BIOMASS AND ITS UTILIZATION IN CONDITIONS OF SLOVAKIA

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ABSTRACT

According to the European Environment Agency, the use of biomass for clean energy generation in EU could be significantly increased in the next decades. There are a wide variety of biomass resources, including tree and grass crops and forestry, agricultural, and urban wastes. This paper deals with possibilities of generating energy from biomass resources in Slovakia.

1. INTRODUCTION

Biomass is any organic matter such as wood, crops, seaweed, some garbage or animal wastes that can be used as an energy source. Biomass is probably the oldest source of energy after the sun. Biomass has been used for energy purposes ever since man discovered fire. For thousands of years, people have burned wood to heat their homes and cook their food. Biomass gets its energy from the sun. All organic matter contains stored energy from the sun. During a process called photosynthesis, sunlight gives plants the energy they need to convert water and carbon dioxide into oxygen and sugars. Biomass as the solar energy stored in chemical form in plant and animal materials is among the most precious and versatile resources on earth. It provides not only food but also energy, building materials, paper, fabrics, medicines and chemicals. Biomass is a renewable energy source because we can always grow more trees and crops, and waste will always exist. The use of biomass energy has many unique qualities that provide environmental benefits. It can help mitigate climate change, reduce acid rain, soil erosion, water pollution and pressure on landfills, provide wildlife habitat, and help maintain forest health through better management.

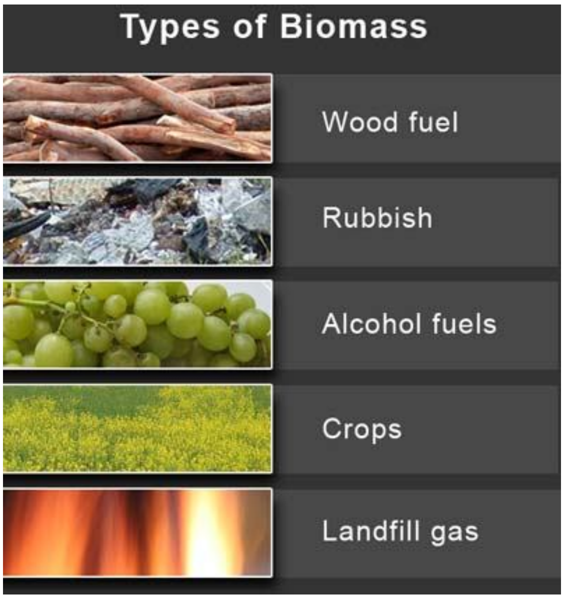

Figure 1 – Types of biomass [4].

2. METHODS OF GENERATING ENERGY FROM BIOMASS

2.1. Combustion

The technology of direct combustion as the most obvious way of extracting energy from biomass is well understood, straightforward and commercially available. Combustion systems come in a wide range of shapes and sizes burning virtually any kind of fuel, from chicken manure and straw bales to tree trunks, municipal refuse and scrap tyres. Some of the ways in which heat from burning wastes is currently used include space and water heating, industrial processing and electricity generation. One problem with this method is its very low efficiency no better than 2%.

Designing a stove or boiler which will make rather better use of valuable fuel requires an understanding of the processes involved in the combustion of a solid fuel. Modern combustion facilities (boilers) usually produce heat, steam (used in industrial process) or electricity. Direct combustion systems vary considerably in their design. The fuel choice makes a difference in the design and efficiency of the combustion system. Direct combustion technology using biomass as the fuel is very similar to that used for coal. Biomass and coal can be handled and burned in essentially the same fashion. In fact, biomass can be “co-fired” with coal in small percentages in existing boilers. The biomass which is co-fired are usually low-cost feedstocks, like wood or agricultural waste, which also help to reduce the emissions typically associated with coal. Coal is simply fossilized biomass heated and compressed over millions of years. The process which coal undergoes as it is heated and compressed deep within the earth, adds elements like sulphur and mercury to the coal. Burning coal for heat or electricity releases these elements, which biomass does not contain.

2.2. Pyrolysis

Pyrolysis is the simplest and almost certainly the oldest method of processing one fuel in order to produce a better one. A wide range of energy-rich fuels can be produced by roasting dry wood or even the straw. The process has been used for centuries to produce charcoal. Conventional pyrolysis involves heating the original material (which is often pulverised or shredded then fed into a reactor vessel) in the near-absence of air, typically at 300 - 500 °C, until the volatile matter has been driven off. The residue is then the char - more commonly known as charcoal - a fuel which has about twice the energy density of the original and burns at a much higher temperature. For many centuries, and in much of the world still today, charcoal is produced by pyrolysis of wood. Depending on the moisture content and the efficiency of the process, 4-10 tonnes of wood are required to produce one tonne of charcoal, and if no attempt is made to collect the volatile matter, the charcoal is obtained at the cost of perhaps two-thirds of the original energy content.

Pyrolysis can also be carried out in the presence of a small quantity of oxygen (‘gasification’), water (‘steam gasification’) or hydrogen (‘hydrogenation’). One of the most useful products is methane, which is a suitable fuel for electricity generation using high-efficiency gas turbines.

With more sophisticated pyrolysis techniques, the volatiles can be collected, and careful choice of the temperature at which the process takes place allows control of their composition. The liquid product has potential as fuel oil, but is contaminated with acids and must be treated before use. Fast pyrolysis of plant material, such as wood or nutshells, at temperatures of 800-900 degrees Celsius leaves as little as 10% of the material as solid char and converts some 60% into a gas rich in hydrogen and carbon monoxide. This makes fast pyrolysis a competitor with conventional gasification methods (see bellow), but like the latter, it has yet to be developed as a treatment for biomass on a commercial scale.

At present, conventional pyrolysis is considered the more attractive technology. The relatively low temperatures mean that fewer potential pollutants are emitted than in full combustion, giving pyrolysis an environmental advantage in dealing with certain wastes. There have been some trials with small-scale pyrolysis plants treating wastes from the plastics industry and also used tyres - a disposal problem of increasingly urgent concern.

2.3. Gasification

Gasification based on wood as a fuel produces a flammable gas mixture of hydrogen, carbon monoxide, methane and other non flammable by products. This is done by partially burning and partially heating the biomass (using the heat from the limited burning) in the presence of charcoal (a natural by-product of burning biomass). The gas can be used instead of petrol and reduces the power output of the car by 40%. It is also possible that in the future this fuel could be a major source of energy for power stations.

2.4. Fermentation

Fermentation of sugar solution is the way how ethanol (ethyl alcohol) can be produced. Ethanol is a very high liquid energy fuel which can be used as the substitute for gasoline in cars. This fuel is used successfully in Brazil. Suitable feedstocks include crushed sugar beet or fruit. Sugars can also be manufactured from vegetable starches and cellulose by pulping and cooking, or from cellulose by milling and treatment with hot acid. After about 30 hours of fermentation, the brew contains 6-10 per cent alcohol, which can be removed by distillation as a fuel.

Fermentation is an anaerobic biological process in which sugars are converted to alcohol by the action of micro-organisms, usually yeast. The resulting alcohol is ethanol (C2H3OH) rather than methanol (CH3OH), but it too can be used in internal combustion engines, either directly in suitably modified engines or as a gasoline extender in gasohol: gasoline (petrol) containing up to 20% ethanol. The value of any particular type of biomass as feedstock for fermentation depends on the ease with which it can be converted to sugars. The best known source of ethanol is sugar-cane - or the molasses remaining after the cane juice has been extracted. Other plants whose main carbohydrate is starch (potatoes, corn and other grains) require processing to convert the starch to sugar. This is commonly carried out, as in the production of some alcoholic drinks, by enzymes in malts. Even wood can act as feedstock, but its carbohydrate, cellulose, is resistant to breakdown into sugars by acid or enzymes (even in finely divided forms such as sawdust), adding further complication to the process. The liquid resulting from fermentation contains only about 10% ethanol, which must be distilled off before it can be used as fuel. The energy content of the final product is about 30 GJ/t, or 24 GJ/m3. The complete process requires a considerable amount of heat, which is usually supplied by crop residues (e.g. sugar cane bagasse or maize stalks and cobs). The energy loss in fermentation is substantial, but this may be compensated for by the convenience and transportability of the liquid fuel, and by the comparatively low cost and familiarity of the technology.

2.5. Anaerobic digestion

Nature has a provision of destroying and disposing of wastes and dead plants and animals. Tiny micro-organisms called bacteria carry out this decay or decomposition. The final product of these processes is a mixture of Methane (CH4) and Carbon dioxide (CO2) and is commonly called as the 'Biogas'. The technology of scientifically harnessing this gas from any biodegradable material (organic matter) under artificially created conditions is known as biogas technology.

Anaerobic digestion, like pyrolysis, occurs in the absence of air; but in this case the decomposition is caused by bacterial action rather than high temperatures. It is a process which takes place in almost any biological material, but is favoured by warm, wet and of course airless conditions. It occurs naturally in decaying vegetation on the bottom of ponds, producing the marsh gas which bubbles to the surface and can even catch fire.

Anaerobic digestion also occurs in situations created by human activities. One is the biogas which is generated in concentrations of sewage or animal manure, and the other is the landfill gas produced by domestic refuse buried in landfill sites. In both cases the resulting gas is a mixture consisting mainly of methane and carbon dioxide; but major differences in the nature of the input, the scale of the plant and the time-scale for gas production lead to very different technologies for dealing with the two sources.

The detailed chemistry of the production of biogas and landfill gas is complex, but it appears that a mixed population of bacteria breaks down the organic material into sugars and then into various acids which are decomposed to produce the final gas, leaving an inert residue whose composition depends on the type of system and the original feedstock.

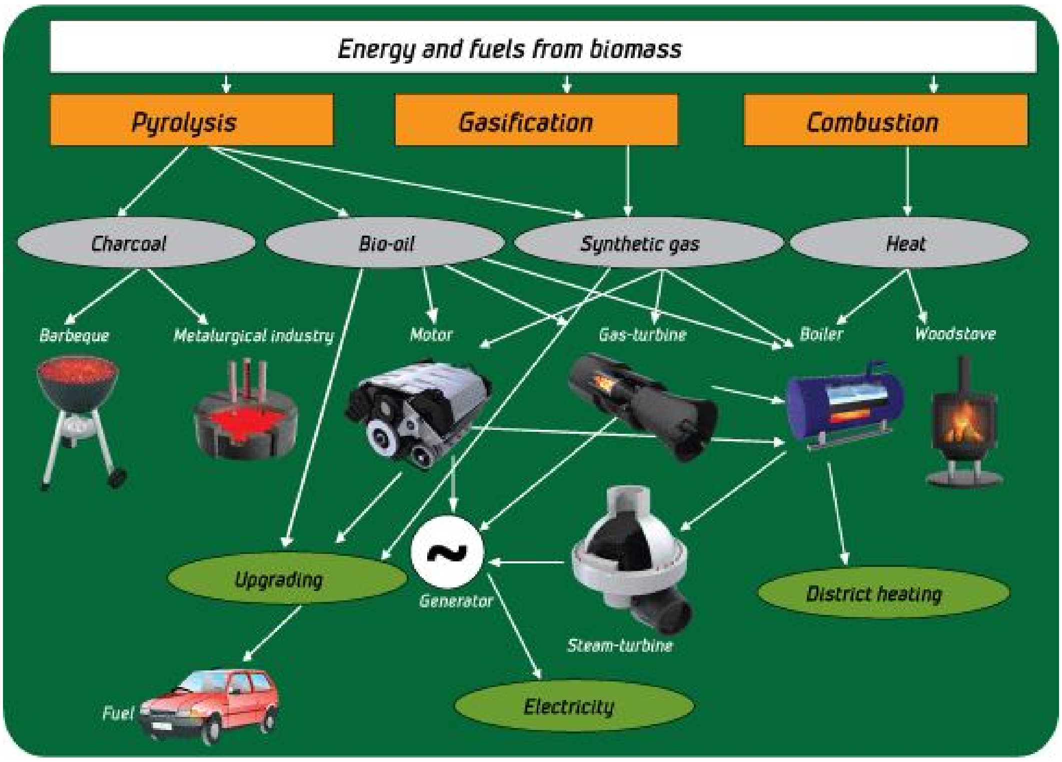

Figure 2 – Utilization of biomass energy.

3. BIOMASS POTENTIAL IN EUROPE

Extracted from agriculture, forestry and organic waste, biomass can provide heat, power and transport fuels in an environmentally friendly way. Consequently, its use can both help reduce greenhouse emissions and achieve the European renewable energy targets.

Currently, 4% of EU's energy needs is obtained from biomass (69 Mtoe in 2003). According to energy projections, the use of biomass for energy generation in Europe should double by 2010 (180Mtoe) and triple by 2030 (210-250Mtoe) in order to meet the European renewable energy targets.

However, the extended biomass production may create adverse environmental pressures, mainly on biodiversity, soil and water resources. It is therefore of major importance to safeguard sustainable production of biomass by assessing the quantity of the potential biomass that can be used without creating such additional pressures.

The European Environment Agency is currently assessing the quantity of the potential European "environmentally-compatible biomass" –the quantity of biomass that is technically available for increased energy generation that does not pose threats to biodiversity, soil and water resources and that is in line with other current and future environmental objectives.

The preliminary results of the assessment show that the potential of environmentally compatible biomass for producing energy could increase from the predicted 180 Mtoe in 210 to about 300 Mtoe in 2030. This means that there is sufficient biomass potential in the EU to support the renewable energy without harming the environment.

The calculations were realized by taking into account the key drivers of bioenergy production (agriculture, forestry, waste, greenhouse emissions reductions) and a number of environmental constraints.

4. ALTERNATIVE USE OF AGRICULTURAL WASTE AND SURPLUSES IN SLOVAKIA

Cereals are grown on 800,000 ha of arable land in Slovakia with straw production of 3 million t and one third of it is waste. The theoretical potential of the straw, as an agricultural waste, produced yearly by the Slovak agriculture is approximately 2 mil. tons a year. The theoretical potential in case of its combustion in cogenerative units represents 1.6 bil. kWh of electric energy and 4.8 bil. kWh of thermal energy a year.

In spite of it the only experimental power plant on straw burning in Slovakia is the Agrozet in Zvolen. Now the straw is used mainly for agricultural purposes or it is exported to Austria. An enormous energy potential is contained in biogas - from the animal produced excrements, as other kind of agricultural waste. In fact, biogas is used only in few farms, e. g. in Bátka. One of the newest biogas plants is at the farm of the Slovak Agricultural University in Nitra.

The biogas is also utilized in several sewage treatment plants, e. g. in Nižná or Dolný Kubín. The biogas potential of Slovakia is 15 PJ (10% from manure, 5 from other resources, mainly from water sewage treatment plants) but most farms are too small for processing organic waste. It means that the suitable biogas potential of Slovakia is only 5 PJ. There are problems with utilization of biogas technologies, because the contemporary technology is very expensive and the farmers are worried about the future of animal breeding in Slovakia. The production of biogas is 0,3-0,45 m^3 from 1 kg of solid waste.

Slovakia produces 40 000 tons of communal organic wastes yearly also usable in production of biogas. From this amount we could recover 0.3 bil. kWh of electric energy. Industrial and municipal solid wastes are reclaimed in plant specialised to alternative use of waste in Pezinok with production of 0.5 PJ. It was a first plant of this character in Central Europe.

4.1. Use of wood biomass

The forests cover 42% of the Slovakian area and thus wood wastes represents a big potential from a viewpoint of energy accumulation. A large potential for biomass based projects are especially in the wood processing industry, having a considerable heat demand and high availability of low cost wood residues. The wood wastes production in Slovakia is 2.3 million ton per year with energy potential of 27 PJ. Unfortunately only 20% of it is used for energy or material output. The annual production of wood brickets is 18.000 ton, but 90% of it is exported.

4.2. Organic fuel production

A special category is represented by the cultivation of energetically usable rapidly growing wood species and plants with a possible annual profit of 4 PJ. In Slovak conditions the most perspective energy plants are the fast growing trees for burning (experiments at Research Institute of Grasslands in Krivá na Orave or at the Slovak Agricultural University in Nitra), plants suitable for ethanol production by fermentation and plants rich in oil e. g. oil-rape. The rate of input and output energy in energy plant production is 1:1 or 1:1,3 for oil-rape and 1:5 for sugar-sorghum (equal to 11 ton of oil from 1 ha). There is already available technical equipment for the production of 5500 tons of bio-oil/year. Seven power plants have been built to produce biopetroleum in Slovakia (5 with 500 t annual production and 2 with 1500 t production). The biopetroleum called MDT (30% esterificated oil MERO made from plants + 70% mineral oil) was successfully tested in Slovakia. Gas station OMV Slovakia, Ltd. is a single one distributor of bio-oil in Slovakia, but the sales are still relatively small, in spite of lower price. The planned area for energy production plants is limited to 400.000 ha (with energy potential of 100 PJ sufficient for heating of all houses in Slovakia).

5. CONCLUSIONS

In addition to the many environmental benefits, biomass offers many economic and energy security benefits. By growing our fuels at home, we reduce the need to import oil and reduce our exposure to disruptions in that supply. Biomass is the most important fuel and energy resource in Slovakian condition, which could easily replace fossil and nuclear energy. More than 73% of the biomass arise from wood waste, since 42% of Slovakian area is covered by forest. However, in spite of incessant conventional energy resources decreasing and deterioration of the environment status, we are not giving sufficient attention to mentioned matter in question. At this time of switch-over to sustainable energy and endeavour for environmental awareness, it is also necessary to solve the problem of peoples insufficient informing about the feasibility of biomass utilising at all.

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