- Caring for the energy of tomorrow

Back-Up Power with Fuel Cells
Meeting in Wien, Ostrich
22nd of April 2015
Focus. Trust. Initiative.

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Content:

• Dantherm Power
• Back-Up Power
• Examples of installations
Dantherm Power A/S

- Founded January 2007
  - Spin off from Dantherm Air Handling A/S
- Located in Hobro, Denmark
- 40 employees
- Business focus:
  - Fuel Cell Systems, R&D, Engineering, Sales and Service
- Manufacturing:
  - Hobro, Denmark
  - Tijuana, Mexico
Dantherm Power - Ownership

**BALLARD®**
52%
- Established 1979 and started fuel cell development in 1983
- Headquarters: Burnaby, British Columbia
- The world wide leader in fuel cell technology
- Market focus: backup power, buses, forklifts and distributed power

**Dantherm®**
38%
- Est. 1958 and worked with fuel cells since 2003
- Headquarters: Skive, Denmark
- Specialized in air management
- Supplier of electronics cooling for telecom OEM’s since early 90’s

**Azure Hydrogen**
10%
- Est. 2011
- Headquarters: Beijing, China
- Focused on sales of fuel cell hydrogen systems in China
- Specialized on telecom backup
Dantherm Powers Market Focus

Dantherm Power Focus: 0,5 kW to 100 kW
Tetra network with 1,7 kW fuel cell backup

Backup Power fully integrated in cabinet
ElectraGen™- H2 Specifications

Key Features
- Direct hydrogen PEM fuel cell technology
- Compact and scalable
- Zero-emission
- Fast start-up
- Low temperature operation
- Load following
- 4,000 hours operating lifetime specification for typical backup power applications
- Durable across a wide range of duty cycles
- Automatic self-test ensures reliability
- Battery free configuration available – ultra caps

<table>
<thead>
<tr>
<th>ElectraGen™- H2</th>
<th>1.7kW</th>
<th>5kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Range, VDC</td>
<td>48 to 55 or -48 to -55</td>
<td>-20 to +46</td>
</tr>
<tr>
<td>Ambient Temperature, °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel Cell</td>
<td>Direct-hydrogen PEM</td>
<td></td>
</tr>
<tr>
<td>Cooling Method</td>
<td>Air</td>
<td></td>
</tr>
<tr>
<td>Bridging Energy</td>
<td>VRLA batteries1 or Ultracaps</td>
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</tr>
<tr>
<td>Certifications</td>
<td>CE, ANSI/CSA FC1:2012</td>
<td>CE</td>
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<tr>
<td>Fuel Type</td>
<td>Gaseous Hydrogen</td>
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<tr>
<td>Fuel Purity</td>
<td>&gt;99.95% purity</td>
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</tr>
<tr>
<td>Fuel Consumption2, Nm³/kWh</td>
<td>0.82</td>
<td>0.80</td>
</tr>
<tr>
<td>Run Time3, hrs</td>
<td>35</td>
<td>12</td>
</tr>
<tr>
<td>Communication interface</td>
<td>Dry Contacts</td>
<td></td>
</tr>
<tr>
<td>Size, W x D x H, cm</td>
<td>45 x 63 x 36</td>
<td>50 x 57 x 62</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>40</td>
<td>75</td>
</tr>
<tr>
<td>Location</td>
<td>Rack-mountable, indoor &amp; outdoor</td>
<td></td>
</tr>
<tr>
<td>CAN bus</td>
<td>RJ-45 connector</td>
<td>RJ-11 connector</td>
</tr>
</tbody>
</table>

1 VRLA batteries1 or Ultracaps

2 Fuel Consumption2, Nm³/kWh

3 Run Time3, hrs
8 years in the field of back-up

Currently more than 300 systems in Denmark (April 2015)
Emergency network - TETRA

• Tetra is used by firefighters, police, ambulances, defense, .... in a closed encrypted network.
• Tetra is a digital radio communication system
  – substituting existing walkie talkie systems.
• Tetra has many advantages:
  – enabling joint operations
  – enabling text messages
  – enabling central coordination
Dantherm Power Market Focus
Back-Up power with fuel cells

Customers:
Products & Solutions

Design your own backup power system...

Fuel Cell Modules
- DBX2000 1.7kW Net Power
- DBX5000 5kW Net Power
- Master Module "series connector"

Energy Storage
- Dantherm supplied batteries
- Customer supplied batteries
- Power Module Ultra caps

Electrical Interface
- 48V
- 24V DC - DC
- AC Inverter

Enclosure
- Indoor: Rack mount
- Outdoor: Container, Integrated Power Cabinet, Wall Mount, Portable

...Or Dantherm will engineer a turnkey solution
Indoor/Outdoor Solutions

• Dantherm Power offers modular customizable solution up to 10kW

• Multiple system configurations available
  : Outdoor fuel cell with outdoor H₂ storage
  : Indoor fuel cell with outdoor attached H₂ storage
  : Indoor fuel cell with indoor H₂ storage

• Outdoor cabinets Mount on concrete pad

• All incorporates the ElectraGen™- H₂ 5kW or 1.7kW rack-mountable systems and steel or composite cylinders for H₂ storage

Example of an outdoor cabinet for fuel cell and outdoor fuel storage (10 kW / 90 kWh solution) - next to a shelter.

Example of an indoor fuel cell with indoor fuel storage (5 kW / 45 kWh solution).

Example of an indoor fuel cell with outdoor attached fuel storage (1.7 kW / 120 kWh solution).
Outdoor ElectraGen™- H2 Solution

• New outdoor cabinet solution
  • Modular customizable solution up to 10kW
    : 2 cabinet options – standard or compact
    : Multiple system configurations available
  • Incorporates the ElectraGen™- H2 5kW & 1.7kW rack-mountable systems

• ElectraGen™- H2 5kW System
  • Now with Ballard’s next generation FCgen®-1020 stack
    : Offers increased stack durability and lifetime
  • New 2.5kW and 3.3kW systems in development
    : Based on 5kW unit
    : Available mid-2014
Danish Fiber Grid Operator
Danish Fiber Grid Operator

11 x 5kW sites deployed in September 2007. (Pre-Commercial)
By now we have **65 x 5kW** systems in this customers network.

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20150422
Per Balslev
30 kW installation in Germany

- 30 kW configured as 6 x DIB5000 making 30 kW as instant backup with no batteries needed at all for instant and uninterrupted backup.
- Provides safe and redundant operation from 500 W up to 30 kW due to best turn down in market
- Installed in Berlin, Germany
10 kW in Italy through Ericsson

Configured with two DBX5000 + Master Module
Installation in Italy
Rooftop installation, Aalborg, Denmark

ElectraGen 1.7kW

Attached cabinet for H2 bottles.
Rooftop installation, Copenhagen, Denmark

ElectraGen 1.7kW

Attached cabinet for H2 bottles. Can be assembled on-site
Rooftop installation, Toronto, Canada

ElectraGen 1.7kW Outdoor

No cabinet for H2 bottles. (installation not finalized on pictures)
Handling H2 steel cylinders
Cold Climate Operation Example

- Wind Mobile Canada: Commercial competitive replacement of Diesel Generators
- Average of 9000 h of stack lifetime achieved
- 2 of the systems exceeded 11000 h
- Expect to reach 12000 h on average in next stage
- Operated in -40°C to +45°C
- >1,5 GWh in total
- One interrupt in a total of >300,000 h
Cold Climate Operation Example

Nødnett (Tetra), Norway
Installation in Siberia

- Operating down to -40C
- Equipped with Cold Climate Kit
Continuous Power – Temporary

- Commercial competitive replacement of Diesel Generators.

Average of 11000 h of stack lifetime achieved.

Expect to reach 12000 h in average in current stage.

Operated in -36°C to +45°C

Facts:
>120 MWh
>120000 L diesel replaced
>318 tons CO2 removed
NO interrupts in a total of 280,000 h
Field Experience

- Delivered >800 systems worldwide under a variety of conditions
  - Few yearly outages in Denmark
  - Continuous power in Canada
  - Cold climates in Norway and Canada
  - Hot climate in India

- Dantherm Power has 120 systems in operation with the Danish Tetra Net where reliability is absolute top priority
  - Reliability 99.7%
  - Availability 99.997%

- Dantherm Power has had 15 systems running in continuous operation at Wind in Canada.
  - >300,000 hours of operation
  - One single power outage of < 1 hour (availability > 99.9997%)
  - Temperatures from -40°C to 35°C

- Dantherm Power has 25 systems running 8 hours per day in India
  - >45°C operation
  - Daily start stops
Thank you for your attention!

Questions?

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