Fuel cell Electric Bus: It works and it’s ready!
INTRODUCTION VAN HOOL

- 70 Years Bus Experience
- Family owned and managed
- Export 90% of our products Worldwide
- 4,900 Employees in two production facilities with the latest addition in Morristown Tennessee (Under Construction)
- 1,200 Output Buses and Coaches yearly
- 4,000 Industrial vehicles yearly
- Flexibility in Design and Market requirements
- Innovator in technologies
For over 70 years, Van Hool has a reputation for designing and building high quality, state-of-the-art, customized transportation products.

HISTORY
More than 70 years
With regard to solutions for zero-emission, Van Hool is technology neutral, thus all solutions are being developed.
FUEL CELL BUS REFERENCE PROJECTS

131 FC buses sold
Hydrogen has most potential to become the disruptive technology driving large scale zero-emission deployment. **It is physics driving the solution**

<table>
<thead>
<tr>
<th>Battery-Electric Bus</th>
<th>Fuel Cell-Electric Bus</th>
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<tbody>
<tr>
<td>Usable energy on the bus</td>
<td>250 kWh</td>
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<td>Energy density H2 = 33 kWh/kg</td>
<td>600 kWh</td>
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<td>Time to charge</td>
<td>1 hour</td>
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<td>H2 = Gas/liquid</td>
<td>7 minutes</td>
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<td>Assume 5 stacks H2:(36 kg useable H2 or 1.200 kWh) x 50% efficiency</td>
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<td>250 kW of charging power</td>
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<td>Standard filling</td>
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X 2.4 MORE  
X 8.5 FASTER
Hydrogen has the potential to become the most disruptive technology being accepted by society. **WHY? It’s habits will be “driving” the acceptance of the solution!**

### Habits Driving the Acceptance

**Charging habit**
- **Battery-Electric Bus**
  - Connection to charging infrastructure/charging protocol's/driver waiting times/monitoring systems
- **Fuel Cell-Electric Bus**
  - Fuel filler pistol
  - Full day autonomy

**Driving habit**
- **Battery-Electric Bus**
  - The “What if” Stress
- **Fuel Cell-Electric Bus**
  - As easy as diesel
  - As easy as diesel

**Growing importance @ higher volumes**
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<td>1. gen. Europe 3-axle</td>
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<tr>
<td>Number Buses</td>
<td>5</td>
<td>16</td>
<td>1</td>
<td>5</td>
<td>22</td>
<td>82</td>
</tr>
</tbody>
</table>

- 13 years of building experience
- Running over several development phases
- Small scale projects
- Highly supported by FCH JU
READY FOR LARGE SCALE PRODUCTION

Standardised technical definition for Low Floor City Bus

- **Flat Urban Service Line**
  24 kWh traction battery and 85 kW hydrogen fuel stack
- **Regional and hilly City Service Line**
  36 kWh traction battery and 85kW hydrogen fuel stack

Standardised service concept

- Spare parts management
- Dedicated service technicians
- SLA contracts with main suppliers

Standardised documentation

- Manuals, service documents
- Training packages
FUEL CELL BUS SERIES PRODUCTION
INAUGURATION AT UITP STOCKHOLM

Inauguration of the first fuel cell bus for RVK Cologne

First fuel-cell bus of a 35 bus order

First bus produced in a standardized series of buses at Van Hool

Current capacity of fuel cell bus production line : 2.5 buses/week.
Increased Direction of Activities to Realize a “Hydrogen-Society”:
- Hydrogen as a means to store energy
- Sector integration with hydrogen as a decoupler
- Large-scale hydrogen production
- Large-scale hydrogen ocean transportation network
- Charging infrastructure constraints in congested cities
- Carry-over effects with H2 cars, H2 trucks, H2 trains
- Strategic importance to keep added-value in Europe...

Top-down analysis
Efficiency @ “Big system” level

- Full day autonomy (also in winter)
- Fast fuel filling concept
- No driver waiting times
- No excess spare buses
- Flexibility in service
- Charging infrastructure in centralised location at depot

Efficiency @ operator level

- Battery electric
  - 125 miles/Bus/day

- Fuel cell electric

Energy efficiency at bus level
Bottom-up analysis

Strategic Development Intent of Van Hool:

Fuel Cell solutions have a growing importance:

- Fuel Cell dominant bus with “small” batteries vs.
- Battery buses with fuel cell range extender

Battery electric solutions will remain important:

- Opportunity charging for dedicated lanes (BRT systems – range + 125 miles)
- Plug-in solutions if autonomy less than 125 miles
Thank you, Just think....... 

During this presentation 2 Hydrogen Fuel cell buses have been refuelled!