Brennstoffzellen und Wasserstoff in der Energieversorgung – Technisch-Industrieller Einsatz

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Hydrogenics GmbH, Gladbeck, Germany
Key Facts about Hydrogenics

- Leading manufacturer of electrolysers and fuel cells
- Listed on NASDAQ (HYGS) and TSX (HYG)
- Headquartered in Canada with European facilities in Germany and Belgium
- Offices in China, India, Russia, USA
Lines of Business

Onsite Generation
Water Electrolyzers

Power Systems
Power Modules

Industrial Hydrogen  Hydrogen Fueling  Stationary Power  Mobility Power

Energy Storage
Load Control, Smart Grid and Power to Gas
P2X – Hydrogen – Cross Sector bridgeing link

POWER GRID

Power-to-Hydrogen

Electrolysis $\rightarrow$ $\text{H}_2$ storage (optional)

Power-to-Gas

Methanation $\rightarrow$ Blending

Power-to-Power

Wind turbine
Solar PV
Gas turbines
Fuel cells
CHP

Power-to-Fuels

Power-to-Industry

Industry
Ammonia
Speciality chemicals

Power-to-Mobility

Hydrogen Vehicles (FCEV)

GAS GRID

Hydrogen network
Power network
Gas network
Liquid fuels network
Targets of the German Federal Government

Renewable Energy Targets Act (EEG)

The purpose of this Act is to facilitate a sustainable development of energy supply,… and to promote the further development of technologies for the generation of electricity from renewable energy sources.

…increase the share of renewable energy sources in electricity supply to

- 2020: 40%
- 2030: 55%
- 2040: 70%
- 2050: 80-95%

1Energiekonzept vom 28. Sept 2010
Daten zur Umwelt zeigen: Verkehr beim Klimaschutz noch nicht auf Kurs
Flüsse und Bäche nur zu zehn Prozent in „ökologisch gutem Zustand“ – Trinkwasser fast überall sehr gut


Quelle:
http://www.umweltbundesamt.de/presse/pressemitteilungen/daten-zur-umwelt-zeigen-verkehr-beim-klimaschutz
Global Hydrogen Market

INDUSTRY: protecting atmosphere (H₂/N₂), hardening of metals
- Float glass
- Metallurgy
- Semi-conductors

CHEMISTRY & REFINERIES: C, H, O, Ammonia
- Fertilizers
- Refineries

OTHERS: cooling agent, hardening of oil, power generation, mobility
- Electrical power plants
- Food industry
- FCEV

Production

Storage / Transport / Distribution

End-use (global market in 2010: +/- 43 Mtons)

NB: 5% is merchant hydrogen (free market), onsite production represents 95%
Hydrogenics Product Philosophy: Simple and Modular
What is special about Hydrogenics‘ products?

a practical analogous example to engines

a stack

Hydrogenics‘ HyPM™ Power Module
Where would you start when you were to design an application based on fuel cells?

Here?

Or here?

Or even here?

…operating a fuel cell properly is like balancing a pencil on your finger tip…

…innovative fuel cell system design should „balance the pencil“ automatically for you…
Small puzzle pieces - Some History about Fuel Cell Systems

**FC Stack Subsystems**
- MEA (Membrane Electrolyte Assembly)
- Flowfield Plate
- End Plate

**Fuel Cell BOP Subsystems**
- Coolant Pump
- Air Flow Meter
- Controls
- Air Filter
- Humidifier
- Air delivery
- Fuel delivery
- Inertization
- Electric heaters for freeze protection

Lots of engineering, tubing, sensors, regulators, wiring AND experience
We say: *The larger the puzzle pieces the easier the integration*

...let's assemble very small puzzle pieces into larger groups...

...reduced number of puzzle pieces = easier completion...
Fuel cell stack – analogy to engine block

What is missing to make the engine block a functional engine?

- Ignition system
- Cylinder head
- Camshaft
- Fuel injection system and pump
- Oil pump
- Timing belt
- Starter
- Crankshaft
- Oil sump
- Coolant pump
- Engine management system
- Exhaust system
- Air filter

...and ...lots of engineering, testing, experience and time to put all this together
Hydrogenics’ supply – the HyPM Series Power Module

„The Engine“- all integrated and ready to run

- Ready to integrate – connect and start
- Reduced time to integrate into application
- Avoids expensive errors during integration
- Cuts down engineering cost
- Generally available know-how is sufficient for integration
- Warranty on all components

Unique technology

- No humidification, inert gas or DI water needed
- Automated freeze protection down to -40°C without heating
- Cold start from -10°C without ancillary units
- Unlimited Start-Stop cycles
- Balance of plant integrated
- Designed to deliver > 12,000 hours lifetime
- Easy integration due to few customer interfaces
  - Electrical terminals
  - Coolant in/out
  - Hydrogen in/out
  - Air in/out
  - Communication port (CAN)

…and …lots of engineering, testing, experience and time to put all this together
Anwendungsgebiete

- Straße
- Schiene
- Luft
- Stationär
Wide spread portfolio for all mobile Heavy Duty applications

**HD Series**

<table>
<thead>
<tr>
<th>HyPM™</th>
<th>HD 8-500</th>
<th>HD 10-500</th>
<th>HD 12-500</th>
<th>HD 15-500</th>
<th>HD 20</th>
<th>HD 30</th>
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<tbody>
<tr>
<td>Continuous Power [kW]</td>
<td>8.5</td>
<td>10.5</td>
<td>12.5</td>
<td>15.5</td>
<td>20</td>
<td>33</td>
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</table>

**Heavy Mobility**

<table>
<thead>
<tr>
<th>HyPM™</th>
<th>HD 60</th>
<th>HD 90</th>
<th>HD 120</th>
<th>HD 180</th>
<th>HD 300</th>
<th>Vehicle Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Power [kW]</td>
<td>66</td>
<td>99</td>
<td>132</td>
<td>198</td>
<td>298</td>
<td>3…MW</td>
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</tbody>
</table>
… to complete bundled and functional packages as well as their integration
Flexible adaption – Flexible cost – Lower TCO
Gobal Approach

We are working with North American, European and Chinese bus manufactures and vehicle integrators.

The activities cover more than 2000 vehicles over the course of the next 3 to 5 years.

More details can be disclosed later this year.
Reference Urban Transit Bus Applications
Trucks: flexible power as needed, easy Integration,
Reference Heavy Commercial Fleet Applications
2016-09-20: ALSTOM unveils zero-emission train

Project Hy4

Source: http://h2fly.de/projekte/hy4-facts/

Technical Data
- Wingspread: 21.26 m
- Length: 7.40 m
- Max. weight: 1.500 kg
- Max. speed: 200 km/h
- Cruise speed: 145 km/h
- Range: 800-1500 km

Fuel Cells
- Type: LT PEM
- Nom power: 45 kW
- Qty modules: 4
- Cathode gas: air
- Tot. Weight: 100 kg

Source: http://h2fly.de/projekte/hy4-facts/
CRITICAL POWER
- Top Speed: 35 knots, Passenger capacity: 150
- Total installed power: 4.92 MW (4.4 MW for propulsion at top speed, 120 kW for auxiliary power, and the remainder for margin) consisting of (41) 120 kW PEM fuel cell racks, each rack containing four 30 kW PEM fuel cell stacks.
- Fuel: 1,200 kg (~4,500 gallons) of LH2 contained in a single Type C (pressurized vessel) storage tank on the top deck, enough for two 50 nm round trips before refueling, with 200-400 kg
- Electrical architecture: DC power from the fuel cells converted to AC power for the motors.
- Propulsors: Waterjet or Voith linear jet
P2X – Hydrogen – Cross Sector bridgeing link
RENEWABLE HYDROGEN & GRID BALANCING
HYDROGEN FUELING
Hydrogen Infrastructure

H2 Production Capacity: 6t/d
Modular set-up
Stations grows with demand
Vielen Dank

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2018
Vendeé Globe
Solo Circumnavigation Race