Overview of CO₂ conversion R&D in Europe

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Introduction

Many different activities related to CO$_2$ conversion takes place in Europe

Examples:

- Search for better electrolytes
- Search for better electrocatalysts/electrodes
- Search for improved and less expensive interconnects and other cell stack components
- Development of less expensive BOP
- Demonstration of efficient and inexpensive capture devices, electrolysers and full systems for green fuel production.
Some European actors in electrolysis and CO$_2$ conversion

It is not possible to include everyone – too long a list

**Britain:**
Electrolysis: University of St. Andrews; Imperial College; Sheffield University (also CO$_2$ capture); all research in SOEC incl. proton conducting ceramic electrolytes.

**Denmark:**
Electrolysis: Haldor Topsøe A/S/Topsoe Fuel Cell A/S - development and demonstration of SOEC/power to fuel – 40 kW; Technical University of Denmark – research and development of SOEC and advanced alkaline (250 °C, 40 bar) and of “classical” alkaline electrolysis; IRD and Aalborg U. – PEMEC

**France:**
Electrolysis: CEA (SOEC, Alkaline, PEM). Methanation of CO$_2$
European actors in electrolysis and CO₂ conversion

**Norway:**
University of Trondheim; University of Oslo;

**Germany:**
Electrolysis: EIfER; FZ-Jülich; KIT; Fraunhofer-Institute for Ceramic Technology, IKTS Dresden, all SOEC for CO₂ and H₂O electrolysis.

Demo of power to gas: Audi

**All Europe**
Research in catalytic conversion of CO₂ and syngas takes place in many universities and some companies.

It is everything from DFT calculations to development of commercial products. I do certainly not have an overview of all this
Electolyser status

Typical ranges polarization ranges for state-of-the-art water electrolysis cells. \( E_{th,\text{water}} \) and \( E_{th,\text{steam}} \) are the thermoneutral voltages. \( E_{rev} \) is the reversible voltage at standard state.

i - V curves for a Ni-YSZ-supported Ni/YSZ/LSM SOC: electrolyzer (negative current density) and fuel cell (positive current density) at different temperatures and steam or CO$_2$ partial pressures - balance is H$_2$ or CO.  
Advanced DTU SOEC type

Degradation rate ca. 1%/kh
H$_2$ production – cost estimation

* Conversion of H$_2$ to equivalent crude oil price is on a pure energy content (J/kg) basis

Green fuel will probably 2 – 3 times more expensive – further processing

Demonstration of full systems for green fuel production

• Climeworks AG and Audi has agreed to make one. http://audi-encounter.com/magazine/technology/01-2014/104-aus-der-luft-gegriffen

• Audi has built a methane (CH$_4$) synthetic natural gas production plant in Werite, Emsland in Germany

• It is in the commissioning phase

• H$_2$ is produced by conventional electrolysis and used for methanation of CO$_2$. The Audi plant is expected to produce roughly 1,000 metric ton of CH$_4$ per year, binding 2,800 ton of CO$_2$

• Climeworks has been developing a air capture devise; the first goal is collection of 1,000 ton CO$_2$ per year
Climeworks AG air capture device

1 Valve
2 Air intake blowers
3 Adsorption chamber
4 Air evacuation blowers
5 Heating
6 Heating control unit
Thank you for your attention