Comparison of Biomass Energy Conversion Systems

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Abstract —This paper aims to analyze the performances and the economic feasibility of different arrangements of combined cycle (CCGT) power plants able to utilize biomass. In particular, the first CCGT arrangement includes a recovery boiler that is conveniently converted to a biomass post-combustion system. A second way is based on the co-firing of the syngas produced in a biomass gasifier. A third, hybrid configuration, includes a two output gasifier: a first gas stream is co-fired with the main fuel, while the second stream, characterized by low quality syngas, feeds a post combustor at the gas turbine outlet. Different hybrid configurations have been taken into account, depending on the high quality syngas proportion: 10%, 20% and 50%. Finally, a techno-economic analysis has been carried and the three plant arrangements analyzed have been compared with two reference plants: a standard CCGT and a typical direct biomass power plant. The plants have been modeled by using the commercial software Thermoflex®. The analysis has been conducted with the objective of determining the conversion rate of energy added by the biomass and the investment required for plant modifications. To this purpose, a new efficiency parameter has been introduced, defined as the ratio between additional electrical power output and heat power from biomass input. Then the kWh generation cost has been calculated taking into account both incremental capital and maintenance costs. Results show a reduction in energy production cost with the biomass conversion efficiency, except for the hybrid configuration, when it has a gasifier output less than 20% in high quality syngas. Although the thermodynamic result and the economic profitability are strongly related, as is evident in the co-fired system, an economic advantage can also be achieved in hybrid systems, despite their lower efficiency, as they can manage also a poor quality, less expensive biomass.

Keywords—*biomass, combined cycle*