Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

ERA-NET Bioenergy | IEA FORSCHUNGS KOOPERATION | FFG Forschung wirkt. | klima+ energie fonds

Highlights of Bioenergy Research 2020
January 24th, 2020, Messe Congress Graz, Austria

Abstract

BIO-CCHP: Advanced biomass CCHP based on gasification, SOFC and cooling machines – Solid oxide fuel cell performance with gases from biomass gasification

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Due to the climate change, there is a steadily growing demand for CO2 neutral supply of heat, power and, in the last years, additionally for cold. Combined heat and power (CHP) production by combustion of solid biomass, through steam cycles or organic Rankine processes (ORC), is already a consolidated technology. However, it offers low electrical efficiencies, even at large scales (in CHP operation, 25% can only be obtained for tens of MWth). Gasifiers coupled with gas engines increasingly replace steam turbine cycles as state-of-the-art systems for converting solid biomass to power because they provide higher electric efficiencies (about 25-30%), especially for small- to medium-scale plants. However, also in this case, the efficiency is limited by the thermodynamic cycle. Combined with high prices for biomass feedstocks, this reduces the attractiveness of electricity production from biomass.

Coupling gasifiers with high temperature solid oxide fuel cells (SOFCs) instead of gas engines would increase the electrical efficiency to values up to over 40%, in addition to providing high temperature heat and therefore increasing the attractiveness of power production from solid biomass. In the course of the transnational ERANET bioenergy project "Advanced biomass CCHP based on gasification, SOFC and cooling machines (BIO-CCHP)", a novel trigeneration system maximizing the electric efficiency (target: > 40%) and flexibility of the system with the aim to produce electricity, heat and cold (CCHP) is developed. This offers an optimal adaptation to the energy demands, increasing the operating hours at full load and including the production of cold, which is relevant due to its growing demand for air conditioning and industrial processes.

The maximum achievable power output of a SOFC used as an energy converter in such a CCHP system is strongly dependent on the cell design, operating conditions, main gas composition and impurity concentrations. Therefore, to identify favorable fuel gas compositions and cell operating conditions for an efficient coupling with gasifiers at low degradation risk and maximum performance yield is of major importance to ensure stability, reliability and durability of the systems used, thus increasing attractiveness of electricity production from biomass.

This work presents the results of a comprehensive analysis on (i) benefical cell designs for the coupling with biomass gasifiers, (ii) the influence of main biomass gasification product gas componentes H2, H2O, CO, CO2 and CH4 on the cell performance as well as (iii) the performance decreasing impact of H2S on commercially available cell designs. Moreover, a 500 h degradation stability test was conducted using the theoretically most promising gasifier product gas leading to no performance or anode degradation. Benefical gasification technologies, cell types and their H2S thresholds are presented.

More information about the event, photos and presentation slides are available for download: https://nachhaltigwirtschaften.at/en/iea/events/2020/20200124-highlights-bioenergy-research.php