Thermodynamic analysis of an integrated gasification solid oxide fuel cell plant combined with an organic Rankine cycle - DTU Orbit (02/01/2019)

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A 100 kWt hybrid plant consisting of gasification system, solid oxide fuel cells and organic Rankine cycle is presented. The nominal power is selected based on cultivation area requirement. For the considered output a land of around 0.5 km$^2$ needs to be utilized. Woodchips are introduced into a fixed bed gasification plant to produce syngas which fuels the combined solid oxide fuel cells and organic Rankine cycle system to produce electricity. More than a hundred fluids are considered as possible alternative for the organic cycle using non-ideal equations of state (or state-of-the-art equations of state). A genetic algorithm is employed to select the optimal working fluid and the maximum pressure for the bottoming cycle. Thermodynamic and physical properties, environmental impacts and hazard specifications are also considered in the screening process. The results suggest that efficiencies in the region of 54-56% can be achieved. The highest thermal efficiency (56.4%) is achieved with propylcyclohexane at 15.9 bar. A comparison with the available and future technologies for biomass to electricity conversion is carried out. It is shown that the proposed system presents twice the thermal efficiency achieved by simple and double stage organic Rankine cycle plants and around the same efficiency of a combined gasification, solid oxide fuel cells and micro gas turbine plant.

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