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Anode fuel recirculation on solid oxide fuel cells (SOFCs) fueled with landfill gas

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Landfill gas, consisting of methane, carbon dioxide and nitrogen as well as impurities like sulfur, is formed over time from landfill, e.g. domestic waste. Only landfill gas with a high share of methane can be converted into electricity and heat by standard combustion engines. This is a challenge as the methane content is declining over time. Solid oxide fuels cells (SOFCs) are an option for a highly efficient transformation of landfill gas with a low heating value into electricity and heat.

For a stable operation of the SOFC the prevention of degradation caused by carbon formation is of great importance. For avoiding carbon formation, a reforming agent like steam or carbon dioxide is needed. A certain amount of the needed reforming agent can be covered by the carbon dioxide present in the landfill gas. The idea is to obtain the remaining part from recirculating a certain amount of the anode exhaust gas, which contains steam and carbon dioxide. This has the advantage that an external reforming agent source is only needed for the initial phase, but not for the continuous operation.

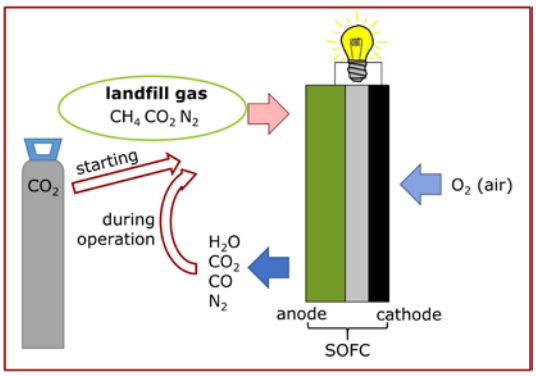

Figure 1: Principle of anode fuel recirculation for landfill gas fueled SOFCs.

The presented work consists of two parts. In the first part a semi 1D model was developed to find suitable operation conditions for landfill gas fueled SOFCs, using fuel recirculation to avoid carbon formation. In the second part different anode fuel recirculation rates were tested based on the results of the first part of the study. For this purpose a planar 16 cm^2 cell was operated at 750 ˚C, fueled with pre-mixed and real landfill gas from one of the largest Danish landfill sites in Odense.

The theoretical analysis showed that the recirculation rate has to be proportional to the amount of methane present in the landfill gas to ensure an avoidance of carbon formation. A SOFC cell fueled with real landfill gas and an anode fuel recirculation rate of 30% was successfully operated for around 150 hours. It was observed that the electric efficiency could be increased by around 4-5% using fuel recirculation instead of extra carbon dioxide as a reforming agent.