Integration of a Fuel Cell Range Extender in Warehouse Logistic Vehicles

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Fronius Company

Division Battery Charging Systems

Division Welding Technology

Division Solar Electronics
A closer look at the Fronius Group

- Employees worldwide: 2677 (2009), 2500 (2008)
- Employees R&D: 358 (2009), 309 (2008)
- Investment quota: 14.9% (2009), 8.6% (2008)
- Export quota: 93% (2009), 90% (2008)
Fronius Energy Cell

Available for Projects

<table>
<thead>
<tr>
<th>Power</th>
<th>4 kW</th>
<th>2 kW</th>
<th>1 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>48VDC</td>
<td>24VDC</td>
<td></td>
</tr>
<tr>
<td>IP Protection Compliance</td>
<td>IP20 (upgradable to IP54)</td>
<td></td>
<td></td>
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<tr>
<td>Certification</td>
<td>EN62282-5-1:2007</td>
<td></td>
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<tr>
<td>Fuel Supply</td>
<td>Standard Compressed Hydrogen 30-700 bar Hydrogen Gas Grid Electrolyser</td>
<td></td>
<td></td>
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<tr>
<td>Applications</td>
<td>DC/AC Power Generator Mobile Applications</td>
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</tbody>
</table>

- PEM fuel cell power generator
- High overall efficiency
- Silent operation
- Perfect safety strategy
- Easy to use and service, user-friendly
- Complete remote system monitoring
Energy Efficiency Fronius Energy Cell

Efficiency Fronius Energy Cell 25F (24V/2kW)
Ambient Temp. 25°C, LHV = 2,995kWh/Nm³

- η^ges (Pth*0,75)
- η^el
The HyLOG Project

1. Fronius Facility Sattledt, Central Production & Logistics:
   - Employees: 650, Production Space: 37,000 m²
   - 615 kWp Photovoltaic Power Plant

2. Fronius IG500 Inverter

3. Biovest / Proton Energy
   - HOGEN® S40 Electrolyser

4. Hydrogen Refuelling Station
   - Air Products S100, 350 bar

5. H₂ Bitter Tank
   - STS 26 l, 350 bar, 0.7 kg H₂

6. Fronius Energy Cell 25F

7. Linde P30 Tow Truck
   - Tractive Force 3000 kg
   - Range-Extender Drive, 2 x range / 7 x refuelling / week
Status Demonstration / Results

- Since May 2009: 5 days/week 2-shift operation
- 4 – 5 shifts / cartridge exchange

Key advantages
- Fast refuelling increases system flexibility and availability
- Increased productivity through constant power, reduced maintenance, reduced space demand
- Energy management capability
- No emissions

Improvement potentials / critical aspects
- Minimum vehicle fleet size for economic operation required
- Competitive price for hydrogen as an energy carrier
- Replacement of cartridge by indoor / onboard refuelling
- System cost reduction through volume manufacturing
Future of Warehouse Logistics

Schenker Facility Sofia, Bulgaria (Photo courtesy of Schenker & CO AG)

Gazeley Park Blue Planet Chatterly Valley (Photo courtesy of Gazeley UK Ltd.)

Fronius Facility Sattledt, Austria

Kühne+Nagel Hub Chaponnay, France (Photo courtesy of Kühne+Nagel Int. AG)
Energy Costs in Warehouse Logistics

Energiekostenaufteilung eines Logistikzentrums

- Beleuchtungstechnik: 15%
- Förder-, Lager- und Kommissionier-technik: 48%
- Heizungs- und Lüftungstechnik: 35%
- Rest: 2%

Quelle: Kramm, M.: Der Energieausweis für Distributionszentren
Energy Infrastructure Perspective
Energy Infrastructure Perspective

- Future
- State of Art
- Customer Site
- High Pressure Electrolyser
- H2 Storage
- Indoor Refuelling
- Fuel Cell Truck
- Battery Charger
- Battery Truck
- Heat Storage
- °C
- H2 Storage

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Energy Infrastructure Perspective

Future

High Pressure Electrolyser

H2 Storage

Heat Storage

H2 Reformer

H2 Storage

Compression

Heat Storage

Fuel Cell Truck

Battery Charger

Battery Truck

Customer Site

State of Art

Natural Gas / Biogas

H2 Delivery
Warehouse Vehicle Requirements

- Onboard energy: 5,2 – 9,6 kWh
- Driving range (net): >4 hours
- Refuelling time (indoor / onboard): <3 min
- Temperature range: -10 to 70°C
- Water / dust protection: IP53
- Extreme vibration and shock load
Load Cycle

Average power drive cycle: 0,4 to 3,1 kW
Average power shift / recharging cycle: 0,2 to 1,9 kW

Max. Current -270 to 550A @ 19V (~10,5 kW)
Standards System Safety

- **New Machinery Directive 2006/42/EC, active since 29 Dec 2009**
  - System safety functions (pneumatic, electronic, hydraulic, mechanical functions on sub- and total system level) require qualitative AND quantitative reliability assessment
  - Assessment according to
    - EN 62282-5-1:2007 Fuell cell technologies - Part 5-1: Portable fuel cell power systems - Safety
    - EN ISO 13849-1 Safety of machinery (Replaced: EN 954-1 Safety of machinery, Safety related parts of control systems)
    - EN 61508 Functional safety of E/E/PE electronic safety-related systems

- **Challenges:**
  - Low availability of safety related data (SFF, PFH values) of components of the safety function causes demanding and costly engineering solutions
  - High documentation effort

- **Standards gas vehicle refuelling (incl. indoor)**
  - ÖVGW G97 NGV filling stations - Design, production, installation and operation
  - VdTÜV MB514 / 04.2009: Compressed gases, Requirements for hydrogen fueling stations
E-LOG-Bio-Fleet

Objectives

- Development, certification and demonstration of a warehouse tow truck fleet (15 vehicles) with fuel cell range extender
- Installation, authority approval and demonstration of indoors and onboard bio-hydrogen refuelling of the warehouse truck fleet
- CO2 neutral generation of bio-hydrogen using reformed biogas as source of energy
- Environmental and socio-economic assessment of the innovative and sustainable warehouse logistic application
- Preparation for enhanced market entry

This project is selected for funding by the Austrian Climate and Energy Fund within the program „Technologische Leuchttürme der Elektromobilität“
Summary

- The HyLOG project demonstrates a safe and zero emission solution for warehouse logistics.
- Key benefits of fuel cells for warehouse logistics are fast refuelling, constant performance, reduced maintenance and less space demand @ zero emission.
- A Fuel Cell Range Extender enables both high peak current capability and drive cycle efficiency.
- Compliance with EU safety standards is evident but costly.
- The E-LOG-Bio Fleet project will further enhance market entry of the innovative technology.