Siemens Electrolyzer Technology for Large-Scale Hydrogen Production

Manfred F. Waidhas
Siemens AG
D-91050 Erlangen
Siemens started very early with the development of electric vehicles and electrochemical energy conversion ….
Why does Siemens invest in Hydrogen?

- Increasing price volatility in power markets due to fluctuations

- Siemens is solution provider for the energy market. Energy storage is considered as key issue.

- Siemens expertise in electro-chemical energy conversion ranges back to early 1960s

- Siemens established in Oct 2010 the business unit `Hydrogen Electrolyzer´
Large Scale Energy Storage
Options to address `grid storage´ are limited

segmentation of large-scale (electrical) energy storage

- Battery storage applications are limited in the hour range
- Energy storage >100 MW can only be addressed by Pumped Hydro, Compressed Air (CAES) and Hydrogen
- The potential to extend pumped hydro capacities is very limited
- CAES has limitations in operational flexibility and capacity

Hydrogen is the only option to cover energy capacities > 10 GWh
Photovoltaics require highly dynamic storage
PV is predicted to get ahead of wind power

electricity production of a 300 kWp PV-installation (near Erlangen, Germany)

- photovoltaic power generation better follows the daytime power demand than wind power
- most crucial in PV is the very high local dynamic of power generation
- dena expects that PV installations will more than double to 38 GW by 2015 !!!
- In addition to a certain storage capacity storage for PV should be capable to buffer extreme dynamic behavior
Electrolyzer Development @ Siemens
The Focus clearly lies on PEM-Technology

PEM Electrolyzer Technology
- Range of regulation
- Application of dynamic load changes
- Stability against differential pressure
- Investment costs today
- Investment costs projected
- Environmental friendliness
- OPEX
- Maturity

emerging technology
capable to operate under fluctuating conditions of renewable energies

Roadmap: Electrolyzer Portfolio
- 20 --> 20,000 Nm³/hr H₂
- 100 kW --> 100 MW
- Gen II 10 - 100 MW
- Gen I 1 – 10 MW
- Demonstrators 0.1 - 0.5 MW

© Siemens AG 2011. All rights reserved
PEM Electrolyzers @ Siemens
100 kW Demonstrator

key statements:

- rated power of the system is 100 kW, peak power 300 kW (electrical input)
- H₂ and O₂ are produced at an outlet pressure of 50 bars
- The container is an „self-sustaining“ system. Power supply as well as water purification are onboard
- the 100 KW-demonstrator will be delivered 2012 to RWE in the context of the BMBF-funded project CO2RRECT (lead: Bayer)

first units of highly dynamic Siemens-Electrolyzers will be available in 2012.
There is no relevant deviation between requested and measured load.
Hydrogen as multi-fuel
Conversion of electrical into chemical power

<table>
<thead>
<tr>
<th>Power Generation</th>
<th>Conversion In / Out</th>
<th>Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fossile/Nuclear</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Conversion In / Out**
- **Intermittent generation**
- **Steady generation**
- **Direct utilization w/o storage**

**Utilization**
- **Mobility (H₂-Fuel)**
- **Energy (Re-Electrification)**
- **Industry (H₂-Utilization)**

**H₂ drives the convergence between energy & industry markets**
The BMBF Project “CO₂RRECT“ – The utilization of CO₂

Siemens is providing the electrolyzer
The BMBF Project “CO₂RRECT“ developing new methods of utilizing carbon dioxide using renewable energies

RWE

- Power Generation
- Optimizing the utilization of fluctuating energy
- Load dynamic requirements
- Estimation of long term stability

RWE power plant side: Niederaußem

Siemens

- Hydrogen Electrolysis

Joint evaluation:
- Overall concept
- Integration of Electrolysis in a chemistry plant structure

Bayer

- CO₂ Utilization
- Carbon Chemistry

Material characterization for an electrolysis concept with operation Temperature >100°C

Universities

- Catalysts, reactor concepts, storage options

1 CO₂- Reaction using Regenerative Energies and Catalytic Technologies
PEM Electrolyzers @ Siemens

Status

- Siemens started its PEM electrolyzer development in 1998
- Siemens’ reference list in electrolyzer technology:
  - continuous lab operation > 40,000 h
  - 10y field operation (prototype)
  - 100 bar prototype
  - 40y electrode know-how
  - 50+y experience in heavy duty rectifiers
- Complete solution in one hand
  - heavy duty rectifiers (up to 70,000 A)
  - transformers
  - control units
  - grid connection
  - gas turbines

100 kW demonstrator, eg. to be delivered into the CO2RECT Project (BMBF)

Heavy duty rectifier SIPOREC
We cannot promise you a future like a US startup company did…..

Source: http://www.drivewithwaterfuel.com/?hop=wealthprom

Would You Like To Know How You Can Easily Convert Your Car To Run On Water and Gas Today To Double Your Gas Mileage and Save Thousands Of Dollars On Fuel Costs?

…. but we believe that green hydrogen from grid excess is the enabler for fuel cell mobility.

…..
• Energy storage is key for a sustainable and CO₂-
  minimized energy scenario

• Hydrogen is the only viable option to store energy
  quantities > 10 GWh

• PEM electrolyzers are very robust and extremely
dynamic. They can follow volatile wind and solar power

• Siemens is addressing the demand in energy, industry
  and mobility by developing high capacity PEM-
electrolyzers

• Green hydrogen from grid excess will be the enabler for
  fuel cell mobility.
Hydrogen Solutions @ Siemens

I IS IN HE

Industry Sector
Industry Solutions Division
Industrial Technologies
Hydrogen Electrolyzer

Contact:
Dr. Manfred Waidhas
+49-9131-7 21406
Head of Business Development
Hydrogen Electrolyzer
mailto:manfred.waidhas@siemens.com

Roland Käppner
+49-9131-7 22847
VP & General Manager
Hydrogen Electrolyzer
mailto:roland.kaeppner@siemens.com