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Techno-economic feasibility assessment of a biomass cogeneration plant based on an Organic Rankine Cycle

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Abstract— Biomass-fueled Organic Rankine Cycle power plants in a cogeneration topping layout have been operated in Central Europe since 2000. These plants are usually integrated into a district heating system and located near to the villages whose thermal and electric energy demands are to be covered. In this paper, a technical and economic feasibility assessment of this kind of plants is presented. The energy performance has been analyzed in different scenarios. Four different typical organic fluids (two silicone oils, toluene and isopentane), subcritical and supercritical cycles and the inclusion of a recuperator have been considered. Thermal and electric energy are sold to a nearby village at competitive market prices. Spanish market prices have been used as a reference. No subsidies have been considered in the case of electricity, so that the Spanish average power pool market price has been considered. The size of the plant, the cost of biomass and the annual operation schedule have been considered for the economical analysis. According to the technical analysis, hexamethyldisiloxane (HMDSO) in recuperative cycles has turned out to be the best choice in both the subcritical and the supercritical layouts, due to its favorable global behavior (harmfulness, reliability and efficiency). The economic assessment shows a lower profitability in the case of supercritical cycles because of the fact that the increase in electric efficiency implies a decrease in the amount of produced useful heat, which is the main source of cash inflow. The size of the plant can be established according to the cost of fuel in order to achieve a similar profitability (i.e. a 1 MWe plant fueled with biomass priced at 5.5 €/MWhth has a similar internal rate of return than a 2 MWe plant fueled with biomass priced at 15.5 €/MWhth). In order to obtain a 5% internal rate of return with subcritical recuperative plants, the annual operation time must be 2750 h in the case of a 2 MWe plant fueled with biomass priced at 5.5 €/MWhth and 5500 h in the case of a 1 MWe plant fueled with biomass priced at 15.5 €/MWhth.

Index Terms— ORC; Cogeneration with biomass; District heating; Silicon oils

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