EFOY Pro Fuel Cells

EFOY fuel cell operation in arctic environments

8th Annual Polar Technology Conference
SFC Energy Inc.
Frank Heid
Vice President
Agenda

I. SFC - World leading manufacturer of fuel cells

II. The EFOY Pro fuel cell technology

III. Reference case: SRI International

IV. Commercially proven -40° C operations
SFC Energy Group

Facts and figures

☀ SFC Energy
  ☀ Founded in 2000
  ☀ Sole company developing, producing and selling **commercially available DMFC products**
  ☀ 95 employees in the two locations Brunnthal (D) and Rockville (USA)

☀ PBF Group
  ☀ PBF was founded 1999 as MBO from Philips Electronics
  ☀ PBF develops, manufactures, and markets **power supplies and higher level power management solutions**
  ☀ 100 employees in the two locations in Almelo (NL), and Cluj (RO)
  ☀ Acquired by SFC Energy AG in 2011
Fuel Cell Market Traction

Over 24,000 fuel cell systems shipped
Market Segments

Consumer
- Caravanning
- Marine
- Cabins

Industrial
- Oil & Gas
- Traffic Management
- Wind Industry
- Environmental Data
- Telecommunication
- Surveillance (commercial)

Defense & Security
- Armed Forces
- Homeland Security
- Law Enforcement
Agenda

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Off-grid and Mobile Energy Supply

Reliable off-grid and mobile energy supply can be difficult and costly

Solar panels often do not provide sufficient energy and are weather dependant

Using batteries only limits autonomy and increases personnel costs

Generators are noisy, not economically-friendly and produce high maintenance-costs

Reliable and economically-friendly energy supply can save costs and time
The fuel cell technology
The fuel cell technology

- EFOY Fuel Cartridge
- EFOY Pro Series
- Battery
- Load

**Graph:**
- Battery voltage range: 0 V to 14.2 V
- Optimum charge level
- Deep discharge level

**Key Points:**
- Fuel cell on/off states
- Comparison with and without EFOY Pro

**Diagram Details:**
- Illustration of fuel cell technology components
- Voltage levels and charge/discharge stages

**Legend:**
- with EFOY Pro
- without EFOY Pro
The fuel cell technology

Methanol + Oxygen → Carbon dioxide + Water vapor

\[ 2 \text{CH}_3\text{OH} + 3 \text{O}_2 \rightarrow 2 \text{CO}_2 + 4 \text{H}_2\text{O} \]
EFOY Fuel Cartridges: Advantages

That delivers **10 kWh** electricity

<table>
<thead>
<tr>
<th>Methanol</th>
<th>Lithium Batteries</th>
<th>Lead-Acid Batteries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weight:</strong> 8 kg</td>
<td>110 kg</td>
<td>270 kg</td>
</tr>
<tr>
<td><strong>Volume:</strong> 10 l</td>
<td>120 l</td>
<td></td>
</tr>
</tbody>
</table>

*Empamle: 10W application (24 h operation) runs 259 days without any user intervention with 56 l Methanol*
EFOY Pro fuel cells + photovoltaic

Easy Integration: Plug & Play solution
Backup for solar energy systems
The fuel cell technology

<table>
<thead>
<tr>
<th></th>
<th>EFOY Pro 600</th>
<th>EFOY Pro 1600</th>
<th>EFOY Pro 2200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Energy Output</td>
<td>600 Wh/day</td>
<td>1,560 Wh/day</td>
<td>2,160 Wh/day</td>
</tr>
<tr>
<td>Nominal Power</td>
<td>25 W</td>
<td>65 W</td>
<td>90 W</td>
</tr>
<tr>
<td>Nominal Current @12 V / 24 V</td>
<td>2.1 A / 1.05 A</td>
<td>5.4 A / 2.7 A</td>
<td>7.5 A / 3.75 A</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-20 to + 45 °C (-2 to +113 °F) Rated at &lt; -40 °C in special enclosures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol Consumption</td>
<td>0.9 l/kWh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions (l x w x h)</td>
<td>433 x 188 x 278 mm (17 x 8 x 11 in)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>ca. 8 kg (18 lbs)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Key Benefits of the EFOY Pro Fuel Cell

- Reliability and Operating Safety
- Long Periods of Autonomy, Maintenance-free
- Remote Monitoring
- Lightweight and Compact
- Easier logistics, reduced operating costs
- Quiet & Economically-friendly
- Plug & Play solution

EFOY Pro was specially developed for professional daily use
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Imnavait Creek Communications Node

- 65-Watt EFOY Pro 1600 Fuel Cell for winter power
- Wind power not reliable in Interior Alaska in winter
- 40-Watt PV panel for Spring – Fall primary power

Ambient Temperatures at Ridge Site

- System running well at -39 °C
SRI International – Exhaust Water Challenges

**Water Vapor Port Icicle Formation**

- Fuel turns mostly into water
- Fuel cell errors indicate when tube is blocked with ice
- Installed Vapor Port Tube w/ Heater does not avoid icicle formation

45 days

Blocked water exhaust → Fuel Cell failure
Overheating Event Causes Fault

- Restricted air intakes to keep warm air inside
- Interior temperature exceeded EFOY spec
- Service fluid reservoir dried out, shutting down fuel cell before SRI could limit run time

Interior drops to ambient temperature → stack freezes
SRI International – drifting snow challenges

Elevated Support

- Eliminates drifting snow that could clog air ports

Communications Node

RE Power Station
Conclusions by SRI International

- Proper **thermal** and **water management** permits winter operation of a fuel cell
- Open ports caused extra fuel to be used
- Need to monitor Service Fluid level to prevent unrecoverable stack failure/freezing
- Elevated enclosure prevents drifts from forming and blocking air ports
- Remote Control could get very complex if there is no self regulating heat management

**SFC and its Partners have addressed that in order to succeed in the industry**
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Key market for SFC Energy fuel cell products

Oil & Gas production North Canada

Opportunity for SFC:
The environmental challenges in the field mean largest opportunity in North Canada

The Challenge:

- Temperatures average -19°C in winter
- Lowest recorded -50.6°C, (-58°F).
- Short Summer, less sun hours/day
- Solar panels do not work
Very demanding Oil & Gas Industry

Demand by the industry:

- 0% downtime (saves $$$$)
- Easy to deploy (time is $$$$)
- Hybrid for all-year operation
- Proven concept
- Easy logistics

Task: development of a reliable -40°C solution

Design of a standard heat and waste water management

...“You have only one shot to prove your technology within the oil & gas industry“...
Success Story: Surveillance at < -40° C

Mobile Video Detection System for Gas well site surveillance & bird monitoring

~ 80% of all deployed surveillance systems are down in winter time up north in Canada (Jason Lefort, Netvision)

☞ Power demand: 60-90 watts nominal

☞ Solar Power: Four (4) 225W photovoltaic modules only covers ~70% of the year
EFOY Pro fuel cell being deployed and set up in temperatures down to -44 °C

Hybrid systems: Solar + EFOY Pro fuel cell → full year operation

Deployment of dozen units in 2011 - in temperatures as low as -48 in Ft. Mac Murray, Canada

→ Proven -40°C concept resulted into further deployment of a significant amount of EFOYs in 2012 by various customers in West Canada
EFOY Pro hybrid solution

Proven -40°C Enclosure concept customized for highest latitudes (vertical solar panels) & an elevated support (drifting snow)
EFOY fuel cell in the oil & gas environment

**Communication Tower power package**

- Excellent results putting an insulated exhaust line into a secondary collection chamber sized for roughly ~70-90% of the fuel cell cartridge volume.

- Secondary chamber is then exhausted through the bottom of the enclosure (most is CO₂).

- Minimal exhaust moisture amount

- Open basement as elevation against drifting snow possible
EFOY fuel cell in the oil & gas environment

🌊 Thermostat controlled air intake and outlet
Drilling rig where the fuel cell is being used to power fuel gas metering skid that keeps the entire rig operational

Without this unit the drilling rig would be out of commission

It was -35C with high winds and blowing snow when this unit was installed

Installation was done on an emergency basis to get the rig back up and running

Fact that once the unit was installed fall 2011 the rig has not gone down since
EFOY fuel cell in the oil & gas environment

Air Compressor to power pneumatic instrumentation

秦皇岛 -35°C during the winter with lows of -40 to – 50°C

now downtime since deployment in Nov. 2011
PALAOA observatory, Antarctica

PALAOA, worldwide unique underwater acoustic observatory, celebrated 2011 its 5th anniversary – live sounds of seals and whales from Antarctica

EFOY fuel cell was part of it at the very first beginning
Application Scenarios: Telecommunication

Base Transceiver Station (Austria) since 2008

Internet via Radio Link Mast, EFOY Pro in Insulated Outdoor Box (Norway)
Application Scenarios: Telecommunication

- Base Transceiver Station
  TETRA Radio (Italy)

- Repeater Stations
  EFOY Pro in Insulated Outdoor Box (Norway)
Thank you very much for your attention

Any Questions???

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