TEKA Kom. Mot. Energ. Roln. – OL PAN, 2010, 10, 209–215

OVERVIEW OF TECHNOLOGICAL METHODS OF ENERGY PRODUCTION FROM BIOMASS

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Summary. Biomass is mass of organic matter contained in the organism of the animal or the plant, also organic matter produced by the population, team of organisms of the given environment, on the determined space, in the given individual at a given time. The rational management of non-renewable raw materials in our country assumes an increasing of the participation of alternative energy sources in the energy balance. It also out of necessity results from limiting the CO_1 need. Since agricultural waste and energy plants constitute the considerable part of biomass, the greatest benefits from the development of the biofuels production are to be found in the farming. In the article a review of the technologies of acquiring the energy from biomass was presented.

Key words: biomass, biofuels, renewable energy, technologies, energy crops

INTRODUCTION

In the contemporary world we are using huge amounts of energy. Non-renewable stores, such as natural gas, coal and petroleum are shrinking at an alarming rate. Next generations can already be devoid of the possibility of using fossil fuels. Energy conservation both by factories and private users (construction of passive houses, applying less energy-intensive technologies), is a chance for longer keeping of the non-renewable stores. Alternative energy sources, among which we are ranking the following, have a great future:

– biomass coming from organic matter, including organic waste and sewage settlements,
– energy of water, converted mainly by wheel mills,
– geothermal energy, called also the energy from the inside of the Earth,
– windpower, converted with wind turbines,
– energy of the Sun, provided to the ground by the solar radiation.

Reserves of biomass in Europe are very large. It is estimated that in Poland within one year over 20 mln tone of scrap straw, 20 mln tone of waste of a tree, and 6 mln sewage deposits are coming into existence which corresponds to 15 - 20 mln tone of coal [Solińska, Soliński 2003].

Using agricultural raw materials for energy purposes means the building of new markets, revenue growth in arable farms and coming into existence of new places of employment. In Poland correlation between renevable energy source and the labour market has not been examined so far, however it is obvious that in Germany four times more jobs are being generated here than in coal energetics [http://paze.pfrr.pl].

KINDS OF BIOMASS

Biomass is the third in amount natural source of energy with a range of kinds such as: energy crops, wood and tree waste, biogas, agricultural waste, biooil, biodiesel and ethanol.

Energy crops are being used for production of electricity, warmth and fuel. The increase in biomass depends on the cleanness of water and the soil as well as on the intensity of the solar exposure. Energy plants should be characterized by a great annual increment, high calorific value, resistance to illnesses and vermin and should have little soil requirements. The most popular are the willow miskantus, rape and virginia fanpetals. In Poland, on account of the great demand for energy, large areas of neglected fields as well as those of low class soils are being allocated to investments connected with the production of energy plants.

At present in Poland forests occupy almost 9 mln hectares i.e. 29% of the country's area, while afforestation rate in Europe reaches 33%. Lubuskie Province has the greatest afforestation rate of 48.7%, and the Łódzkie Province has the lowest one, about 20% (Fig. 1).

Fig.1. Afforestation rate of Poland according to provinces [www.naukawpolsce.pl]

Acquisition of wood and waste from trees coming from forests, orchards, urban areas and the wood industry is greatly limited. Wood as biofuel is found either in the processed form as briquettes or pellets or the raw one as firewood, bark, conifer needles, leaves, branches, shavings, wicker, sawdust, frameworks of trees.

Biogas is a gas fuel produced by micro-organisms during the anaerobic fermentation of organic substance. The content of the constituents is different depending on the stage in the process. The amount of methane which influences an increase in the calorific value ranges between 55% and 85%, however of carbon dioxide whose presence decreases the calorific value, between 14% and 48%. In energetics, biogas from the fermentation of the following is being used:

– of sewage deposits coming into existence in sewage treatment plants,
– of organic waste deposited on landfill sites,
– of animal waste found in households.

Straw and the energy grain belong to the group of agricultural products and agricultural waste. The Polish farming produces 25 mln tones of straw annually [Frąckowiak 2000]. For a few years a fall in the agricultural products and waste application has been seen, caused by surpluses of potential fuels. Using straw for energy purposes is linked with avoidance of its burning in the fields and thus prevention of possible environmental pollution. Controlled straw burning is being practiced and its ash can be used as fertilizer on account of the large content of phosphorus and potassium.

Vegetable oil, biooil, biodiesel, ethanol and methanol rank among liquid biofuels. Due to limited resources of fossil fuels as well as the fact that, applied in transport, they are generating bulks of pollutants, it is important to launch alternative liquid biofuels. They are bioalcohols applied as propellant or added to petrol.

TECHNOLOGIES OF THE CONVERSION OF BIOMASS TO ENERGY PURPOSES

The main objectives of energy policy in Poland include the use of 15% renewables in the energy balance in 2020 and 20% in 2030 in the market of transport fuels and the maintenance of this level in the following years [www.mg.gov.pl]. In order to meet requirements of the EU, energy from renewable sources should be widely applied in technology. At present four technologies of the biomass use are applied: burning (direct, co-burning), the gas-supply service, the pyrolysis and biochemical processes.

Burning

Burning biomass is far less harmful for the environment than burning fossil fuels, on account of smaller emission of toxic substances. During the photosynthesis process plants are absorbing the carbon dioxide which is transmitted back to the atmosphere due to their metabolizm. As a result the balance of the CO_2 content in the atmosphere is zero.

Since biomass compared with conventional fuels has different composition (e.g. large content of volatile parts), a proper selection of the technology is important. Blends of biomass with fossil fuels are applied, bringing about many notable benefits. A high-temperature corrosion is a considerable problem of their burning [Rybak 2006].

On account of specific properties of biomass models of pots were drawn up with different types of hearths. The commonest types are:

- pots with the hearth for consuming straw in the form of beam, of briquettes or pellets;
- pots with the hearth for consuming wood in the form of tree frameworks_pellets, of sawdust and pellets.

Pots heated with firewood

Choice of the hearth for consuming wood depends on the form of wood and the thermal strength of the pot. Among the most often applied types of hearths are: grate with the permanent or sliding grate, fluidized (vesicular or circulating), retort for burning pellets and cyclone. In the low-powered pot there are three bevels of consuming wood. At first in the storage container biomass is dried and degased, burning tree gas of in temperature 1200^{0}C. In the final phase gas is left burnt, and warmth conveyed with the help of the exchanger. Burning in pots of higher power must be preceded by grinding down, drying and the proper storage. Using grates about the steplike structure enables the incineration of waste of wet surfaces, even to 50% humidity. Incineration of waste dry is held in pots equipped with permanent or moving horizontal grates.

Tanned pots with straw

Pots for consuming straw can be divided according to the way of giving fuel into: batch (flow, anti-electricity) for burning beam/pallets, cigar for constant burning pallets, mechanized pot for consuming ground straw. Consuming straw in pots relies mainly on anti-electricity for the principle

of burning. Air blown by the nozzle is divided into the primary and secondary stream. The primary stream is entered into the combustion chamber, where it creates primary gases which are turned back and joined to the secondary stream of the fresh air, which causes secondary, final burning [Gradziuk et al. 2003]. The steering apparatus in a pot is measuring the combustion temperature of straw and on the basis of data with the help of the fan an inflow of the fresh air to the combustion chamber is regulated. Well extended thermal exchangers guarantee small losses of the warmth.

Pyrolysis

Pyrolysis is the name of thermal conversion of organic substance without the access of oxygen, causing the creation of liquid biofuel, called biooil or oil pyrolysis. The process occurs in temperatures 380 - 550^{0}C, at the pressure 0,1–0,5 MPa [www.czystaenergia.pl]. Properties of the created biofuel depend, for example, on the time, the temperature and features of the raw material, including its humidities. Depending on the duration we can distinguish the free, fast and very fast pyrolysis. During the free pyrolysis charcoal is a staple product whose content amounts to 35%, as a result of fast pyrolysis 70% biofuel constitutes the product, however the combustible gas is created in the amount over 65%. Reducing mass and volumes of fuel are the primary goal of the process at simultaneous storing up calorimetric values in the created products.

Gas-supply service (gassifying)

Gassifying is the technologically most advanced manner of the energy biomass use. The created gas can be burnt in pots with gas rings, in internal-combustion engines or in gas turbines. The advantage is the great effectiveness of the process, the possibility of applying raw biomass with high damp content and little emission of harmful substances into the atmosphere. The technology of gassifying consists in converting biofuels of solids into gas by heating and chemical reactions of biomass with oxidants in conditions of their deficiency. Fuel arising in the form of gas is deprived of harmful elements, including the pollutants. Depending on the way of delivering the central heating the process of gassifying can run directly, when the part of biofuel provided by the reactor is undergoing burning, and indirectly, when the warmth for gassifying will wear the separate device from burning biofuel and the reactor is provided with the help of permanent, liquid or gas carrier. The process of the gas-supply service is conducted either in ordinary reactors or with the fluidized plentiful supply. The obtained gas can be directly converted into the electric current with the help of fuel cells [Lewandowski 2002].

Biochemical processes

The too large content of water in biomass prevents it from effective burning, however it predisposes for surrendering it to biochemical processes, such as the methane or alcoholic fermentation.

Methane fermentation

This process consists in decomposition of carbohydrates and proteins by micro-organisms with the appropriate pH and the limited access to oxygen. It is possible to distinguish four phases of fermentation: enzymatic hydrolysis, acidogenesis, acetogenesis and methanogenesis [www.biomasa.org]. Biogas is the product of the process whose main components are: methane, carbon dioxide, hydrogen. Nitrogen, oxygen, hydrogen sulphide, ammonia, ethyl thioalcohol, ethane, acetone, hy-

drocarbons and benzene are found in paucities [Rosik-Dulewska 2000]. We distinguish three basic technologies of the biogas production:

- constant fermentation, consisting in constant passing the fermenting raw material to the container,
- alternating fermentation, requiring the construction of at least two containers filled with the raw material in turns,
- periodic fermentation periodic, relying on periodic filling the container and its total emptying [Ney et al. 1993].

Fermentation involves: methane organic waste, sewers from the food industry, sewage settlements, animal excrements and cultivated plants, e.g. maize subjected to the process in the form of silage. The biogas production from organic waste reqiures an installation with biogasworks. The effectiveness of biogas production is affected by: time of fermentation, the way of dosing and mixing biomass up and the presence of agents and toxic. Biogas containing methane above 40% is directed to generators of the electric current for the purpose of the production of electricity, and to gas boilers for the production of thermal energy. Part of the gas is directed to the gas mains [Tytko 2009]. Perhaps also after prior purification it can be used as fuel to drive engines. It is estimated, that in Poland total emission of biogas from dumps amounts to 80 000 m3/h, which contains 50% of methane and corresponds to the electric power of about 120 MW [Gradziuk et al. 2003]. Waste is a considerable source of biogas from farm households. It is estimated that from 1 m3 excrement it is possible to get 20 m3 of biogas, but from 1m3 of manure - 30 m3 [www.krir.pl].

Alcoholic fermentation

Aalcoholic fermentation is a transformation of simple sugars (glucoses, fructoses) to ethyl alcohol and carbon dioxide in anaerobic conditions under the influence of enzyme included in yeast. In the outcome of the process apart from ethyl alcohol and carbon dioxide a row of by-products is coming into existence, among others, glycerine, succinic acid and acetic acid. On account of the large content of carbohydrates the most often applied as biomass for the production are: sugar cane, sugar beets, the wheat, the rye, straw and potatoes. Bioethanol is used both as an independent fuel and as an additive to petrol in the amount from 5% to 10%.

Also ranked among biochemical processes is the esterification of oil: a two-stage chemical reaction occurring in the presence of a catalyst between acids and alcohol, as a result of which a methylic ester of higher fatty acids and glycerine is created. Biodiesel is a clean fuel, non-toxic with almost identical properties as petroleum diesel. The quality of oil and its possibility of using to the production of fuel depend on the content of fatty acids. At present two basic production technologies of biofuel are applied on the basis of oil seeds:

- cold; the process is conducted in the temperature 20-700C with using alkaline catalytic converters,
- hot; the conducted process is in the temperature 2400C, under pressure 10 MPa [Mokrzycki et al. 2005].

The process of getting biofuel in the hot technology is carried out at large chemical units, however the cold technology is applied in small food-processing plants, producing biofuels below 500 ton annually. For the production of the biodiesel in Poland rape is an initial basic raw material. Fuel is applied in diesel engines as independent fuel or as fuel biocomponent, in heating and power-generating systems, in the water and train transport as well as for the production of spreadable agents.

More and more mini manufacturing companies of biodiesel have been established recently all over the country. Manufacturing companies of fuel are completely safe, since the process is

conducted in low temperatures and under low pressure, in the way not threatening people and the environment. By-products can be used in agricultural farms: oilcake can be added to fodders and glycerine, after watering down, is used for concentrating natural fertilizers.

CONCLUSIONS

The state of the development of individual technologies of the energybiomass use is currently at various stages. The best-developed technology, introduced on the industrial scale, is burning. In the pilot scale there are prototype ways of energy generation: gassifying, pyrolysis and biochemical processes. Environmentally-friendly factors of the application and the high- technology development of energy production cause that biomass constitutes the chance for the development of agriculture.

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PRZEGLĄD TECHNOLOGII POZYSKIWANIA ENERGII Z BIOMASY

Streszczenie. Biomasa to masa materii organicznej zawartej w organizmie zwierzęcia lub rośliny, także materia organiczna wytworzona przez populację, zespół organizmów danego środowiska, na określonej przestrzeni, w danej jednostce czasu. Racjonalna gospodarka surowcami nieodnawialnymi w naszym kraju zakłada zwiększenie udziału alternatywnych źródeł energii w bilansie energetycznym. Wynika to również z konieczności

ograniczenia emisji CO_2. Ponieważ znaczną część biomasy stanowią odpady rolnicze oraz rośliny energetyczne, największe korzyści z rozwoju produkcji biopaliw notuje się w rolnictwie. W artykule przedstawiono przegląd technologii pozyskania energii z biomasy.

Słowa kluczowe: biomasa, biopaliwa, energia odnawialna, technologie, uprawy energetyczne

Publication carried out as part of the work stipulated in the Articles of Association no. 11.11.100.280.