BIOMASS UTILISATION FOR ELECTRIC POWER GENERATION

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ABSTRACT

This paper gives a proper overview on various possibilities for power generation from biomass in small-scale. One should note that the concept power generation from biomass in the article refers straight to combined heat and power (CHP) production based on biomass.

1. INTRODUCTION

Biomass is plant matter such as trees, grasses, agricultural crops or other biological material that can be used as a solid fuel, or converted into liquid or gaseous forms, for the production of electric power, heat, chemicals, or fuels. Figure 1 clarifies the bio-energy chain from biomass origin to energy usage [1].

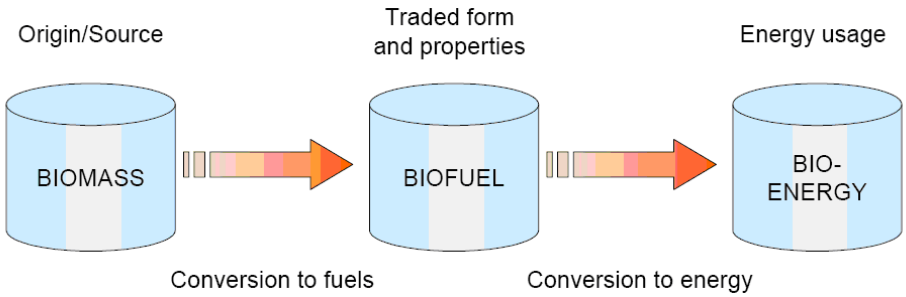

Fig.1. Bioenergy chain [1]

Biomass energy, one type of renewable energy, is important from two perspectives: firstly, from the perspective of climate change and energy; and secondly, from the viewpoint of a recycling society. Biomass energy is superior to other forms of renewable energy sources in its ease of storage and transportation. Promoting the use of biomass energy has the potential to mitigate climate change, offer a sustainable energy supply, and achieve a sustainable and recycling social system for the future.

Furthermore, biomass energy has the following advantages: [2]

- unaffected by natural conditions,
- energy combined efficiency by producing heat and electricity,
- labour absorption in energy resource production, superior to other forms of renewable energy.

In spite of the advantages of biomass energy, various barriers such initial high costs, insufficient biomass energy resources and insufficient market development must be solved for the use of biomass energy to progress [2].

2. BIOMASS CONVERSION TECHNOLOGIES FOR POWER GENERATION

Biomass conversion is about converting solid biofuels into such form that are usable for energy generation. Biomass conversion technologies can be divided into biological, chemical and thermo-chemical conversion methods. The thermo-chemical methods involve heat treatment of the biomass material, the biological conversion uses microbiological action to convert the biomass material into usable fuel, while chemical conversion makes use of the technologies of extraction and transesterification [1].

The purpose of conversion methods is to convert solid biomass feedstock into a form usable for energy production, as solid biomass can be utilised in direct combustion methods only. Figure 2 presents the main potential pathways for bio-fuel based power generation, starting from grouping of conversion technologies and resulting in technological alternatives for power generation [1].

Biomass conversion technologies illustrated in the Figure 2 are currently the main "starting points" to electricity generation from biomass. Other known biomass conversion methods that are not shown in the Figure 2 are liquefaction and hydro thermal upgrading. Up to now, these two alternatives have not proven to be economically feasible solutions for near future, due to which they are presented in minor way compared to other conversion methods [1].

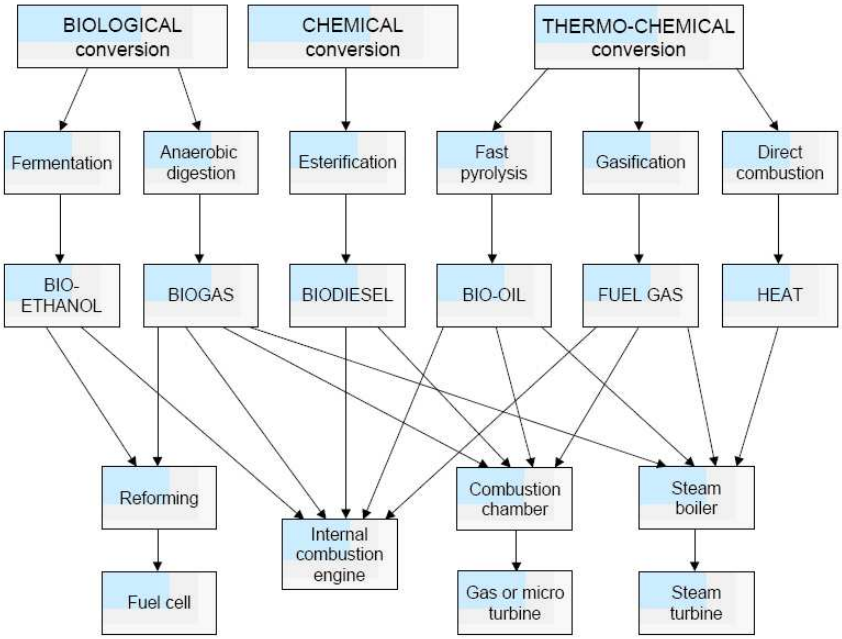

Fig. 2. Overview of the major technological routes for biomass based power generation [1]

Possible biomass based fuels for engines are bioethanol, biogas, biodiesel, bio-oil and fuel gas from biomass gasification (Figure 2). Currently, the most effective way to generate electricity out of biomass is the gasification and the use of the gas in gas engine: the conversion of the organic carbon with the gasification of biomass in higher than 95% [1]. Biomass gasification represents a rather new generation of biomass energy conversion processes and thus, electricity production based on a fixed-bed gasifier system coupled to a gas engine has been the focus of many R&D projects in Europe during the last few years. It should be noted, though, that this kind of technology is still in the stage of development and has not yet reached commercialization [1].

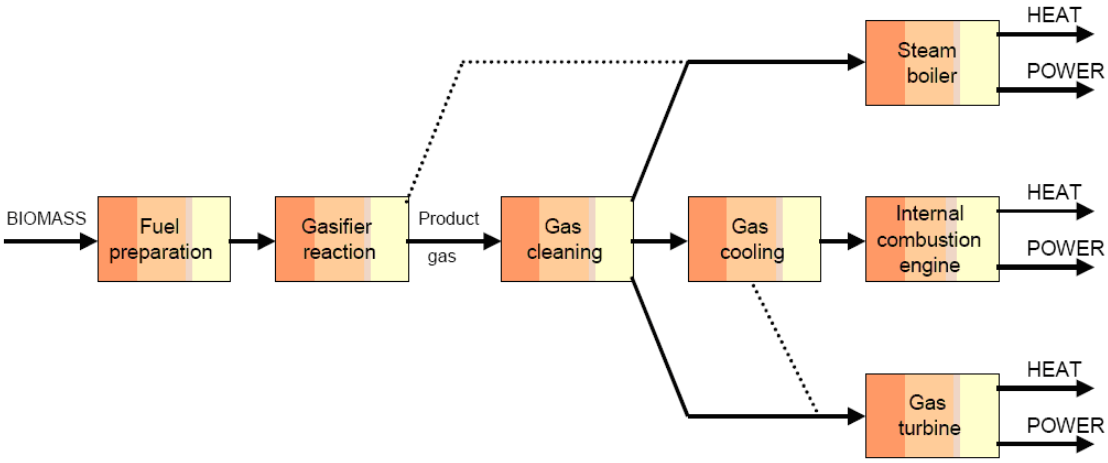

Fig. 3. Gassification routes to heat and power [1]

There are three basic alternatives to utilise gasifiers for combined heat and electricity production (Figure 3). The gasifier can be connected to steam cycle, i.e. a steam boiler with a steam turbine, or the product gas can after cleaning be either used in an intemal combustion engine or led to a gas turbine [1].

3. APLICATIONS OF POWER GENERATION BROM BIOMASS

Technological development and governmental subsidies directed towards environmentally sustainable electricity generation have increased the share of distributed generation in many countries during recent years. Combined production of heat and power is suitable for small-scale applications, and micro and small-scale biomass-fired CHP units are one of the alternatives for distributed generation. This relatively new technology has reached the commercialization stage and could replace conventional boilers in dwellings and provide both electricity and heating to dwellings concerned.

More specifically out sorted, the smallest biomass based CHP systems with power output under 10 kWe, (Stirling engines and fuel cells) could replace the conventional boiler in a dwelling and provide both electricity and heating to that dwelling, possibly with surplus electricity exported to the local grid. Systems with power output ranging from 10 kWe to 100 kWe, in turn, are applicable to blocks or groups of dwellings, as well as non-domestic buildings.

The aptitude of small scale biomass CHP technologies for different applications is the most extensive in size class between 100 kWe - 1 MWe, as all presented technologies are included in this size category (Table 1). Possible applications for systems having power output between 100 kWe and 1 MWe are hospitals, green houses, small sized industry, swimming halls, and also bigger schools and hotels.

Mode	**Conditions**	**Liquid (%)**	**Char(%)**	**Gas (%)**
Fast pyrolysis	Moderate temperature, short residence time	75	12	13
Carbonisation	Low temperature, very long residence time	30	35	35
Gasification	High temperature, long residence time	5	10	85

Tab. 1. Typical product yields (dry wood basis) obtained by different modes of wood pyrolysis [1]

Possible applications for biomass CHP systems with power output rate from 1 MWe to 10 MWe are small regional electricity and heating systems, university campus areas, i.e. the ones in USA, and medium sized industry. Technologies included in this size category are internal combustion engines. ORC turbines and steam engines or turbines (Table 1).

4. CONCLUSIONS

The use of biomass, including biogas, for electricity generation represents an insufficiently used potential. At the same time, biomass provides additional perspectives for the domestic agriculture and forestry. The compensation rates have been increased substantially above the rates laid down in the 1991 law in order to enable operators of biomass installations to operate their installations cost-effectively, thereby initiating a dynamic development. Compensation rates differ in accordance with the electrical capacity of installations in order to give due account to the fact that power production costs of smaller decentralized installations are higher [3].

Renewable energy has an important role in reducing CO_2 emissions for increasing sustainability and fulfilling Kyoto commitments as a major Community policy objective. Apart from that, renewable energy sources are thinkable alternatives to fossil ones helping to improve the security of energy supply by reducing the dependence on imported energy sources. Renewable energy sources are a growing market contributing to European economic growth and job creation, and additionally EU-funded R&D projects contribute to decreasing costs and finding new technological solutions [1].

5. REFERENCES

[1] Alakangas, E. – Lensu, T.: Small-scale electricity generation from renewable energy sources (A glance at selected technologies, their market potential and future prospects), (2004) [online]. [citing 25.6.2007] Available on internet: <http://www.esv.or.at/esv/fileadmin/opet_res_e/VTT-OPET-Report13_RESe_final.pdf>

[2] Promotion of biomass energy, Overall summary, Background and objectives. (2004) [online]. [citing 25.6.2007] Available on internet: <http://www.iges.or.jp/APEIS/RISPO/p_report_2nd/15_3_4_2_promotion_of_biomass_energy.pdf>

[3] Maegaard, P.: Sensational German Renewable Energy Law and its Innovative Tariff Principles, Eurosun 2000 conference in Copenhagen, Denmark, (2000) [online]. [citing 25.6.2007] Available on internet: < http://www.folkecenter.dk/en/articles/EUROSUN2000-speech-PM.pdf>

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