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Study Review: Scalable stand-alone Direct Air Capture System using Zeolites

For the production of greenhouse gas-neutral synthetic hydrocarbons, the question of the carbon source must be considered. Therefore the need of building an infrastructure providing a sustainable carbon feedstock, e. g. for the industrial and transport sectors (aviation, shipping) occur. DAC systems should be part of a decentralised carbon infrastructure, not necessarily having access to waste heat or other thermal sources. Consequently, a system should be developed that can be operated with up to 100 % renewable electrical energy. Doing so supports the idea of a liberal carbon market, as the CO_2 is not exclusively generated for a specific purpose or location, but can also be used for example in DACCS (Direct Air Carbon Capture and Storage) to address global carbon dioxide removal. Furthermore, the scalability of a system was taken into account, with the design size being based on the requirements of a PtL demonstration plant (65,000 tonnes CO_2 per year), which the PtX Lab Lausitz has been commissioned to build by the german federal government.

Based on the example of a DAC process developed jointly with the Fraunhofer IEG, the thermodynamic behaviour of a zeolite adsorption process is evaluated and its suitability for an industrial PtL production process is investigated. The physical properties as well as the process engineering challenges associated with their use are presented. Various zeolites and alternating adsorption processes (pressure swing, temperature swing, and moisture swing adsorption) were investigated based on literature data followed by modelling a preferred variant. A two-stage moisture swing adsorption model with a heat pump system as the heat supplier was developed in order to fulfil the site-specific independence from an external heat source. Based on this model, initial estimates were made of the costs associated with the energy input, allowing a qualitative comparison with other systems available on the market.