Fuel cell electric buses across North-East Europe, Riga activities

BSR Hydrogen Network Conference
Riga

7th December 2017
The consultancy team is being led by Element Energy (also the UK cluster coordinator), and includes partners to coordinate activities across Europe:

- **France** – Hydrogène de France
- **Germany** – ee energy engineers & hySOLUTIONS
- **Netherlands** – Rebel Group & Twynstra Gudde
- **Northern Europe** – Latvian Academy of Sciences
- **UK** – Element Energy
Objectives

- Deploy 142 FC buses across nine cities
- Achieve 30% cost reduction versus state of the art
- Operate 50% of the vehicles for at least 36 months
- Deploy the largest capacity HRS in Europe
- Achieve near 100% reliability of HRS
- Demonstrate technological readiness of FC buses and HRS
- Encourage further uptake

JIVE: Joint Initiative for hydrogen Vehicles across Europe

JIVE will be a six year project, that started on the 25th of January 2017
JIVE 2: Joint Initiative for hydrogen Vehicles across Europe Phase 2

Objectives
Deploy 152 FC buses across 14 cities
Achieve a maximum price of €625k for a standard fuel cell bus
Operate buses for at least three years / 150,000 km
Validate large scale fleets in operation
Enable new entrants to trial the technology
Demonstrate routes to low cost renewable H₂
Stimulate further large scale uptake

Total = 291 new FC buses for Europe

- Benelux Cluster (50 FC buses)
- France Cluster (15 FC buses)
- Germany / Italy Cluster (88 FC buses)
- Northern / Eastern Europe Cluster (50 FC buses)
- UK Cluster (88 FC buses)
Northern Europe cluster cities

- Riga (Latvia);
- Gavleborg (Sweden);
- Oslo (Norway);
- Herning (Denmark);
- Reykjavik (Iceland);
- Vejle (Denmark);
- Kolding (Denmark);
- Landskrona (Sweden);
- Copenhagen (Denmark);
- Trondheim (Norway);
- Tallinn (Estonia);
- Parnu (Estonia);
- Warsaw (Poland);
- Gdynia (Poland);
- Poznan (Poland);
- Liepāja (Latvia);
- Helsinki (Finland);
Riga chronology

- Study "Use of hydrogen technologies in Riga public transport, environmental and economic aspects";


- HIT 2 – Corridors Hydrogen Infrastructure for Transport. As part of this project HRS were deployed in Gothenburg, Stockholm and Voikoski (Finland). HRS implementation plans for Finland, Riga region, Poland and Belgium were developed. Study: Hydrogen as transport fuel refueling infrastructure implementation in Riga and Riga region. Co-financed by TEN-T;

- “NewBusFuel” - Engineering studies for hydrogen refueling infrastructure development for large scale bus depots. Funded by FCH JU;
“H2 Nodes”

GA CEF TRANSPORT No: INEA/CEF/TRAN/M2014/1025986
Action No.: 2014-EU-TM-0643-S
H2Nodes – evolution of a European hydrogen refueling station network by mobilizing the local demand and value chains.

- H2Nodes Action looks into planning and realizing a chain of HRS and boosting implementation of FCEV along the North Sea - Baltic TEN-T core network corridor;

- The focus is on market sided innovation by real-life deployment with local studies and processes to boost market introduction;

- RM LLC “Rigas Satiksme” pilot of the innovative concept HyTrolleys where two alternative fuels electricity and hydrogen are combined to allow the benefit from the advantages of both technologies and provide greater flexibility in the urban transport system - less noise, zero emissions and better energy efficiency
Riga city public transport routes
Riga city, bus and trolleybus routes
bus route nr.40: Jugla3 - Ziepniekkalns
By evaluating existing routes of diesel buses, for replacement possibilities by trolleybus with spare traction power provided by diesel generator or hydrogen fuel cell, it was concluded that it is feasible. In the calculation were compared spare traction power providing diesel generators and hydrogen fuel cell FC velocity HD7 operating expenses.

Potential savings:

- Bus / Trolleybuss with diesel genset - 25 %
- Bus / Trolleybuss with FC - 27 - 35%*

* Significant impact on results have hydrogen source and production solution.
Comparison of different powertrains

<table>
<thead>
<tr>
<th>Similar performance</th>
<th>Differentiated performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Passenger capacity</strong></td>
<td><strong>C</strong> CNG</td>
</tr>
<tr>
<td><strong>Curb weight</strong></td>
<td>Lowest: Diesel (11.6 t)</td>
</tr>
<tr>
<td>(12-m bus)</td>
<td><strong>O</strong> Overnight e-bus</td>
</tr>
<tr>
<td><strong>Highest: Overnight e-bus (13.5 t)</strong></td>
<td><strong>O</strong> Overnight e-bus</td>
</tr>
</tbody>
</table>

### Acceleration, time to accelerate to 30 km/h, sec

<table>
<thead>
<tr>
<th>Powertrain</th>
<th>12.5</th>
<th>10.0</th>
<th>7.5</th>
<th>5.0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O</strong> Overnight e-bus</td>
<td><strong>V</strong> V</td>
<td><strong>H</strong> H</td>
<td><strong>C</strong> C</td>
<td><strong>P</strong> P</td>
</tr>
</tbody>
</table>

### Range, km

<table>
<thead>
<tr>
<th>Powertrain</th>
<th>0</th>
<th>50</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>&gt;300</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O</strong> Overnight e-bus</td>
<td><strong>V</strong> V</td>
<td><strong>H</strong> H</td>
<td><strong>T</strong> T</td>
<td><strong>C</strong> C</td>
<td><strong>P</strong> P</td>
<td><strong>S</strong> S</td>
<td><strong>D</strong> D</td>
</tr>
</tbody>
</table>

### Range in pure-electric mode, km (logarithmic scale)

<table>
<thead>
<tr>
<th>Powertrain</th>
<th>0</th>
<th>3</th>
<th>10</th>
<th>30</th>
<th>100</th>
<th>&gt;300</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C</strong> CNG</td>
<td><strong>D</strong> D</td>
<td><strong>P</strong> P</td>
<td><strong>S</strong> S</td>
<td><strong>O</strong> O</td>
<td><strong>V</strong> V</td>
<td><strong>H</strong> H</td>
</tr>
</tbody>
</table>

### Refuelling time, logarithmic scale

<table>
<thead>
<tr>
<th>Powertrain</th>
<th>10 hr</th>
<th>5 hr</th>
<th>2 hr</th>
<th>1 hr</th>
<th>30 min</th>
<th>10 min</th>
<th>5 min</th>
<th>1 min</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>V</strong> V</td>
<td><strong>C</strong> C</td>
<td><strong>O</strong> O</td>
<td><strong>D</strong> D</td>
<td><strong>P</strong> P</td>
<td><strong>S</strong> S</td>
<td><strong>T</strong> T</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Typical values shown here – pure electric range of hybrid powertrains varies depending on concept of auxiliary units and battery capacity
2. Based on a 60 kWh battery and a consumption (incl. losses from charging) of 2 kWh/km

Source: FCH JU study “Urban buses, alternative powertrains for Europe”
Bus and trolleybus depots

- Ganibu dambis 32
- Kleistu street 28
- Vestienas street 35
- Jelgavas street 37
Bus and trolleybus depots

Operating 142 diesel buses, total area of depo 80 170 m², diesel storage for refueling 250 000 L

Operating 256 diesel buses, total area of depo 47 547 m² and additional is ~ 32 000 m², diesel storage for refueling 250 000 L

Operating 123 trolleybuses (67 equipped with diesel APU). Total area of depo 56 693 m², diesel storage for refueling 9 000 L

Operating 126 trolleybuses. Total area of depo 56 693 m², diesel storage for refueling 9 800 L
Main characteristics:
- H2 production capacity 300 kg/day
- 350 bar and 700 bar dispensers
- H2 storage 600 kg

Disposition of the HRS next to Riga Municipal LLC “Rigas satiksme” 2nd trolleybus park in Jelgavas street 37
Findings

- **Traction power** for public transport most efficiently can be provided with **electric motor**;

- **Security of energy supply** and **energy efficiency** of public transport and urban infrastructure can be provided through introduction of **alternative fuels** and **energy resources diversity** by universal energy carriers - **electricity and hydrogen**;

- The greatest benefits for **air quality** and **environment** by implementing **alternative fuels** and **zero emission vehicles** can be achieved in **urban areas**;
Riga summary

- **“H2 Nodes”** - HRS and 10 FC range extended trolleybuses;

- **“JIVE”** – 10 FCE buses;

- **EIB loan – 75 M EUR** for construction of hydrogen refueling, production and storage facility, purchase of 10 hydrogen fuel cell (HFC) buses and 10 Hytrolleys with HFC range extenders. Purchase of 20 new low-floor tram units to operate in the city of Riga, and modernisation of tramway infrastructure and depot.
Next steps

- Development of the common technical specification for 12m and 18m FCE-buses;

- "joint procurement" legal background;

- Established evaluation criteria together with BSR Hydrogen Network partners;

- Initiation of new FCE-bus demonstration projects.
Thank You for attention!

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