in gross inland consumption. The Slovak energy mix has a balanced share of nuclear fuel and fossil fuels in gross inland consumption. [3] Slovakia agreed to international conventions in the field of air, ozone layer and climate protection and has been meeting the obligations arising from it. The use of renewable energy sources is growing dynamically, since 2001 it has increased from 30PJ for consumption in 2012 to 59 PJ. In Slovakia the greatest energy potential among renewable energy sources (RES) has

biomass with a theoretical potential of 120 PJ. The Slovak Republic is obliged to increase the use of RES in relation to gross final consumption of energy - from 6,7 % in 2005 to 14 % in 2020 and to achieve the use of RES at the level of 80PJ in 2020 and 120PJ in 2030. The increase of the share of RES in energy and heat production in order to create adequate additional sources needed to cover domestic demand is one of the main priorities of the Energy Policy of the Slovak Republic [4, 5]. The link between the education system with the needs of the labour market is a strategical aim of the Slovak Republic and it requires inreasing of the involvement of employers in the creation and innovation of educational content. The central field is the support of vocational education and the creation of the link between studies and practice. Concerning higher education, it is also needed to strenghten quality and content of bachelor´s degree in order to ensure the needs of practice in accordance with the objectives of National Strategy for Smart Specialization of the Slovak Republic RIS3 SK. The creation of bachelor and engineering programmes more focused on jobs in the field of energetics with respect to the use of alternative sources of bioenergy. Within the conception of support of the cooperation with practice a centre of university cooperation was established . Its task is to support research cooperation of university facilities with practice and to ensure the direction of private-sector investment in research and education and to support science and technology education for the needs of industry and practice. The effort is to help and convince the society as well as put into practice the idea of using renewable energy carriers. To initiate and give instructions for businessmen and minicipalities how to use yet undiscovered existing regional potentials of renewable sources of energy, as biomass, geothermal and hydro energy and waste [6, 7].

2 Research and Education Centre of Bioenergy

Research and education centre of bioenergy (RECB) was established on the basis of the implementation of an applied project in 2007 as an EU workplace based in Kapušany. Its purpose is research and development in the field of extraction and recovery of biomass and solar energy and their efficient use for energy purposes in business practice. Also improvement of the education process and knowledge and experience production in the development of the conditions of sustainable development in disadvantaged Slovak regions. With the support of the project from the European Structural Funds, the RECB has become a centre of cooperation with practice in the field of renewable energy carriers since 2007. It is situated in the area of the agricultural cooperative Kapušany near Prešov. It is therefore directly connected with practice, it fullfils the function of an integrating and coordinating organisational unit, while it creates the conditions for the use of the latest knowledge in the field of renewable energy carriers in practice in the cooperation with the University of Economics in Bratislava and The Technical University of Košice [8].

One of the essential tasks of the center within the following science and research project is to optimalise the activity of the biogas plan in agricultural cooperative Kapušany which makes use of agricultural products and waste and was built in 2002 (Figure 1). It was an older type of biogas station with technical and operational shortcomings and thus it showed only 50% efectiveness in the conversion of primary energy (biomass and slurry), which accounts for 70 to 100 kWh of the electricity produced. The goal of the project was to increase the efficiency of fermentation and cogeneration processes of the biogas plant. The project was focused on the preparation and replenishment of inputs and the conversion of the substrates in an anaerobic digestion process to produce biogas and their use by the cogeneration process to produce electricity and heat. The optimal performance of this biogas plant should be around 170 to 180 kWh of the produced energy. The fermentation process is strongly influenced by the input which is mostly corn silage. The homogenization to the right size, heat treatment and constant dose are necessary to be done. This is ensured by a homogenizer and a substrate dispenser. The temperature and pressure at the inlet and outlet of the fermentor are being monitored, which are important factors for a proper operation and potencial identification of problems with the operation of the biogas plant. The properties of already generated biogas are regularly monitored before the inlet to the cogeneration unit by the means of content analyzer CO_2, O_2, CH_4 a H_2S.

Figure 1 Biogas plant in the agricultural cooperative Kapušany near Prešov

3 Research and Education Activity of RECB

The workplace is focused on the solutions of the scientific and technical projects as well as grants in the

field of renewable energy sources and the modernization of already existing energy facilities, especially biogas plants, in order to increase their efectiveness. It is directed at authentication and application of the research outcomes into common practice which creates space for the cooperation with entities dealing with the evaluation of alternative energy sources in practice. The workplace also serves as a counseling and information centre for those who are interested in using alternative sources.

In addition to research in the field of renewable energy carriers, the Research and Education Centre of Bioenergy (RECB) is also involved in education and awareness-raising on energy and renewable energy sources (RES). There are two seminar rooms with computer equipment and the possibility to make presentations and visualizations of renewable energy carriers processes (Figure 2). The workplace provides additional education and professional practice for students on the latest knowledge in the field of renewable energy sources and their use in practice. It provides excursions for primary and secondary school students with demonstrations of solutions for the use of new technologies for energetically, environmentally and economically efficient evaluation of RES. It supports new fields of study for university at all educational levels and enables the inclusion of new subjects specialized in the use of renewable energy carriers (REC) into the educational process.

Figure 2 Seminar room for 45 listeners

In the Research and Education Centre of Bioenergy (RECB), there is a solar system with three Bazicx 2.0 collectors and a photovoltaic system with three SF 150 panels installed (Figure 3). The solar system provides thermal water heating with a bilateral water tank which is used for the needs of the bioenergy centre. The electric energy which may be used, if necessary, for the operation of electric equipment in the centre is produced by the photovoltaic system and stored in 12V HAZE accumulator batteries (Fig. 4).

Figure 3 Solar and photovoltaic panels located on the roof of the centre building

Figure 4 Laboratory with solar and photovoltaic control system

4 Research and Education Activity of RECB

It is part of the workplace and predominantly deals with monitoring the operating parameters of the biogas station, on the basis of which a methodology for controlling the performance of the fermentation process was developed and limit values of basic parameters were determined, which best express the state of biogas production. At present, the performance of a biogas station is being continuously checked by measuring the temperature of the collected substrate, its initial pH, the dry matter content in the digestate – substrate, the concentration of biogenic elements C, H, N, S, O and the FOS/TAC parameter. The temperature of the substrate during fermentation is approximately 40°C and it should not fall below 20°C during transport for analysis. The substrate to be analyzed is collected in the second phase of the fermentation cycle, so its pH is usually in the range of 7.5 to 8.1. This value indicates that the anaerobic fermentation has passed into the methanogenic phase in which methane is formed as the main component of biogas. The dry matter content is expressed in % of the original weight

of the sample and its optimal value is 10 to 12%. At lower values the content of organic substances decreases and thus the specific volume production of biogas also decreases. The FOS/TAC method expresses the degree of anaerobic degradation process of the substrate which is given as a dimensionless number. This is the titration of the lower fatty acids, expressed in relation to the concentration of the total carbon, which determines the acid value and the moderating value of the substrate and thus the stability of the process may be best defined. Optimal FOS/TAC values are around 0.3 to 0.4. At these values biogas production is at maximum which represents approximately 55% of the methane content. Simultaneously, the recommendations and necessary measures were developed according to the measured FOS/TAC parameters during the process to ensure maximum efficiency of the fermentation process, see Table 1.

Table 1 Description of the fermentation process control based on FOS/TAC values

FOS/TAC	Process description	Recommendation
> 0,6	Very high biomass supply	Stop adding biomass
0,5 – 0,6	High biomass supply	Add less biomass
0,4 – 0,5	Loaded biomass	Monitoring of input biomass and its treatment
0,3 – 0,4	Biogas production is at maximum	Maintain input values
0,2 – 0,3	Biomass supply is low	Slowly increase biomass supply
< 0,2	Biomass supply too low	Rapidly increase the supply of biomass

The chemical-biological laboratory for testing the properties of biomass which is equipped with laboratory equipment in order to monitor operating parameters and increase the efficiency of the biogas station (BGS) may be divided into several parts according to the focus of their use as follows.

4.1 Sample preparation

Primary quartation of the samples taken is performed by quartation. The secondary preparation of the samples is provided by homogenizer on the Figure 5.

Figure 5 Grindomix GM 200 homogenizer by RETSCH

4.2 Macroelements analysis

The main building elements of biomass are carbon, nitrogen, hydrogen, sulphur and oxygen. These components are determined on the analyzer in Figure 6.

Figure 6 CHNS(O) analyzer Flash 2000 by Thermo Scientific

To assess lower organic proportions in digestate such as lactic, butyric, propionic, vinegar and formic acid, the analyzer in the Figure 7 is used.

4.3 Microelements analysis

The ZEEnit 700P atomic absorption spectrophotometer by Analytic Jena AG is used to

trace elements analysis, together with flame, hydride and electrothermal techniques for the determination of chemical elements in both liquid and solid samples (Figure 8).

Figure 7 Electrophoretic analyzer AE 102 by Villa Labeco

In case of liquid samples, the spectrophotometer shown in Figure 9 is used to determine Al, Ba, Cd, Co, Cu, Cr, Fe, Pb, Mn, Mo, Ni, polychlorinated biphenyls (PCBs), P, K, Se, Si, Ag and Zn. It may also be used for the determination of water, organic carbon, dissolved oxygen, phenols, PCBs, tannins, lignin, glucose. For the determination of mercury in solids and liquids the DMA-80 analyzer shown in Figure 10 is used.

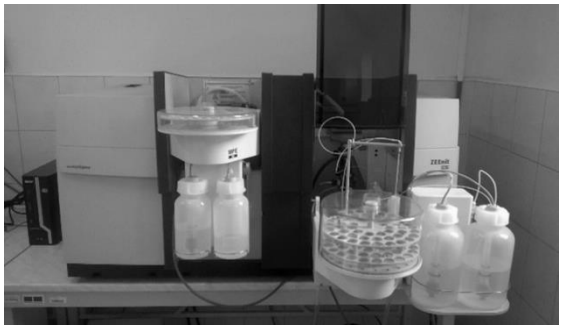

Figure 8 Atomic absorption spectrophotometer by Analytic Jena AG

5 Laboratory of Research of Liquid and Solid Biofuels

It deals with preparation and research of commonly used biofuels (Figure 11). Liquid biofuels include the production of biodiesel and bioethanol which may in principle be obtained in two ways. By fermenting biomass or pressing seeds and obtaining oils from them. The first method is more suitable for the hydrolytic decomposition of cellulose from biomass and the fermentation process. The second method is suitable for seeds with a high content of unsaturated fatty acids. For these purposes the laboratory is equipped with a large-capacity vacuum evaporator with a 20l distillation vessel by Heidolf Company for the preparation of bioethanol, and it is also equipped with pressing, filtering and mixing equipment by Farmet Company for obtaining oils from various types of phytomass.

Figure 9 Spectrophotometer SDR 2800 by Hach

Solid biofuels may be processed from dry biomass into pellets and briquettes. For the production of presswork in the form of pellets, the centre is equipped with a pelletizing line MGL 200 by Kovo Novak with a cutting pulverizer and conveyor. For the production of briquettes the BIOMASSER SOLO SET briquetting line with a cutter and a hygrometer is located in the centre. Pellets and briquettes are made from either wood sawdust or shavings without the addition of chemicals. Lignin found in wood acts as a binder, which at a high temperature caused by friction during their processing, turns into a plastic state. Recently, wood pellets have also been produced from fast-growing energy ground woods.

Figure 10 Direct Mercury Analyzer DMA-80 by MILLESTON

Figure 11 Laboratory of liquid and solid fuels with pressing, filtering and mixing equipment by Farmet Company

6 Conclusion

The reserves of individual energy sources in the territory of the Slovak Republic are constantly decreasing. Exclusively Renewable Energy Sources (RES) and especially biomass may play a significant role in maintaining or increasing them. It is confirmed that the use of RES as domestic energy sources increases to some extent the security and partial diversification of energy supply. The Slovak Republic has supported its determination to continue on the path of sustainable development by adopting the incorporation of basic principles into long-term strategic documents, such as the Energy Policy, The National Renewable Energy Action Plan, and the Concept of Energy Efficiency of the Slovak Republic. Slovakia's priority is to focus on key sectors of growth, and these are, in addition to environmental protection, energy efficiency and RES and also the support for research and development. The operation of Research and Education Centre of Bioenergy (RECB), as an innovative university workplace together with business practice, is focused on acquiring constantly new knowledge and research in the field of alternative energy sources and their utility in practice. It provides support for the educational process at all levels of education and promotes the use of new technologies on the basis of Renewable Energy Carriers (REC) in practice.

The reference list

[1] Ministry of Economy of the Slovak Republic. National renewable energy action plan, Bratislava, 2010, [Online], Available: http://www.rokovania.sk, [17 Feb 2020].

[2] JARÁBEK, M., LUNKIN, V.: *Energy policy of The Slovak Republic.* In: Conference Energy Efficiency until 2020, December 9th 2014 in Trnava, [Online], Available: https://www.siea.sk/materials/files/poradenstvo/aktuality/2014/energeticka_efektivnost_trnava/, [20 Jan 2020].

[3] Ministry of Agriculture and Rural Development of the Slovak Republic. *Report on agriculture and food in The Slovak Republic for 2017* (Green Report), National Food and Agricultural Centre – Research Institute of Agricultural and Food Economics, Bratislava, 2018.

[4] Ministry of Economy of the Slovak Republic. Energy Politics of The Slovak Republic, Bratislava, 2014, [Online], Available: http://www.rokovania.sk, [17 Feb 2020].

[5] Ministry of Economy of the Slovak Republic. Energy Efficiency Action Plan of The Slovak Republic for 2014 – 2016 with a view to 2020 Bratislava: ME SR, 2014, [Online], Available: http://www.rokovania.sk, [20 Jan 2020].

[6] Slovak Environment Agency, Ministry of Environment of the Slovak Republic, Department of sustainable environmental development. *AGENDA 21(CSD 2014)*, Bratislava, 2015. [Online]. Available: https://www.minzp.sk/files/dokumenty/ agenda21-sk.pdf [21 Jan 2020].

[7] Ministry of Education, Science, Research And Sport of the Slovak Republic. Research Agency. Research and Innovation Strategy for Smart Specialisation of the Slovak Republic (RIS3 SK) Bratislava, 2013, [Online]. Available at: http://www.vyskumnaagentura.sk/sk/o-nas/dokumenty/send/8-strategia-vyskumu-a-inovacii-ris3, [18 Feb 2020].

[8] Internal Regulations of The University of Economics. Organisation Rules of the Research and Education Centre of Bioenergy of The University of Economics in Bratislava – Kapušany workplace Bratislava, EU BA, 2018, [Online], Available: https://euba.sk/www_write/files/SK/docs/vnutorne-predpisy/2018/op_vvcb_kapusany_2018.pdf, [25 Jul 2019]

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