PEM Electrolysis: Research on Cost Reduction and System Durability

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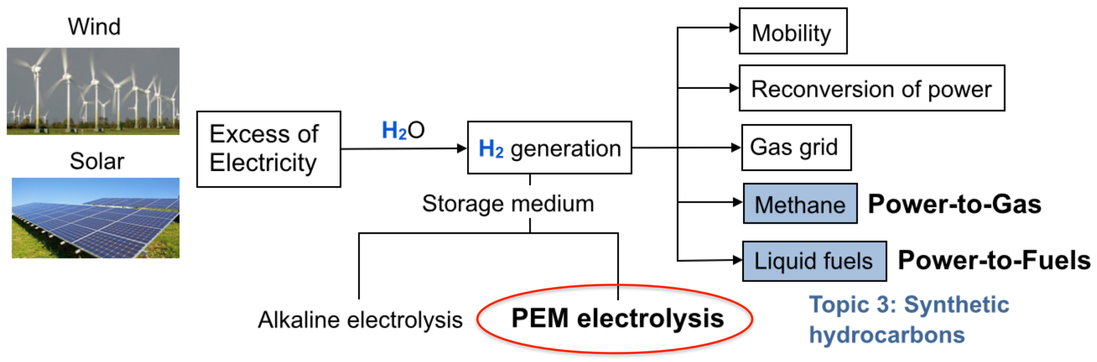
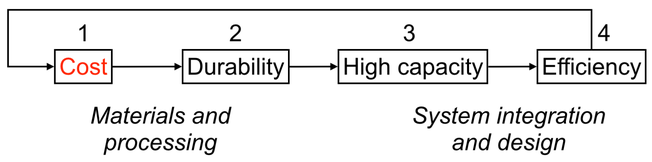
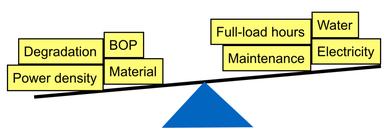
Motivation

Hydrogen as a storage medium for renewables



PEM electrolysis is the platform for large scale H_2 production from renewable energy thanks to its rapid response under dynamic operation and high specific energy density

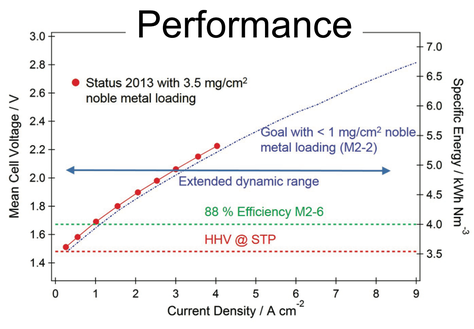


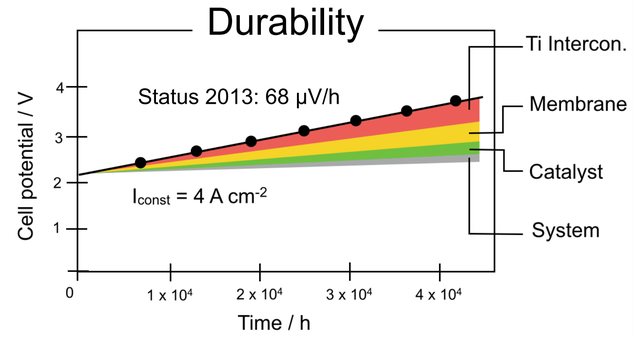


Objectives

	2013	2018
Degradation @ 4 A/cm²	68 µV/h (1400 h)	< 15 µV/h (>20,000 h)
Life time	10,000 h	> 40,000 h
CCM catalyst loading	3.5 mg/cm²	< 0.4 mg/cm²
CCM ohmic resistance	200 mΩ cm²	< 100 mΩ cm²
Stack base material	Titanium	Stainless steel
Efficiency @ 1 A/cm²	4.2 kWh/Nm³	< 4 kWh/Nm³
Dynamic range	0.3 – 4 A/cm²	0.3 – 9 A/cm²

Main priorities for the large scale H_2 production are not efficiency but high capacity, long lifetime and cost reduction





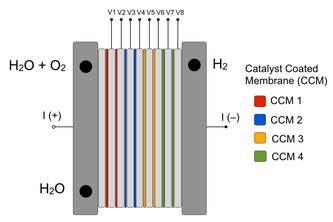
Approach

System

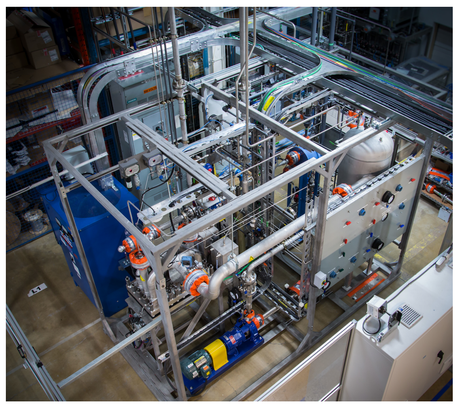
Degradation analysis with segmented cell and test units systems

20 kW_{el} test station

Individual potentials



25-50 kW_{el} test station



Heat exchange:

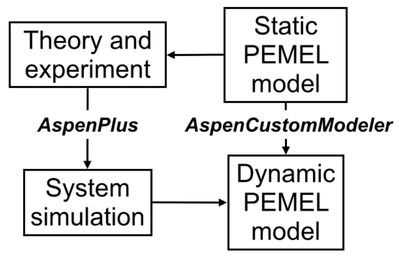
$$\langle C_p \rangle \frac{dT}{dt} = \left(\frac{dQ_{gen}}{dt}\right) - \left(\frac{dQ_{loss}}{dt}\right) - \left(\frac{dQ_{cool}}{dt}\right)$$

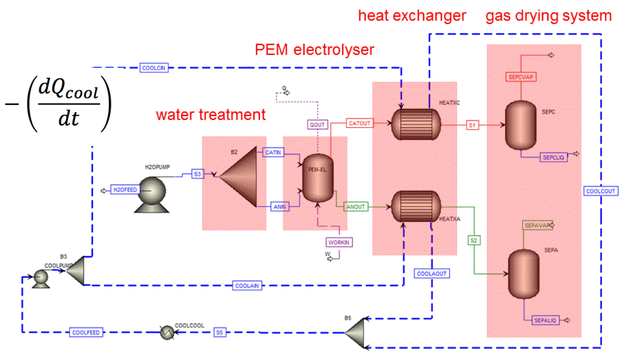
Stack voltage:

$$E(T) = E_0(T) + \frac{RT}{2\alpha_A(T)F}\ln\frac{J}{J_{A,ref}} - \frac{RT}{2\alpha_C(T)F}\ln\frac{J}{J_{C,ref}} + R_{MEM}(T)J$$

Modelling

Assessment of degradation issues through modelling





Corrosion protection

Dense coatings of Ti or low cost electro-ceramics for corrosion protection of stainless steel bipolar plates

Vacuum thermal spraying facility (coatings on surfaces > 2 m^2)

Catalysts

R&D of cost effective catalyst with reduced PMG content, meeting the following requirements:

Activity	> 6.6 A/g
Durability	< 21% ad*
Cost	< 100 €/g
Availability	> 1 g/day

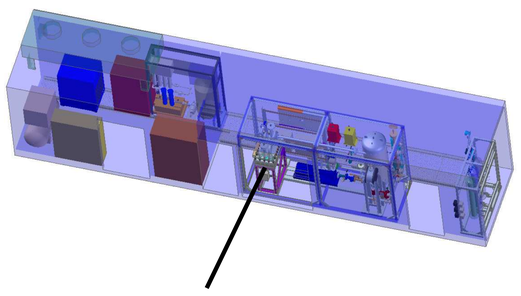
*ad: activity decay under dynamic operation

Characterisation techniques such as XRD, SEM, XPS and RDE are being used. CCMs with novel catalysts are tested in the 20 kW_{el} test station

Results

System

Electrolyser container for gas station in Stuttgart (expected mid 2014)

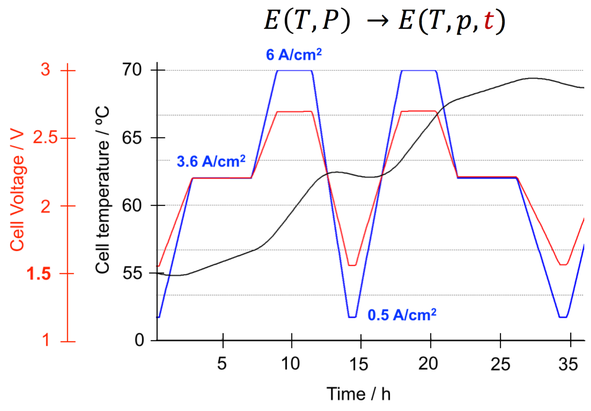


25-50 kW_{el} PEM electrolyser

Modelling

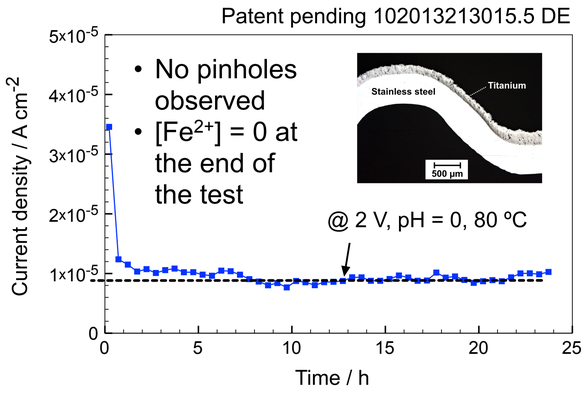
An accelerated stress test (AST) protocol has been conceived based on wind energy input

$$E(T,P) \rightarrow E(T,p,t)$$



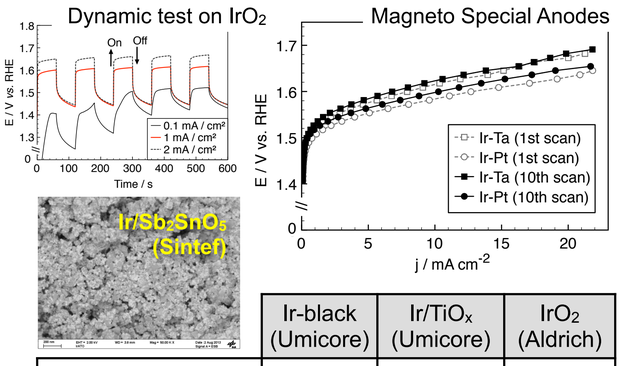
Corrosion protection

Developed thermal spraying Ti coatings protect the stainless steel substrate from corrosion



Catalysts

State of the art catalysts have been screened in simulated environment



	Ir-black (Umicore)	Ir/TiO_x (Umicore)	IrO_2 (Aldrich)
Activity (A/g)	6.6	1.3	2.7
Durability (% ad*)	21	43	47

Collaboration:

HYDROGENICS Advanced Hydrogen Solutions · SolviCore Fuel Cell Technologies · e·on · Fraunhofer ISE · DLR · HELMHOLTZ ASSOCIATION