Bränslecelsbaserad modul för räckviddsförlängning för elfordon ”MoRE-Zero” ERA-NET

Felix Haberl, Timo Keränen
PowerCell Sweden AB, Göteborg

Energirelaterad fordonsforskning 2017
Göteborg, Oktober 4–5, 2017
Hydrogen Modular Range Extender for Electric Vehicles “MoRE-Zero” ERA-NET

- Project time: 2014-06-01 to 2017-03-31
- PowerCell Sweden AB has received 6 904 250 SEK for the development of a modular fuel cell range extender module for electric vehicles as part of the program ”Fordonsstrategisk forskning och innovation (FFI)”
- Project partners have been
  - Applus+ IDIADA (system integrator)
  - Triphase NV (DC\DC supplier)
- Recipient of fuel cell system
  - Volvo Car Cooperation (system integrator)
PowerCell – Global Frontrunner in Fuel Cell Technology!

- Heritage from Volvo Group, the company was founded in 2008
- Innovative, unique and patented Fuel Cell and Reformer technologies
- Northern Europe’s largest and state-of-the-art fuel cell and reformer laboratories
- All central functions located in Sweden – approx. 45 highly skilled employees
- Listed on Nasdaq First North end 2014

**Mission**

Our mission is to offer customers efficient environmentally friendly power products and systems with leading fuel cell and reformer technology for existing and future fuel infrastructure.

**Vision**

To be the world’s leading innovative fuel cell company by:
- creating value for customers in selected segments
- innovative products and systems for existing and future fuels
- providing efficient products that reduce the environmental impact
## PowerCell Product Portfolio Overview

<table>
<thead>
<tr>
<th>Product name</th>
<th>Type</th>
<th>Power range</th>
<th>Fueled by</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Fuel cell stack</td>
<td>1-5 kW, modular in 0.5 kW steps</td>
<td>Reformate fuel or pure hydrogen</td>
<td>Households, commercial properties (Micro CHP) and traffic systems</td>
</tr>
<tr>
<td>S2</td>
<td>Fuel cell stack</td>
<td>5-35 kW, modular in 5 kW steps</td>
<td>Reformate fuel or pure hydrogen</td>
<td>Telecom and automotive range extension (REX)</td>
</tr>
<tr>
<td>S3 (Prototype)</td>
<td>Fuel cell stack</td>
<td>20-100 kW</td>
<td>Hydrogen</td>
<td>Developed in AutoStack Core for powering vehicles</td>
</tr>
<tr>
<td>PowerPac</td>
<td>Fuel cell stack</td>
<td>3 kW</td>
<td>Diesel</td>
<td>Telecom, refrigerated transportation, vehicle APU, reserve power</td>
</tr>
<tr>
<td>PS-5 (Prototype)</td>
<td>Fuel cell system</td>
<td>1, 3 and 5 kW</td>
<td>Hydrogen</td>
<td>Households, commercial buildings, telecom and security systems</td>
</tr>
<tr>
<td>MS20 (Prototype)</td>
<td>Fuel cell system</td>
<td>20 kW, modular</td>
<td>Hydrogen</td>
<td>REX (Range Extenders)</td>
</tr>
</tbody>
</table>

Energirelaterad fordonsforskning, 2017-10-05
Fuel Cell Range Extender Drive

**DRIVING FORCES**

- Fuel Consumption/CO₂
- ZEV / Emissions
- Performance/New features

**Balance Fuel Cell and Battery**
- Weight/Size
- Cost
- Range

**Design freedom**
System design & integration
Why FC range-extender?

- Energy consumed per distance driven much lower for BEVs compared to diesel in delivery truck application*
  - Low average speed
  - Frequent acceleration/deceleration cycles

- BEV faces the weight/range limitation to achieve equivalent drive distance compared to ICE and FCEV

- For a wide range of users the FCREV offers a sufficient and cost efficient solution
  - Daily distance and drive schedule challenging for BEV
  - Full size FCV drivetrain cost still high and utilization low
  - Option for plug-in charging and driving short distances in BEV mode
  - Freedom of movement / no range anxiety

*
Why FC range-extender?

- The range extender offer the best of two technologies
  - Good weight-to-kWh ratio
  - Quick refueling
  - Heat available from FC
  - Run battery optimal (efficiency and lifetime)
  - Option to use shore power for charging

- PCS FC range-extender enables the option to convert electric vehicles of today into hydrogen fueled vehicles of tomorrow
  - Modular design & smaller footprint than full size FC system -> possible to integrate to existing BEVs
  - Recharging / refueling flexibility in presence of underdeveloped infrastructure
Range-extenders fill the gap between BEV and FCV for light-duty transport.

For Delivery Vehicles, duty cycle needs will drive choice of technologies.

- H2 range extender solution kill the limitations of pure battery vehicle:
  - Double the range
  - «instantaneous» refilling time
  - Sweeps the «winter effect»

# PowerCell MS-20, Range Extender System

## Fuel Cell MS-20 main advantages:
- Safety system including hydrogen sensor and alarm I/O
- PEM technology, fast start up and shut down
- Low internal power consumption
- Simple to integrate
- Liquid cooled, wide operation conditions
- Fuel tolerant, for use with lower class hydrogen or reformate hydrogen
- Fully automated control system including cell voltage monitoring

## Specification

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Power</td>
<td>20 kW (_{electric})</td>
</tr>
<tr>
<td>Voltage output</td>
<td>150-250 VDC</td>
</tr>
<tr>
<td>Start-up time</td>
<td>&lt; 30 s</td>
</tr>
<tr>
<td>Life time operation power generation</td>
<td>&gt;&gt; 5000 h (drive cycle dependent)</td>
</tr>
<tr>
<td>Life Time operation</td>
<td>10 years</td>
</tr>
<tr>
<td>Usefull heat (liquid based)</td>
<td>20 kW</td>
</tr>
<tr>
<td>Volume</td>
<td>&lt; 160 l</td>
</tr>
<tr>
<td>IP classification</td>
<td>54</td>
</tr>
</tbody>
</table>
PowerCell MS20 in applications

The system is being integrated in two different vehicles

- Applus+ IDIADA Spain is currently integrating a PowerCell MS20 in a 3.5 ton light duty truck
- Volvo Cars Corporation has integrating the system in a XC90
Activities in the field of fuel cell range extenders

RENault KANGoo ZE-H2
• 5 kW fuel cell
• 22 kWh battery pack

Mercedes GLC F-Cell
• 147 kW total power output
• 13.8 kWh battery pack
Next steps

- Optimisation of existing range extender module
  - Customized BOP
  - Optimize cost, volume, weight
  - Implement advanced control strategy for best FC/battery operation
  - Collect in-field operation data for specification input

- Design of full propulsion fuel cell power train
  - Fuel cell stack with higher power
  - Optimized sizing of battery

https://www.innbalance-fch-project.eu/
Fuel cell vehicle cost

Optimal balance of battery and FC will change over time
With decreasing Fuel Cell cost the optimum will shift to more fuel cell

Production Cost Trend FCEV

Optimal balance of battery and FC will change over time
With decreasing Fuel Cell cost the optimum will shift to more fuel cell
PowerCell S3 – in development within the AutoStack framework

- Powered by hydrogen gas
- High-quality fuel cell stack primarily for powering vehicles
- 20-100 kW power range
- Designed in accordance with automotive cost targets

Goal: Superior quality and performance to meet the requirements from the automotive industry!!

**kW/l-Evo 2**

<table>
<thead>
<tr>
<th>kW/l</th>
<th>Nissan</th>
<th>Honda</th>
<th>Toyota</th>
<th>S3</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>3.1</td>
<td>3.1</td>
<td>3.8</td>
<td></td>
</tr>
</tbody>
</table>

AutoStack Core Consortium

- Automotive OEMs
- Component and System Suppliers
- Research Institutes

Energirelaterad fordonsforskning, 2017-10-05
PowerCell, the Nordic leading fuel cell company

Powercell Sweden AB (publ) noterat på Nasdaq First North
Ruskvädersgatan 12,
418 34 Göteborg

+46 31 7203620
info@powercell.se
www.powercell.se

Med delfinansiering av

Energirelaterad fordonsforskning, 2017-10-05