Depletion of oil and increased emissions of CO₂ are two major concerns in today's society, but there is, fortunately, also an increased interest in energy production from renewable sources, such as wind and solar. A drawback with these sources is their intermittent energy production, which can lead to periods where there is a deficit in electrical energy, but also to periods with excess energy. A process that combines the use of excess energy for production of CO₂-neutral synthetic fuels, such as hydrocarbons and alcohols, is an attractive way to improve and balance the intermittency in such an energy system. The produced fuel can be used either directly for transportation or for production of electricity in periods where there is a deficit in electricity from the renewable sources.

Electrolysis is a well-known technique, among other things used for hydrogen production, but could also be of interest for synthesis of hydrocarbons and alcohols. The aim of this study was to make use of knowledge from existing electrolysis techniques in order to develop an electrolysis technique that can produce hydrocarbons and alcohols by a single-step process using CO₂ and steam (and/or hydrogen) as reactants. The operating temperature should preferably be between 200 - 300 °C, because many hydrocarbons are stable at these temperatures. More precisely, the main focus was to evaluate the feasibility of both known and novel electrolyte materials as well as development and characterization of electrodes and full cells. The electrochemical performance of the fabricated cells was evaluated using electrochemical impedance spectroscopy, cyclic sweep measurements and chronopotentiometry.

The initial part of the study focused on electrolyte materials in order to find a promising candidate to be implemented in the full cells. Ten different phosphor-based electrolyte materials were evaluated, these materials can roughly be divided into three classes of materials: pyrophosphates, orthophosphates and solid acids. Among all tested materials was CsH₂PO₄ found to be the most promising candidate. CsH₂PO₄ exhibit a conductivity of 20 mS·cm⁻¹ at 240 °C. Several different cells with different platinum-based anodes and copper-based cathodes were fabricated and tested both as full cells and individual electrodes. The best cell type had an average resistance of 3.7 ± 0.7 Ω·cm² at an applied cell voltage of 1.5 V. The electrode resistance was 1.1 ± 0.1 Ω·cm². These measurements were performed in a single atmosphere setup (20% H₂O + 5% H₂ + 20% CO₂ + 5% N₂). One initial test using a high pressure test setup which allowed for separate gas compositions at the two electrodes was conducted at pressures from 1 up to 40 bars, using a variety of gases and gas flows at the two electrodes. This test showed that the measured current density at a given applied cell voltage was dependent on both pressure and pH₂ at the Pt-electrode, but not significantly dependent on the CO₂ flow rate at the cathode.

The main conclusion is that no evidence for electrochemical reduction of CO₂ has been found using the Cu-based cathodes that were developed in this study. Although, there is still a chance that CO₂ was reduced via heterogeneous catalysis in the cathode compartment, especially at elevated pressures. It could also be that electrochemical reduction of CO₂ using this cell concept is possible if the cells are modified in order to inhibit hydrogen evolution or to allow for operation at a more negative cathode overvoltage without rapid degradation.