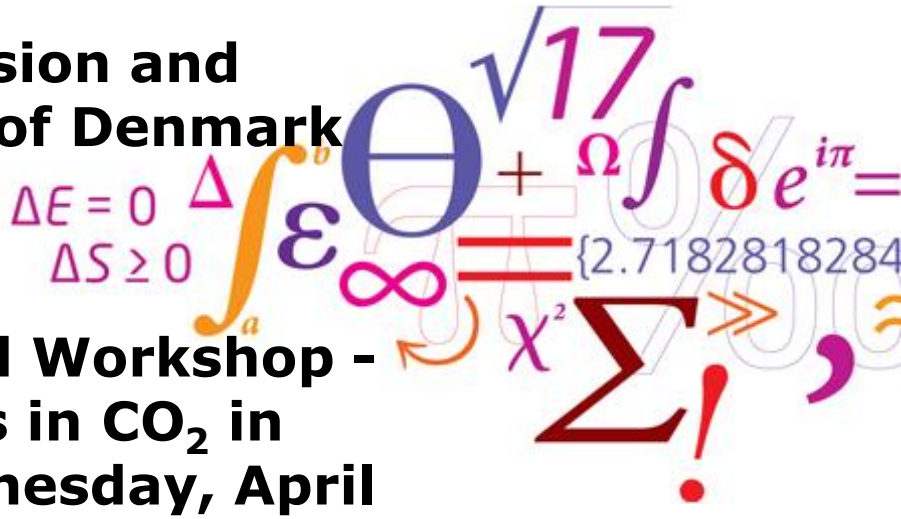
Overview of CO_2 conversion R&D in Europe

Mogens B. Mogensen

Department of Energy Conversion and Storage, Technical University of Denmark



RCN CCUS Annual Meeting and Workshop - Current Status and Challenges in CO_2 in Capture and Conversion, Wednesday, April 16: 9:00-12:00 pm

DTU Energy Conversion
Department of Energy Conversion and Storage

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 CO_2 conversion

Norway:

University of Trondheim; University of Oslo;

Germany:

Electrolysis: EIfER; FZ-Jülich; KIT; Fraunhofer-Institute for Ceramic Technology, IKTS Dresden, all SOEC for CO_2 and H_2O electrolysis.

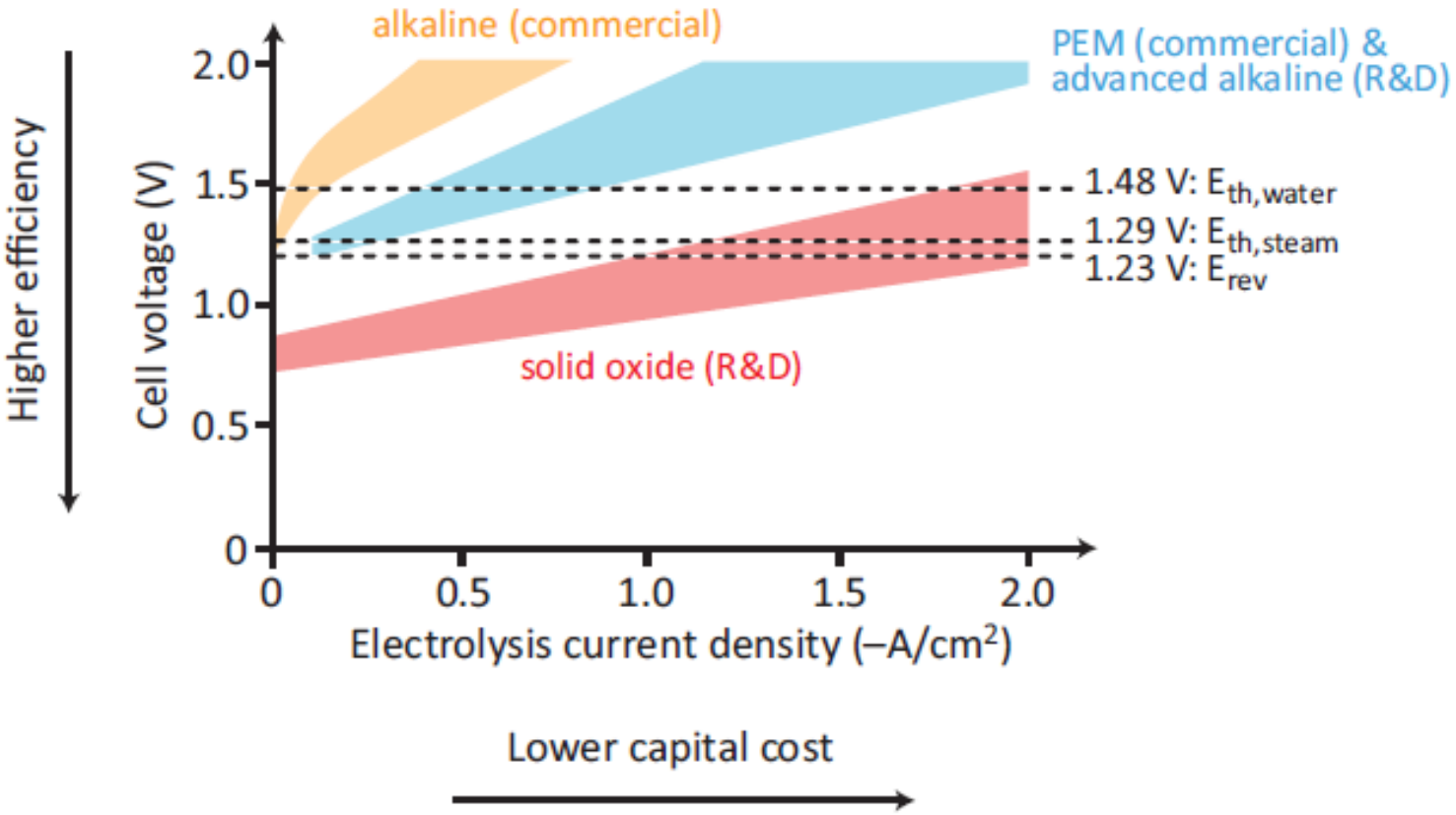
Demo of power to gas: Audi

All Europe

Research in catalytic conversion of CO_2 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

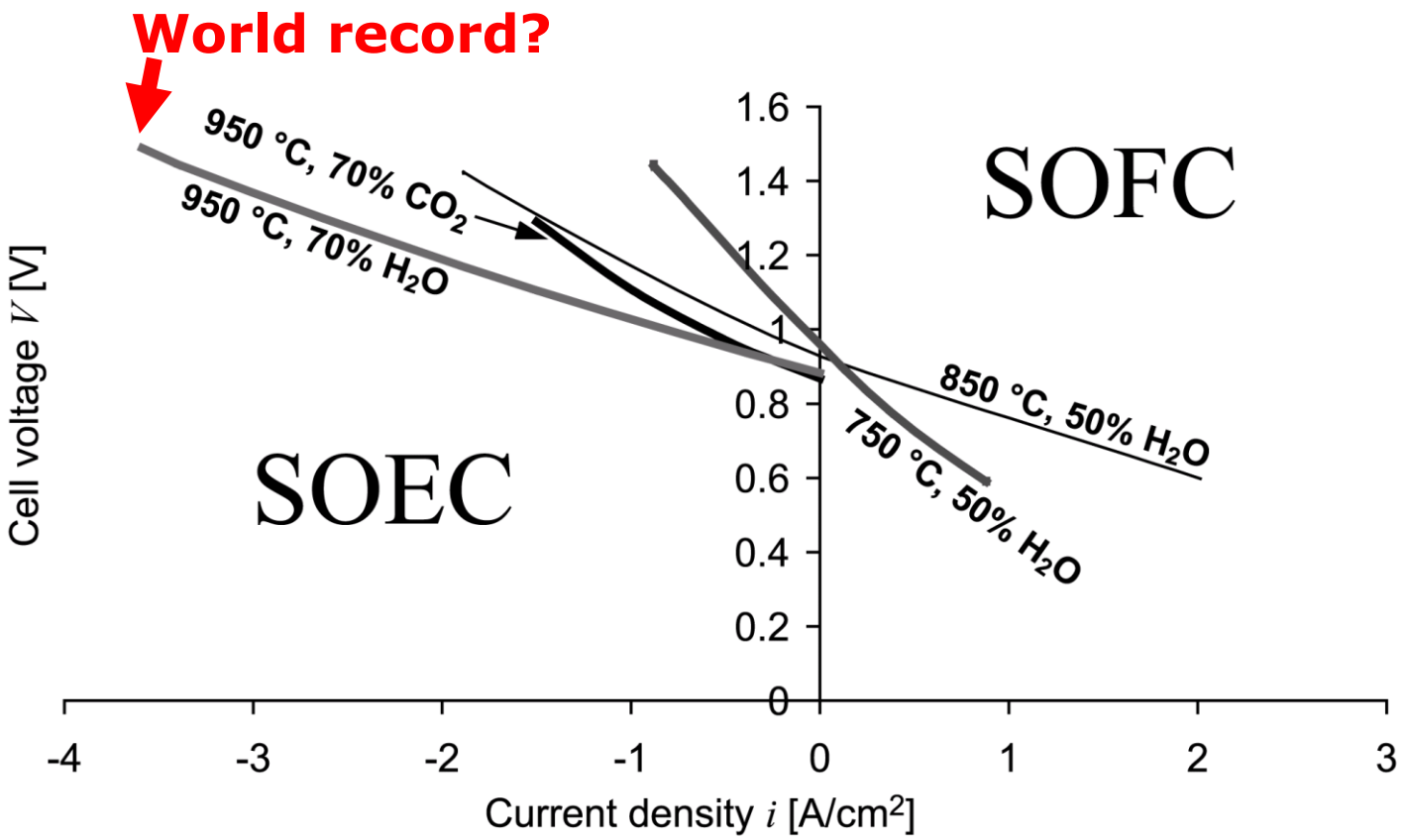
Electrolyser status



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

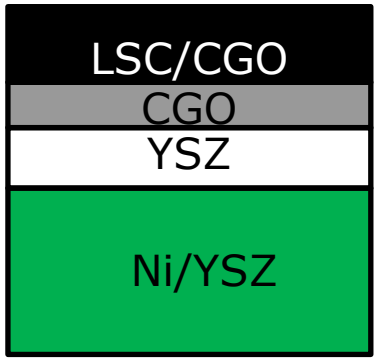
C. Graves, S. D. Ebbesen, M. Mogensen, K. S. Lackner, *Renew. Sustain. Energy Rev.*, 15 (2011) 1–23

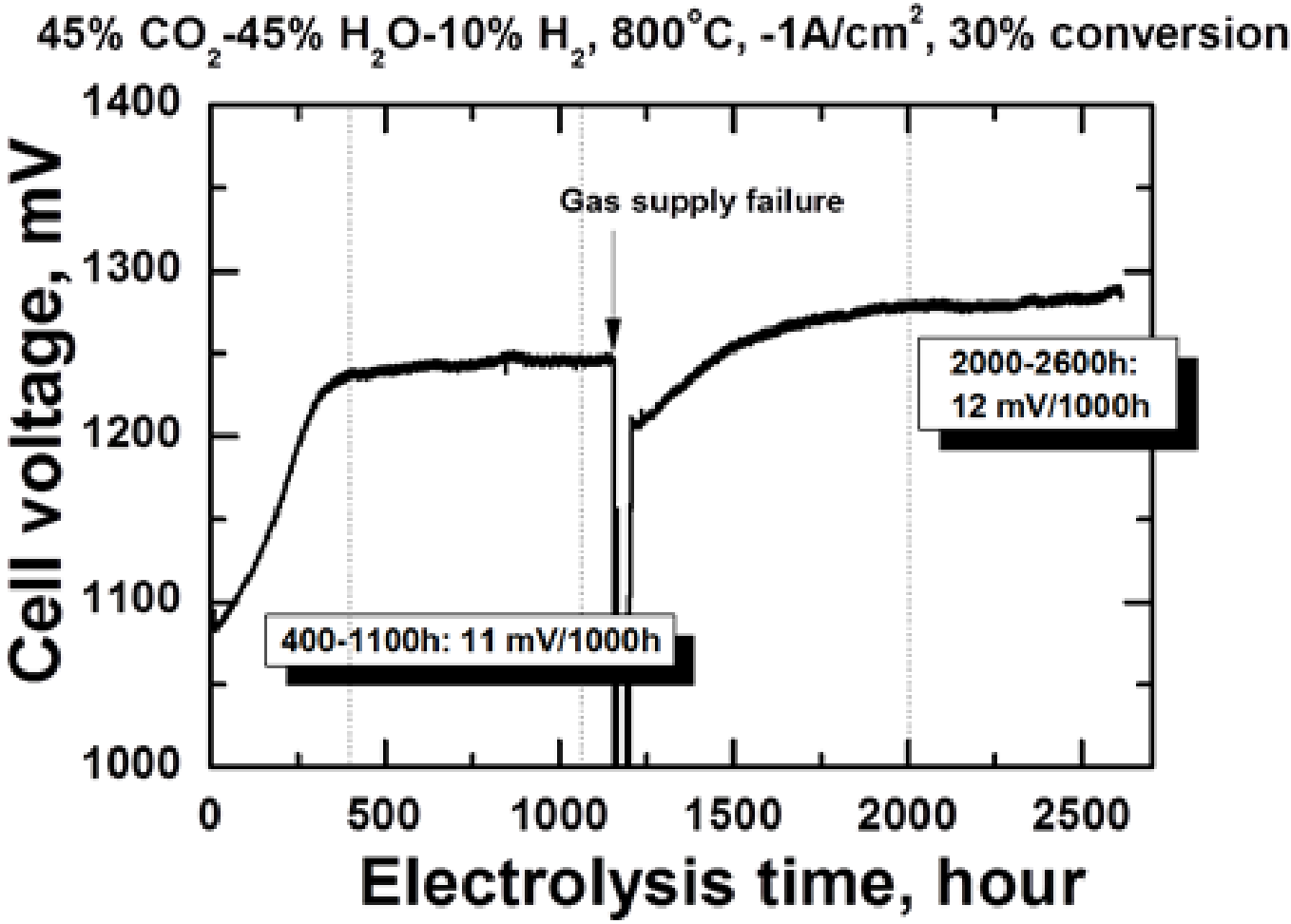
SOEC Cell performance



***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.**
S.H. Jensen, P.H. Larsen, *Internat. J. Hydrogen Energy*, 32 (2007) 3253

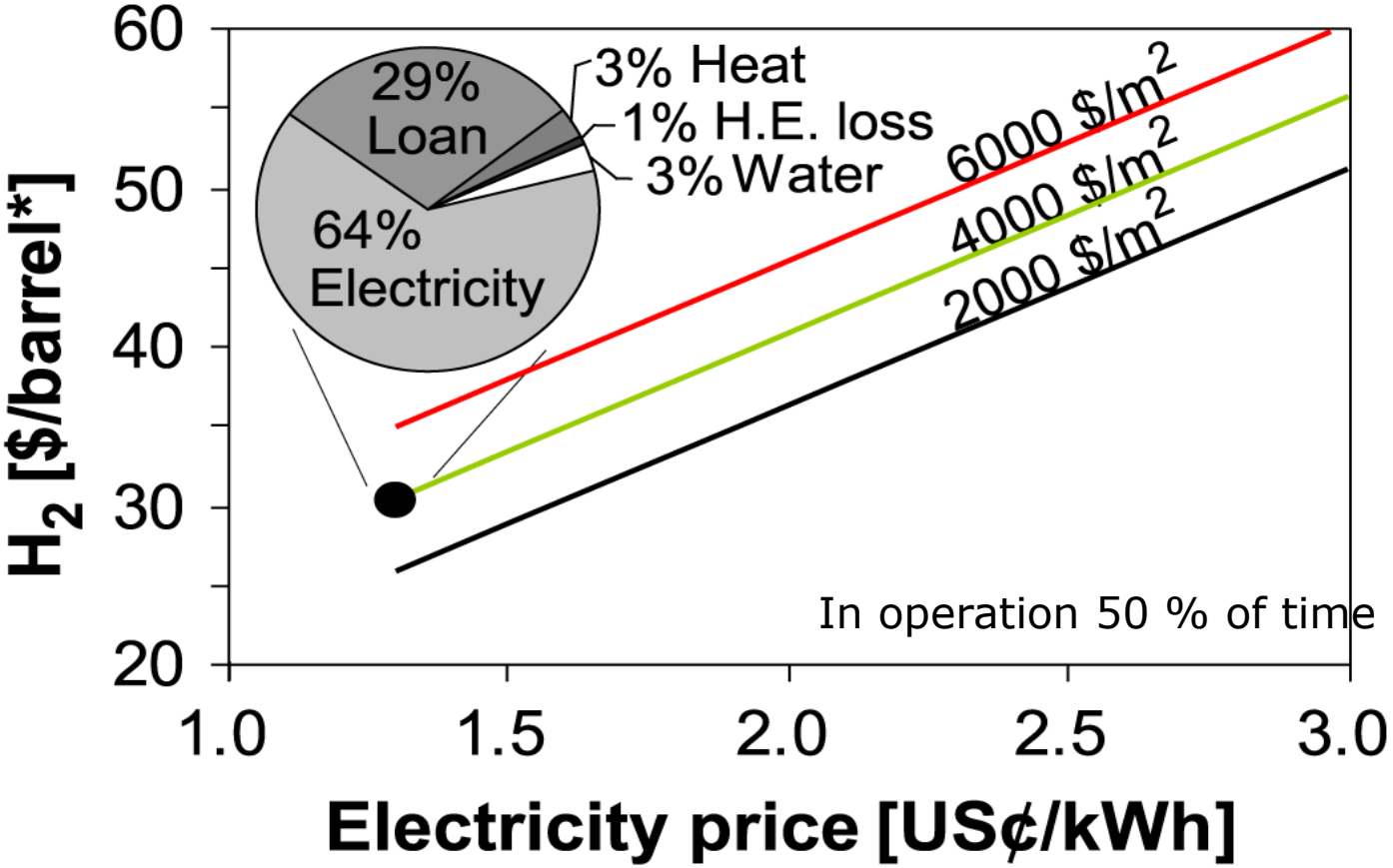
Advanced DTU SOEC type





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

S.H. Jensen, P.H. Larsen, M. Mogensen *Internat. J. Hydrogen Energy*, 32 (2007) 3253

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