High temperature PEM; part of the solution

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Company setup

SerEnergy A/S (DK)
• Research & Product Development
• Business Development
• Prototype and pilot series production

Fischer Eco Solutions GmbH (DE)
• Development of production machinery and processes
• Medium and large scale manufacturing
• Design for manufacturing
SerEnergy

- Located in Aalborg, Denmark
- Established 2006
- ~30 employees (~40 incl. Fischer)
- Privately owned
  - Founders
  - Fischer Group GmbH
fischer group

- Important global supplier of tubes and components made of stainless steel
- Family enterprise since 1969
- 12 production sites worldwide
- 522 Mio € sales volume
- 1545 employees
Business focus

• Focus on HT PEM stacks and modules
  – Air cooled
  – Liquid cooled

• Focus on Reformed Methanol Fuel Cell (RMFC) modules
  – Backup power
  – Auxiliary power units
  – Electric mobility range extention
HT PEM Technology

• **Characteristics**
  – Operation at 160 °C
  – Start up: 5-30 min
  – Ambient +60 °C (ΔT 100 K)
  – No water regeneration or humidification
  – 250 W to 15 kW range

• **Status**
  – 30.000 hours MEA level
  – 5000 hours stack/system level - (12 µV hour)
  – Product/BOP maturing
  – Reformer integration optimized design
### Comparison HT- and LT-PEM Technology

<table>
<thead>
<tr>
<th>HT-PEM</th>
<th>LT-PEM</th>
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<tbody>
<tr>
<td>- Operating Temperature 160°C</td>
<td>- Operating Temperature below 100°C</td>
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<tr>
<td>- No gas cleaning necessary</td>
<td>- Pure fuel gases necessary</td>
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<tr>
<td>- Liquid fuels with reformer</td>
<td>- Pure hydrogen fuels</td>
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<tr>
<td>- Simple fuel storage</td>
<td>- Complex fuel storage</td>
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<tr>
<td>- Heat rejection easy</td>
<td>- High cooling areas necessary</td>
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<tr>
<td>- Power density lower of stack than LT</td>
<td>- Power density of stack higher than HT</td>
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HT PEM stacks

- Air cooled - 1 kW
- Liquid cooled – 5 kW
Serenus Air modules

Serenus Air C - module

S45 - 66 cell stack
Serenus Liquid C modules

Serenus Liquid C - module

S165-120 cell stack

Diagram showing the flow of power and coolant through the system, including components such as Controller, Anode, Cathode, and Coolant, along with heat transfer elements and power sources.
Reformed Methanol Fuel cell

- Power output: 350W
- Voltage: 24 VDC
- Weight: 13 kg
- Fuel consumption: 0,44 L/h
Operation logic

- Charge current
- Battery voltage

(a)

(b)
H3 350 - EOL performance

H3-350 v2.0 performance with EOL-stack

Note the high turn-down ratio
H3 350 start up - EOL

Startup completed after 21min (net power output)
Technology

- Hot Air 140°C
- Exhaust
- Reformat gas
- Evaporator
- Metanol in (Fluid)
- Fuel cell (Liquid cooled)
- (60-90VDC)
- Burner
- 58cm
- Evaporated Methanol
- Weight: ~20kg
- 14cm
- 40cm
H3-5000
5kW methanol module

- Electric power: 5kW
- Thermal power: 4-5kW
- Total efficiency (LHV): >85%
- Elec. efficiency (LHV): 40-50%
- Weight: 45kg
- Dimensions:
  - Width: 19”/430mm
  - Length: 700mm
  - Height (6U/253mm)
  - Volume: 77L
- DC/DC: integrated – bat charging capability
- Output voltage: 24/48/80 or 400-600 VDC
Total Electrical Efficiency, incl BoP Power
H3-5000 RMFC, Ver 2.2

Anode stoichiometry

Stack Electrical Power [W]

04-12-2013
OEM reformer systems

- Raw stacks, Manifolds
- Complete Fuel cell Modules
- TRL 6-7 (small volume test/trial)
Combined Heat & Power

- 20 kW grid connected
- 4 x Serenus 120 modules
- 2 x standard racks
- Reformat gas operation
- Power conversion
- Grid connected

20 kW solution integrated into two standard racks with overall SRO for remote monitoring and communication.
Telco backup deployment

- 700W @ 48 VDC
- 72 hours autonomy
- 7,5 kwA Genset replacement
Small Materials Handling EV

- Onboard Power supply
- Lead acid/Li-ion battery charging
- Integrated HTPEM stack, methanol reformer & power electronics
- In the field trial since 2010
- Direct replacement of diesel vehicles; Cemetery Gartners, airports
- 2 x H3 350 units

http://www.youtube.com/watch?v=EKLaP5ytwxw
Mobile Generator

Telecom Emergency response generator

- Integrated flightcase design
- 700W power pack
- Simple to transport/carry
- Simple/safe fuel concept
Vehicle Range Extender

- Automotive modular drivetrain (with Ecomove from Horsens)
- Battery/Reformed methanol fuel cell hybrid
- 800 km range
- 3 min refueling with existing infrastructure
- High Temperature PEM with integrated reforming
- Waste heat for both heating and cooling
- Superior WtW and energy efficiency
REM 2030

- Regional Eco Mobility 2013
- Baden-Württemberg initiative
- AUDI, Fraunhofer, SerEnergy
- Electro mobility with range extender
- Audi A1 E-tron conversion
- Battery/Methanol fuel cell Hybrid
Summary & outlook

- Performance
- Stability
- Price
- Product

Outlook

- Temperature
- Pressure
- Bipolar plates
Thank you for the attention