Hydrogenics – Alstom Transport Agreement to Commercialize Hydrogen Powered Commuter Trains in Europe

Peter Eggleton  Mech Eng
Railway Applications Advisor to Hydrogenics Corp.
TELLIGENCE Group
Consultants in Transportation Technology
Saint-Lambert (Montreal), Canada

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Agreement Participants

• **Hydrogenics Corporation**  Mississauga, Ontario, a developer and provider of hydrogen generation and fuel cell products and services for stationary and mobile applications.

• **Alstom Transport**, a France-based global Original Equipment Manufacturer (OEM) of railway rolling stock, equipment and infrastructure.
Object of Agreement

- Hydrogenics will supply Alstom Transport with hydrogen fuel cell (HFC) systems to power Regional Commuter Trains manufactured by Alstom for service in Europe;
- Signed May 26, 2015, in Gladbeck, Germany, following a rigorous technical review process over an 18-month period;
- 10 – Year Exclusive Agreement;
Scope of Agreement

• Hydrogenics to supply Alstom Transport with:
  – 200 HFC engine systems, specifically its 200 kW Heavy-Duty HD series fuel cells;
  – Service and maintenance over a 10-year period.

• Value to Hydrogenics of order of €50 million.

• Target is the Alstom Coradia DMU commuter railcars redesigned to HFC-powered EMUs.

• Development work on prototype to commence late 2015, with commercial delivery in 2016.
Alstom CORADIA LINT: Candidate DMU Commuter Railcar for Conversion to HFC EMU
Alstom CORADIA LINT: Trainset Configurations

- 27 m – Seats: 70-80
- 41 m – Seats: 120-150
- 58 m – Seats: 180-195
Hydrogen Fuel Cell Power Module

HyPM™ HD 180

198 kW

Dimensions L x W x H 1582 x 1085 x 690
Mass < 720 kg (b)
Volume < 1122 L (b)
## HD 180 HFC Technical Data

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>Rated Electrical Power</td>
<td>198 kW continuous</td>
</tr>
<tr>
<td>Operating Current</td>
<td>0 to 500 A&lt;sub&gt;DC&lt;/sub&gt;</td>
</tr>
<tr>
<td>Operating Voltage</td>
<td>180 to 360 V&lt;sub&gt;DC&lt;/sub&gt; (2x)</td>
</tr>
<tr>
<td>Peak Efficiency</td>
<td>55%&lt;sup&gt;(a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Response</td>
<td>&lt; 5 s from off to idle</td>
</tr>
<tr>
<td></td>
<td>&lt; 3 s from idle to rated power</td>
</tr>
<tr>
<td>Fuel</td>
<td>Hydrogen &gt; 99.98%</td>
</tr>
<tr>
<td>Oxidant</td>
<td>Ambient Air</td>
</tr>
<tr>
<td>Coolant</td>
<td>De-ionized water (DI H&lt;sub&gt;2&lt;/sub&gt;O) or</td>
</tr>
<tr>
<td></td>
<td>60% ethylene glycol / DI H&lt;sub&gt;2&lt;/sub&gt;O</td>
</tr>
<tr>
<td>Ambient Temperature</td>
<td>-10 to +55°C operating</td>
</tr>
<tr>
<td></td>
<td>-40 to +65°C storage</td>
</tr>
<tr>
<td></td>
<td>(&lt;2°C with automated freeze shutdown feature)</td>
</tr>
</tbody>
</table>

<sup>(a)</sup> Efficiency measured at 100% load, 20°C ambient temperature, and 85% relative humidity.
HD 180 HFC Performance Data
Some Background Activities Facilitating Agreement

- 1) Hydrail 2013 in Toronto was venue for Hydrogenics Corporation to be exposed to H₂ for rail applications.
- 2) Telligence Group was retained to undertake HFC application study for the Toronto UP Express Shuttle railcars to be deployed for 2015 Pan-American Games.
- 3) OEM supplying UP Express railcars was reluctant due to schedule pressure, so other OEMs canvassed.
- 4) Telligence Group also examined HFC powering of TractivePower TP56 industrial switcher and EMD F59PH & F69PHAC Commuter Locomotives as demos.
- 5) Press Release May 26, 2015, on the Hydrogenics-Alstom Transport Agreement to Commercialize HFC.
HFC Powering Study of DMU for Toronto Union Station – Pearson Airport Shuttle
Post Pan-American Games DMU to EMU Conversion

Step 1: DMU Parts Removal
Step 2: Retrofit Electrical Parts for Catenary Powering
HFC Powering Study of TractivePower
TP56 Industrial Switcher Locomotive
Prime Mover Location on TractivePower TP56 Industrial Switcher Locomotive
Hybrid HFC – Battery Buffer Options for TractivePower TP56 Industrial Switcher

<table>
<thead>
<tr>
<th>ID</th>
<th>Device Name</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>Fuel Cell 90kW</td>
</tr>
<tr>
<td>B</td>
<td>DC-DC Booster (400-600V) + Battery (24KWh/75Ah/150Cells)</td>
</tr>
<tr>
<td>CD</td>
<td>Cooling (120kW Heat Removal)</td>
</tr>
<tr>
<td>E</td>
<td>H2 Tank (W205 QTY=12 x5kg)</td>
</tr>
</tbody>
</table>

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<tr>
<th>ID</th>
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<tbody>
<tr>
<td>A</td>
<td>Fuel Cell 30kW+DCDC*+Battery**</td>
</tr>
<tr>
<td>B</td>
<td>Cooling (40kW Heat Removal)</td>
</tr>
<tr>
<td>C</td>
<td>Fuel Cell 30kW+DCDC*+Battery**</td>
</tr>
<tr>
<td>D</td>
<td>Cooling (40kW Heat Removal)</td>
</tr>
<tr>
<td>E</td>
<td>H2 Tank (W205 QTY=12 x5kg)</td>
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*Booster, 300-400V, 100-75A, 30kW Rating
**Kokam XALT 53Ah, 1x String 105 Cells
TP56 Shunting Hopper Cars at Grain Elevator, Cloverdale, B.C., Canada
Datalogger Trace of Actual kW Drawn by TP56 Traction Motors During Shunting
HFC Powering Study of Heavy Rail Commuter Locomotive

- Hydrogen Storage
- Heat Removal Unit
- Power Buffer Storage
- Drive and Controller
- Fuel Cell
Speed Profile of GO Transit Burlington – Toronto – Oshawa Commuter Line

- 18 Station Stops; 101.5 km; 1 hour 37 minutes
Former GO Transit EMD F59PH as Candidate for HFC Repower Demo
Former EMD F69PH-AC as Candidate for HFC Repower Demonstration
(Same Body as EMD F40PHM-2)
Grateful for Suggestions of Candidate Railway Applications for HFC Powering

Thank you

Peter Eggleton
Principal Consultant
TELLIGENCE Group
Saint-Lambert (Montreal),
Quebec, J4S 1H4, Canada
Tel: 1+450-672-5026
Email: peter.eggleton@videotron.ca