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A NOVEL, HIGHLY EFFICIENT AND ENVIRONMENTALLY FRIENDLY PROCESS FOR COMBINED HEAT AND POWER PRODUCTION FROM BIOMASS

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EXTENDED ABSTRACT

A novel, highly efficient process for combined heat and power (CHP) production from biomass with negligible pollutant emissions has been developed. The process aims at the industrial usage of agricultural and forestry products and residues for energy production within the framework of sustainable development.

The process utilizes bioethanol, biogas and synthesis gas as intermediate energy carriers for the production of hydrogen that feeds fuel cells. Sources of biomass may vary but can include energy plants, grains, lignocellulosic materials and low or negative value by-products of agro-industries. Significant amounts of usable biomass are also present in urban refuse whose utilization will reduce demands on constrained disposal methods like landfills. Bio-ethanol is produced from these sources by direct fermentation of the available sugars or by saccharification and subsequent fermentation. Biogas is produced by anaerobic digestion of the remnants of the fermentation process and of all other “wet” biomass not suitable for fermentation to ethanol. Bio-ethanol and biogas are subsequently reformed in suitable reactors to produce a hydrogen rich stream. On a parallel route, biomass not suited for the above treatments is gasified to produce synthesis gas (mainly CO and H_2). Electrochemical oxidation of all hydrogen rich streams in a fuel cell using ambient air produces electricity and heat. Heat can be used either locally or remotely depending on local requirements and economics. Overall, except for electricity and heat, the process produces compost, water and CO_2. Since compost and CO_2 are used in plant cultivation, the process has an almost closed carbon cycle and nearly zero pollutant emissions.

The major advantage of the process is the utilization of a totally renewable and locally produced energy source: biomass. Utilization of biomass for energy production leads to new uses for farmlands, increases farmers’ income, supports local development, especially in remote areas such as islands, and promotes sustainable development while increasing energy security. It avoids all fossil fuels while maintaining maximum flexibility of electricity production close to demand locations via transport of a liquid fuel – bio-ethanol. Bio-ethanol is not toxic and would require only minimal changes in the existing fuel distribution infrastructure. It could also gain wider societal acceptance and face significantly less resistance to implementation in environmentally sensitive areas such as cities, islands, tourist locations or protected areas.

We present alternative process configurations, thermodynamic analysis, novel reactors and catalytic materials and discuss process yields and economics.

Key words: biomass, bioethanol, biogas, hydrogen, fuel cells, electricity, heat, CHP