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Republic of Serbia
Autonomous Province of Vojvodina
Provincial Secretary for Energy and Mineral Sources

STUDY OF POTENTIALS AND POSSIBILITIES FOR BIOGAS PRODUCTION AND UTILIZATION IN AUTONOMOUS PROVINCE OF VOJVODINA
– SUMMARY –

Novi Sad, May 2011

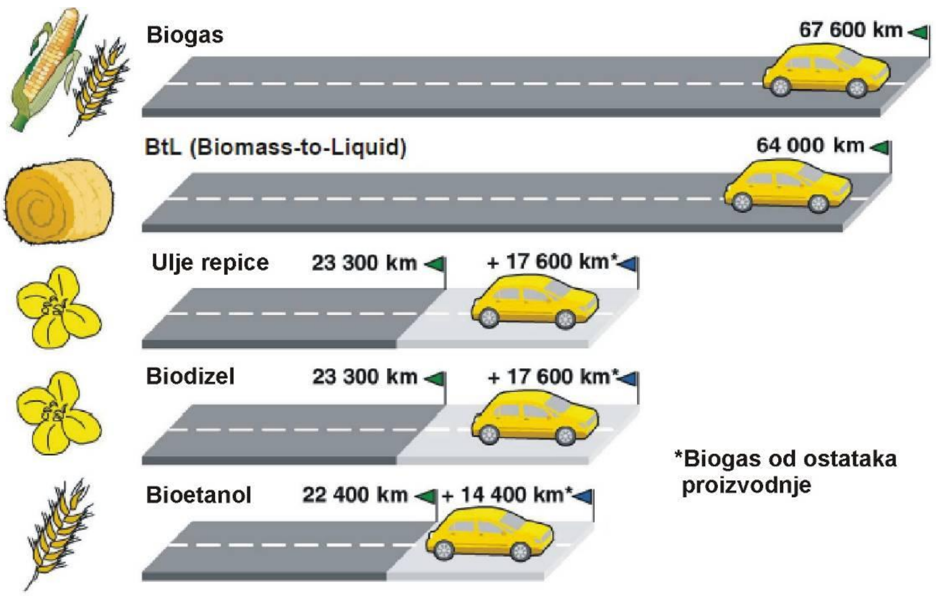
1. IMPORTANCE OF BIOGAS PRODUCTION AND UTILIZATION IN VOJVODINA

Climate changes, mainly caused by the greenhouse effect, as well as continuous decreasing of fossil fuel reserves, boosted numerous global activities. One possibility is to use Renewable Energy Sources (RES). European Union clearly defined aims and tasks in this branch by the Directive 2009/28/EC. The main point is, until 2020, to provide primary energy consumption from RES at least 20 % and electricity production from RES rates minimum 20 % from total production. Therefore, this Directive and initiative are known as RES 2020.

Republic of Serbia accepted to follow EU policy and concrete measures have been undertaken to support the production of „green" electricity. Therewith, some basic prerequisites are ensured for economic feasible electricity production from RES, since *feed-in* tariffs are paid for the delivered electricity to the public electricity network.

Biogas is one sort of RES. Particular importance of biogas production and utilization is avoidance of methane emissions, greenhouse gas, which intensity is 23 times higher than carbon dioxide. By utilization of biogas to produce electricity, it contributes national objectives concerning production and utilization of RES. Additional positive contributions are odor reduction, avoidance of soil and groundwater pollution, when using manure from farms. Socio-economic effects are also positive, rural development is supported and local labor and material resources are used.

Concerning energy efficiency, biogas is considered as the most appropriate fuel, which is illustrated on the following picture. Vehicle which uses biogas produced using substrates from one hectare acreage can drive more kilometers, comparing with other fuels produced from the same acreage. Considering energy potential of fuels produced on agricultural land has particular meaning, since the acreage is intended for food production.



Comparison of energy content of biogas with other fuels

Provincial Secretary for Energy and Mineral Sources recognized the importance and potentially positive contribution of biogas production and utilization in Vojvodina. Additionally, there is no enough knowledge about biogas technology. Therefore, it was initiated ***Study of potentials and possibilities for biogas production and utilization in autonomous province of Vojvodina***. The main results are presented in this summary, and entire version of the study may be downloaded from the internet site of the Secretary (*http://www.psemr.vojvodina.gov.rs/index.php?a=studije*).

The main aim of this study is to assess potentials for biogas production and to determine possibilities for its utilization in energy production. Furthermore, this study serves to potential investors as basic assistance in decision making and to signify them required realization steps, problems and constraints. Economic assessment of potential biogas plants has been done as well. This study may serve for interested readers as source of relevant information in basics of biogas production and utilization. Agricultural biogas plants are primarily considered, since Vojvodina is an agricultural region.

2. BIOGAS PRODUCTION

Biogas is produced during microbiological process under anaerobic conditions (absence of oxygen), in so called process of anaerobic digestion. Under term biogas is considered gas produced in anaerobic digesters under controlled conditions, namely in biogas plants.

Biogas is a mixture of gases, and two thirds is approximately methane (CH_4) and one third carbon dioxide (CO_2). Beside these two gases, other gases can be found in traces.

Biogas composition

Component	Chemical symbol	Volumetric share, %
Methane	CH_4	50-75
Carbon dioxide	CO_2	25-45
Water vapor	H_2O	2-7
Oxygen	O_2	< 2
Nitrogen	N_2	< 2
Ammonia	NH_3	< 1
Hydrogen	H_2	< 1
Hydrogen sulfide	H_2S	20-20,000*

* ppm (particles per million)

There are many developed technologies for biogas production (processes and appropriate equipment). Equipment enables storage, preparation and handling of substrates, production and storage of biogas and storage of digested residue. Most contemporary biogas plants are fully automated, and therefore plant contains equipment for monitoring and control of the process.

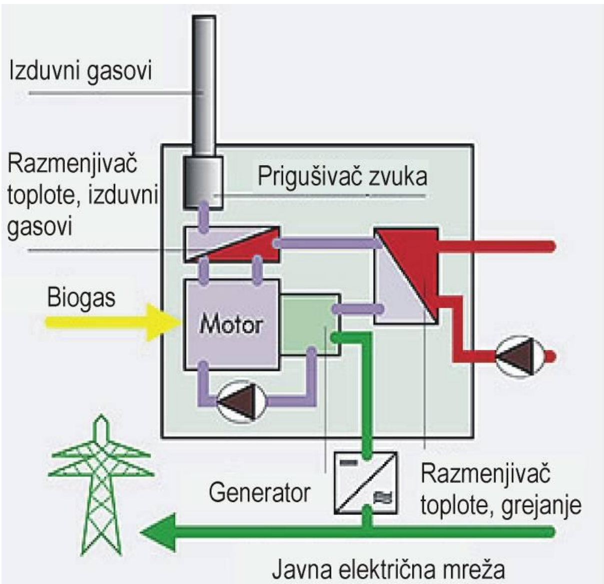
Processes to produce biogas mainly depend on substrate characteristics. These characteristics determine the complexity of biogas plant, which is directly connected with investment costs.

3. BIOGAS UTILIZATION

There are many possibilities to utilize biogas and produce energy from it. After introduction of *feed-in* tariffs for electricity production, the most appropriate pathway is cogeneration, combined heat and power production, with internal combustion engines. This technology is most often used and has the highest maturity. Additionally, positive aspects are high electric efficiencies and low investments.

There are two sorts of internal combustion engines that are used in cogeneration on biogas plants. These are **Gas sparking engines** (german *Gas-Ottomotoren*) and **Pilot injection gas engines** (german *Zündstrahlmotoren*). Pilot injection gas engines use mixture of biogas and diesel fuel for combustion.

Scheme of cogeneration facility with internal combustion engine is presented on the following picture. By biogas combustion, mechanical power is produced on the shaft which is coupled with electric generator. Cogeneration is achieved by utilization of heat energy from cooling fluid and exhaust gases. Heat energy from cooling fluid can produce warm water 90 °C for heating of nearby objects, because of low temperature level. Temperature of exhaust gases, which is between 460 and 550 °C, is suitable for production of water vapor.



Scheme of cogeneration facility with internal combustion engine

Electric efficiency of cogeneration facilities with internal combustion engines are in the range 30 and 40 %. With the increase of nominal electric power, electric efficiency increases as well. Amortization period of pilot injection gas engine is 35.000 h and amortization period of gas sparking engines is around 45.000 h. After that, general overhaul is required. Investments for cogeneration facility depend on engine type. For pilot injection gas engines investments are lower and facility of 200 kW_e has specific investment around 550 €/kW_e. Investment for the gas sparking engine with the same power costs around 800 €/kW_e.

4. POTENTIALS FOR BIOGAS PRODUCTION IN VOJVODINA

Based on statistical data regarding number of cattle on larger farms, potentials for biogas production from manure in Vojvodina have been determined. Potentials are expressed through installed electric power of cogeneration facilities with internal combustion engines, and it is 23 MW. In near future, it is expected enlargement of farms in Vojvodina and consequently enlargement of number of cattle on them.

When additional substrate is used for biogas production, maize silage, potentials are larger. Three scenarios are considered, when using maize silage to increase potentials for 30, 50 and 70 % comparing when using only manure. In these three scenarios, additional potential from maize silage would be 7, 12 and 17 MW_e respectively. Until 2020, this additional potential would be 15, 25 and 35 MW_e.

Total potentials for biogas production from manure and maize silage for the three scenarios in the near future are 30, 35 and 40 MW_e. Because of the expected enlargement of farms in Vojvodina until 2020, total potentials would be 65, 75 and 85 MW_e. In the following table, potential electricity production is presented, as well as requested acreage for the production of maize silage.

Potential annual electricity production from biogas and requested acreage for maize silage

	Near future, 2012		Future, until 2020	
	Electricity, GWh_e	Acreage, ha	Electricity, GWh_e	Acreage, ha
Manure	184	–	400	–
1st Scenario	240	3,200	520	6,800
2nd Scenario	280	5,400	600	11,300
3rd Scenario	320	7,700	680	16,000

Considering only third scenario in the near future, potential electricity production may cover around 4 % of electricity consumption in Vojvodina. Under assumption that electricity consumption would not increase, electricity production from biogas in the third scenario may cover around 9 % of electricity consumption in Vojvodina.

5. REALIZATION OF BIOGAS PLANT

For realization of biogas plant, it is necessary to consider all possibilities and potential effects of biogas plant operation. After idea, primarily it is necessary to consider potential location, available substrates and possibilities to connect the electricity grid. It is necessary to make technical and economical prefeasibility study. In the case of positive results, concrete steps to design and to build biogas plant may be undertaken. Providing of all necessary permissions and administrative documents to build and operate biogas plant is significant activity that requires certain time.

Guidelines to calculate basic parameters of biogas production and utilization are presented in the following table.

Guidelines to calculate parameters of biogas production and utilization

Methane content in biogas	50 to 70 %	
Calorific value of methane	9.97 kWh/Stm^3	
Calorific value of biogas (50-70 % methane)	5 to 7 kWh/Stm^3	
1 CU is an animal weighing	500 kg	
1 CU produces quantity of manure	6.6 to 35 t/a	
1 CU of cattle or pig requires electric power	0.11 to 0.15 kW_e	
1 CU of poultry requires electric power	0.5 kW_e	
1 ha under maize silage requires electric power	2 to 2.5 kW_e	
1 t of maize silage requires storage capacity	1.4 m^3	
1 t of pig liquid manure has biogas yield (% methane)	20 Stm^3 (60 %)	
1 t of cattle liquid manure has biogas yield (% methane)	28 Stm^3 (55 %)	
1 t of maize silage has biogas yield (% methane)	180 Stm^3 (52 %)	
Required volume of digester for 100 kW_e	400 to 800 m^3	
Required volume of horizontal digester for 100 CU	100 to 150 m^3	
Required volume of vertical digester for 100 CU	200 to 250 m^3	
Electric efficiency of CHP unit	30 to 40 %	
Thermal efficiency of CHP unit	40 to 60 %	
Total efficiency of CHP unit	85 %	
Investment for entire biogas plant	150 kW_e	3,500 €/kW_e
	500 kW_e	3,000 €/kW_e
	1,000 kW_e	2,500 €/kW_e
Investment for engine coupled with generator	150 kW_e	680 €/kW_e
	500 kW_e	570 €/kW_e
	1,000 kW_e	400 €/kW_e
Feed-in tariffs for biogas plants with capacity	150 kW_e	16.11 ct/kWh_e
	500 kW_e	15.33 ct/kWh_e
	1,000 kW_e	14.22 ct/kWh_e