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POWER AND BIOMASS-TO-LIQUID (PBtL): HIGHER CARBON CONVERSION EFFICIENCY AND LOWER PRODUCTION COSTS FOR SECOND GENERATION BIOFUELS

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Abstract

In order to reduce greenhouse gas emissions in aviation and heavy cargo transportation, sustainable liquid energy carriers with high energy density are required. Usage of first generation biofuels like biodiesel or ethanol is discussed critically due to the available biomass potential and the competition for farmland. Hence, biofuels of the second generation were alternatively developed, which are made from residues, waste, CO2 rich off-gases and/or excess electricity. The concepts are well-known under the acronyms Biomass-to-Liquid (BtL) and Power-to-Liquid (PtL). A large number of BtL concepts rely on existing state-of-the-art technologies developed for coal gasification and processing. However, biomass gasification based BtL production pathways suffer from low hydrogen concentration in the syngas. At the German Aerospace Center (DLR), an advanced system design called Power and Biomass-to-Liquid (PBtL) has been proposed based on a combination of the BtL and PtL approach.

The PBtL concept combines entrained flow biomass gasification with reverse water-gas-shift reaction (rWGS), FT-synthesis and product separation and upgrading. Renewable hydrogen (from water electrolysis using renewable power) is added in the rWGS reactor to adjust the H_2/CO ratio before fuel synthesis. PBtL production pathways have been modeled in flowsheeting software and optimized in terms of carbon conversion, energy efficiency and fuel production costs. The technical and economic performance has been evaluated and compared with reference BtL and PtL concepts. The techno-economic assessment includes questions regarding investment costs, available biomass potential and electricity prices. Finally, a detailed sensitivity analysis was carried out to identify the most sensible cost factors.

As a result, a carbon conversion efficiency close to 98 % was realized. Fuel output was nearly quadrupled offering a more sustainable utilization of the available biomass potential. The power & biomass to fuel efficiency was estimated to be approximately 45 %. Thus, energetic performance of the designed PBtL system is significantly higher compared to common BtL concepts. Based on 2014 cost data, fuel production costs of 2.11 €/l were calculated. Therewith, PBtL promises fuel costs considerably lower compared to similar BtL and PtL plants. Sensitivity analysis indicates that production costs depends mainly on electricity prices, investment costs for the biomass gasifier, scale of plant and the availability of biomass.

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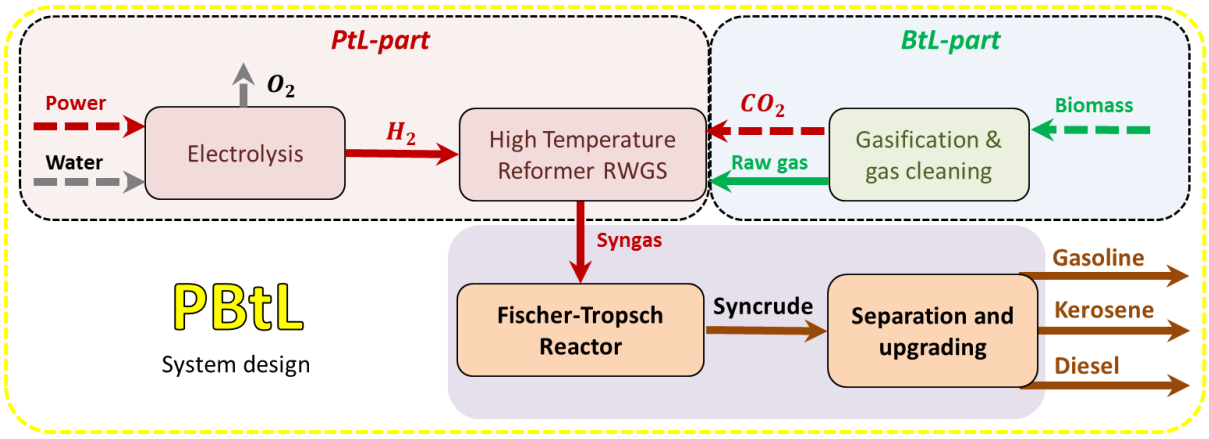

Figure 1: Schematic system design of the PBtL concept