Utilization of Fuel Cells for Trains

Coradia iLint

Wolfram Schwab/Andreas Frixen
Tokyo, 21st January 2018
AGENDA

1. Alstom Transport
2. Coradia iLint
A complete range of transport solutions

- Tram, metro, suburban/regional, high speed, very high speed, locomotive
- E-bus
- Components: traction, bogie, motor

**ROLLING STOCK**

- Signalling solutions portfolio for urban, main line, freight and mining and digital mobility
- Sold as products or solutions

**SIGNALLING**

- Maintenance
- Modernisation
- Spare parts, repairs & overhaul
- Support services

**SERVICES**

- Integrated solutions
- Infrastructure

**SYSTEMS**
2016/17, a sound performance for Alstom

**ACTIVITY (%) of sales**

<table>
<thead>
<tr>
<th>Activity</th>
<th>% of Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolling Stock</td>
<td>43%</td>
</tr>
<tr>
<td>Signalling</td>
<td>19%</td>
</tr>
<tr>
<td>Services</td>
<td>20%</td>
</tr>
<tr>
<td>Systems</td>
<td>18%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7.3</strong></td>
</tr>
</tbody>
</table>

**Billion Sales**

<table>
<thead>
<tr>
<th><strong>2016/17, a sound performance for Alstom</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ORDER (%) per region</strong></td>
</tr>
<tr>
<td><strong>AMERICAS</strong></td>
</tr>
<tr>
<td><strong>EUROPE</strong></td>
</tr>
<tr>
<td><strong>ASIA PACIFIC</strong></td>
</tr>
<tr>
<td><strong>MIDDLE EAST &amp; AFRICA</strong></td>
</tr>
<tr>
<td><strong>%</strong></td>
</tr>
<tr>
<td><strong>29%</strong></td>
</tr>
<tr>
<td><strong>51%</strong></td>
</tr>
<tr>
<td><strong>6%</strong></td>
</tr>
<tr>
<td><strong>14%</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
<tr>
<td><strong>10.0 Billion Orders</strong></td>
</tr>
</tbody>
</table>

**5.8% OPERATING MARGIN**

**€208 MILLION NET DEBT**

All figures at 31 March 2017

*Adjusted EBIT margin
An ambitious strategy for 2020

OUR VALUES
- TEAM, TRUST & ACTION
- ETHICS & COMPLIANCE

OUR STRATEGY
1. CUSTOMER-FOCUSED ORGANISATION
2. COMPLETE RANGE OF SOLUTIONS
3. VALUE CREATION THROUGH INNOVATION
4. OPERATIONAL AND ENVIRONMENTAL EXCELLENCE
5. DIVERSE AND ENTREPRENEURIAL PEOPLE

OUR BRAND POSITIONING
DESIGNING FLUIDITY

OUR VISION
PREFERRED PARTNER FOR TRANSPORT SOLUTIONS
Customer-focused organisation with a global presence

- **32,800 employees** working on **105 sites** in **60 countries** serving **200 customers**

  - **Regions:** close to customers, in charge of execution
  - **Operational functions:** global cohesion, processes and platforms
  - **Support functions:** finance, legal, HR, global efficiency

**Objective:** becoming No.1 or No. 2 on every continent
Clear political objective: drastic reduction of CO₂
Our railway sector can be a pioneer!

The head of the Paris Conference, France's foreign minister Laurent Fabius, said this "ambitious and balanced" plan is a "historic turning point" in the goal of reducing global warming.
Hydrogen as key towards Emission-free Mobility

Alstom’s contribution
Coradia iLint
Key drivers for public transport

- Environmental needs
- New regulations
- New technology
- Economical solutions
- Sustainable public transport

* Source: UN Sustainable Goals
It’s all about Energy and Weight

Energy density (in MJ/kg)

**Coal**
- Picture of coal
- 34 MJ/kg

**Diesel**
- Picture of a diesel train
- 43 MJ/kg

**Hydrogen**
- Picture of hydrogen bubbles
- 120 MJ/kg
Coradia iLint
4 LOIs signed with 4 German PTA’s in 2014

- **Lower Saxony:**
  14 trains until end of 2021

- **North Rhine Westphalia:**
  14 trains until 2021 / 2022

- **Hesse:**
  20 trains until the end of 2021

- **Baden-Wuerttemberg:**
  10 trains until the end of 2022 (plus option of 5 trains)
Coradia iLint with hydrogen as fuel

Premiere at the InnoTrans 2016
The diesel technology is replaced with hydrogen and fuel cell technology

- Electric drive system
- Primary energy by fuel cells
- Intermediate storage by li-ion batteries...
  - …for additional acceleration
  - …for the recovery of braking energy
- Combined propulsion and energy storage system
The manufacturing method of the hydrogen is decisive for the savings of CO₂

Major decrease of CO₂ emission

- Diesel-Lint
- H₂ out of natural gas reformation
- H₂ out of electrolysis with „Green Electricity“

-45%  -95%
Our mission: A joint service out of one hand – emission-free availability!

Operator receives a maintained and tanked vehicle!

Construction and operation of the H2 infrastructure (with partners)

Delivery of the trains

We provide emission-free availability

Maintenance and service
Hydrogen Infrastructure

<table>
<thead>
<tr>
<th></th>
<th>Network 1</th>
<th>Network 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amount of trains</strong></td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td><strong>Km per day</strong></td>
<td>600 km</td>
<td>750 km</td>
</tr>
<tr>
<td><strong>H₂ per km</strong></td>
<td>0.25 kg/km</td>
<td></td>
</tr>
<tr>
<td><strong>Consumption per day</strong></td>
<td>1.500 kg</td>
<td>3.750 kg</td>
</tr>
</tbody>
</table>

Production, Transport and storage of large quantities of hydrogen
Electrolysis
Basis for environmentally friendly traffic solutions

H₂
Production of Hydrogen using regenerative sources

Approx. **10 MW**
Wind power required…

…supply **4 MW** electrolysis…

…to operate a fleet of **15 iLints!**
Hydrogen & Hydrogen Technology from The Linde Group: Hydrogen from electrolysis
Site-Layout – Top-View
Wuppertal, Germany

Source: Hydrogenics
Hydrogen Fueling

Onsite hydrogen generation eliminates need for hydrogen tube trailer deliveries in downtown core.

Hamburg, Germany

780kg/day, 350/700 bar dispensing

Located in the center of Hamburg in front of “Der Spiegel” newspaper offices, the station is the biggest worldwide, capable to refill busses and passenger cars. The station has 120Nm³/h electrolysers, 430kg 45bar storage and 250kg 830bar storage and follows the SAE J2601 refueling protocol.
## Coradia iLint

### Key factors of differentiation

<table>
<thead>
<tr>
<th></th>
<th>Diesel hybrid with batteries</th>
<th>Electric train with batteries</th>
<th>Hydrogen fuel cell train</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Autonomy</strong></td>
<td>900-1000 km</td>
<td>40-60 km (w/o catenary) *)</td>
<td>&gt; 800 km</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>High</td>
<td>High</td>
<td>Low (&lt; 18 t/axle)</td>
</tr>
<tr>
<td><strong>Flexibility in Operation</strong></td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Infrastructure</strong></td>
<td>Diesel re-fueling</td>
<td>Battery charging</td>
<td>HRS - Hydrogen Re-fueling Station</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td>Not emission-free</td>
<td>Emission-free</td>
<td>Emission-free</td>
</tr>
</tbody>
</table>

*) source Bombardier
Coradia iLINT Program

- **Development**
  - 07/2014: Start iLint Project

- **Prototypes / First Trains**
  - 2014 - 2015: Production of two prototypes
  - 2016: Homologation of Prototypes in Germany

- **Orders**
  - 2018-2020: Prototypes in Passenger Service
  - 2021/2022: Start of fleet operations
Coradia iLint
1 Contract + LOIs signed for around 60 trains in Germany

- Lower Saxony: 14 trains until 2020 / 2021
- North Rhine Westphalia: 14 trains until 2020 / 2021
- Hesse: 20 trains until the end of 2021
- Baden-Wuerttemberg: 10 trains until the end of 2021 (plus option over 5 trains)

Great interest from other federal states

Signed 10 Nov 2017
Also ideal prerequisite for emission-free public rail transport in Canada and European countries

- Ambitious climate protection goals
- Trendsetting traffic management
- Local hydrogen production
We would like to go new ways together with you!

- Passenger service of two vehicles in Germany 2018
- Development of the hydrogen infrastructure
- Start of operation in four federal states using up to 60 vehicles in 2020 / 2021
- Further partners are welcome!
Back-up

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