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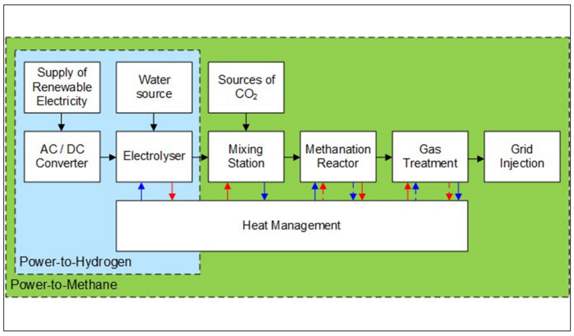
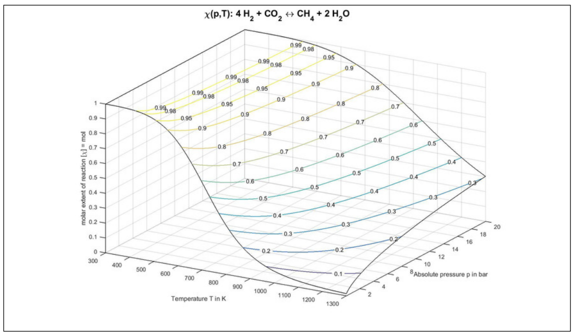
Subject Area	Energy and Environment

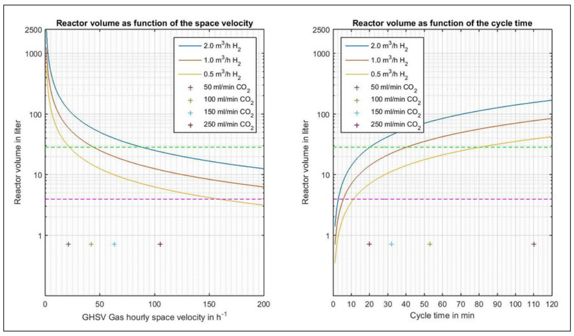
Thermodynamic modelling/concept:adsorption methanation reactor in a power-to-methane plant



System boundary, Concept of a Power-to-Methane plant



The equilibrium surface of methane synthesis



Geometric reactor volume as function of GHSV and cycle time.

Introduction: In order to enable sustainable energy supply today and in the future, a rethinking of energy utilisation must take place. This rethinking does not necessarily necessitate the use of new technologies but, rather the application of innovative concepts. Power-to-Methane is one of the promising innovative concepts. Power-to-Methane is the production of synthetic methane based on the Sabatier process. Chemists Paul Sabatier and Jean Baptiste Senderens discovered this process in 1902. The IET Institute for Energy Technology is engaged in applied research in the field of Power-to-Gas technologies. The latest Power-to-Gas project at IET, is called 'High Efficiency Power-to-Gas Pilot' (HEPP). Within the scope of this project, a newly developed methanation catalyst (sorption enhanced catalyst) should be integrated and tested in the HEPP plant. This catalyst allows a carbon dioxide conversion of 100 %. The water vapour, which is a by-product of the methanation reaction, is adsorbed in the catalyst bed. Due to water adsorption, the methane gas is completely dry at the reactor outlet. This master thesis elaborates the knowledge for the integration of the new methanation catalyst into the HEPP plant. EMPA and ZHAW are project partners of the HEPP project and have over the past few years, cooperated in the development of the sorption enhanced methanation catalyst.

Procedure / Result: The novelty of this catalyst is the supporting material, which consists of a molecular sieves (zeolite 5A). The zeolite fulfils the tasks of carrying the catalyst (Nickel) and absorbs the water vapour produced in the reaction. The sorption enhanced catalyst works in two alternating modes: adsorption and desorption. In adsorption mode, following conditions are recommended: temperature around 300 °C, atmospheric pressure and slow space velocities. At 300 °C the adsorption capacity of the catalyst is 6.7 g water per kg catalyst. A special characteristic of the catalyst is the formation of a reaction front, during the adsorption. The reaction front runs through the reactor (moving hotspot). Behind the reaction front, the molecular sieve is saturated with water. When the entire catalyst bed is saturated, the adsorption process is completed and the desorption process begins. The desorption process is the time-determining step, because it is diffusion-controlled and hence slow. The most promising action to reduce desorption-time, is to flow methane through the reactor. For the integration of sorption catalysts in to the HEPP-plant, a concept with alternating two reactors was developed. Gas flow rate in the reactors in adsorption and in desorption mode can be set individually. Power-to-Methane plants with sorption enhanced methanation reactors allow high flexibility, as these can be operated dynamically.