Hydrogen and Fuel Cells in Passenger Rail Transit

Mark Kammerer, on behalf of Michael Ritter

27.06.2017
Alstom offers a full range of products and services for the growing rail market

Trains

Systems

Services

Signalling
With a worldwide presence, Alstom is able to serve its clients on a global level.

32,000 employees working at 105 sites in 60 countries serving 200 customers.

- **NORTH AMERICA**: 1,900 employees, 9% of sales.
- **LATIN AMERICA**: 2,800 employees, 9% of sales.
- **FRANCE**: 9,200 employees, 18% of sales.
- **EUROPE**: 13,600 employees, 40% of sales.
- **MIDDLE EAST**: 1,500 employees, 12% of sales.
- **AFRICA**: 32,000 employees working at 105 sites in 60 countries serving 200 customers.
- **CIS**: 300 employees, 1% of sales.
- **ASIA PACIFIC**: 2,700 employees, 11% of sales.
Clear political goal for reduction of CO2 – the rail sector can be a leader!

Climate Protection Plan brings Reduction Target for Transport Sector: 40 Percent less CO2 by 2030

Alliance pro Rail welcomes the Agreement / Kickoff for transfer policy?

*Paris Climate Accord in Force*

“This is a turning point for climate protectors. The worldwide climate protection movement receives a fundamental law”, said the German Federal Environment Minister Hendricks.
The vision: Our customers receive emission-free train availability

Construction and operation of the H2 infrastructure (with partners)

Maintenance and service

Delivery of the trains

We provide emission-free availability

Operator receives a maintained and tanked vehicle!
First prototype of Coradia iLint was unveiled to the public at InnoTrans in Berlin in September 2016
Inside the iLint offers the same possibilities as the Lint 54 – e.g.: 150 seats
First two prototypes in full test-operation by the end of this year

- **07/2014**
  - Start of iLint project

- **2014 - 2015**

- **2016**
  - Production of two prototypes

- **2017**
  - 12/2017
    - Homologation of prototypes

- **2018**
  - 2018
    - Prototypes in passenger operation

- **2019 - 2021**
  - 2020/21
    - Possible start of first fleets

Today
In the Coradia iLint the Diesel engine is replaced by hydrogen and fuel cell technology

- Electric drive system
- Primary energy from fuel cells
- Intermediate storage from Li-ion batteries
  - For additional acceleration
  - For recuperative breaking energy
- Combined drive and energy storage system
Alstom develops own energy and power management

- Energy management
- Power management
- Battery
- Fuel cell
- Drive and onboard systems
Refueling occurs in the middle of the vehicle via two connections simultaneously

- 2 standard connections per side of the vehicle
- Fueling is conducted and switched off dependent on pressure and temperature
- Refueling time approximately 15 minutes at 20°C ambient temperature
- Tank filling pressure up to 350 bar
Decisive for CO\textsubscript{2}-savings is the source of the hydrogen – here we go step-by-step

CO\textsubscript{2} emission per vehicle km (in kg)

- **Diesel Lint**: 4.3
- **H\textsubscript{2} from natural gas reforming**: 2.3 (40% reduction)
- **H\textsubscript{2} from electrolysis with “green electricity”**: 0 CO\textsubscript{2}
With green hydrogen, one iLint saves about ~700t of CO₂ per year, a typical fleet of 15 trains more than 11,000t

- **Savings per iLint**

  
  ![Image of iLint train]

  - **minus** 700t CO₂ per year...
  - ...corresponds to the annual output of 400 cars

- **Savings per iLint fleet**

  ![Image of iLint train fleet]

  - **minus** 11,000t CO₂ per year...
  - ...corresponds to the annual output of 6,000 cars
Providing a feasible hydrogen infrastructure is our main challenge

Hydrogen per day (examples)

<table>
<thead>
<tr>
<th></th>
<th>Network 1</th>
<th>Network 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Trains</td>
<td>10 trains</td>
<td>20 trains</td>
</tr>
<tr>
<td>km per day</td>
<td>600 km/day</td>
<td>750 km/day</td>
</tr>
<tr>
<td>H₂ per km</td>
<td>0.30 kg/km</td>
<td>0.30 kg/km</td>
</tr>
<tr>
<td>Consumption per day</td>
<td>1800 kg</td>
<td>4500 kg</td>
</tr>
</tbody>
</table>

Comparison: A large car fueling station typically stores 200 kg hydrogen

Challenge: Production, Transport and Storage of large amounts of hydrogen
Local usage of wind energy provides a solution to increasingly overloaded electricity grids

As **capacity** of renewable energy grows…

… **electricity grids** are increasingly under stress.

Solution: **Local usage of green electricity for electrolysis**
10 MW of wind power can produce enough hydrogen fuel via an electrolysis plant for 15 iLints

About 10 MW of wind power is enough…

…to power an electrolysis plant…

…to run a fleet of 15 iLints
Green hydrogen as a basis for further environmentally friendly transport solutions
Current taxes and other charges impede the competitiveness of true green hydrogen

Fuel cost per km

- Diesel today
- Hydrogen from existing sources
- Hydrogen from renewable electricity
Already today LOIs are signed for more than 50 FC trains – Start of operation in Lower Saxony

- **Lower Saxony:**
  14 Trains, first 2 trains beginning of 2018, full fleet mid 2020

- **North Rhine Westphalia:**
  14 Trains up to the end of 2020

- **Hessen:**
  20 trains by end of 2021

- **Baden-Württemburg:**
  10 Trains by end of 2021 (plus option for 5 trains)

- **Great interest from further German Federal States**
Substantial and growing market potential in several European countries

Characteristics of target markets:

- Ambitious climate protection goals
- Trendsetting traffic management
- High potential in energy generation
- Local hydrogen production