



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





HISTORY

More than 70 years



ZERO EMISSION SOLUTIONS

With regard to solutions for zero-emission, Van Hool is technology neutral, thus **all solutions are being developed.**

Trolley solutions (IMC battery)

Battery electric solutions

Fuel cell electric solutions













YAN HOOL

FUEL CELL BUS REFERENCE PROJECTS

131 FC buses sold







PHYSICS DRIVING THE SOLUTION

Hydrogen has most potential to become the disruptive technology driving large scale zero-emission deployment.

It is physics driving the solution

Usable energy on the bus Energy density H2 = 33 kWh/kg

250 kWh

Battery-Electric Bus

1 hour

Assume 250 kW of charging power

Fuel Cell-Electric Bus

600 kWh

Assume 5 stacks H2:(36 kg useable H2 or 1.200 kWh) x 50% efficiency

7 minutes

Standard filling

X 8.5 FASTER

X 2.4

MORE

Time to charge

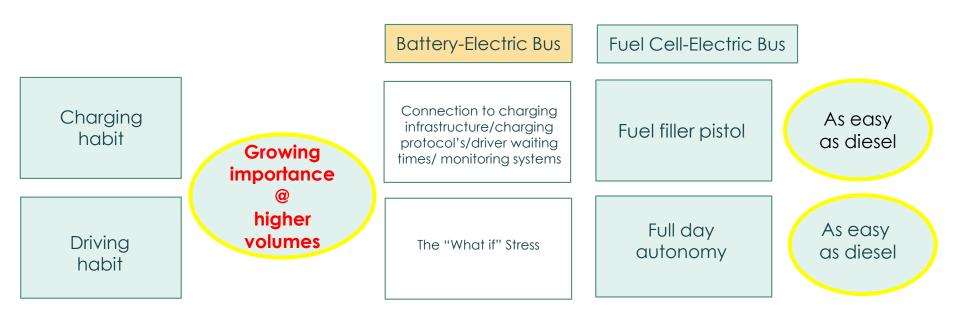
H2 = Gas/liquid



HABITS DRIVING THE ACCEPTANCE

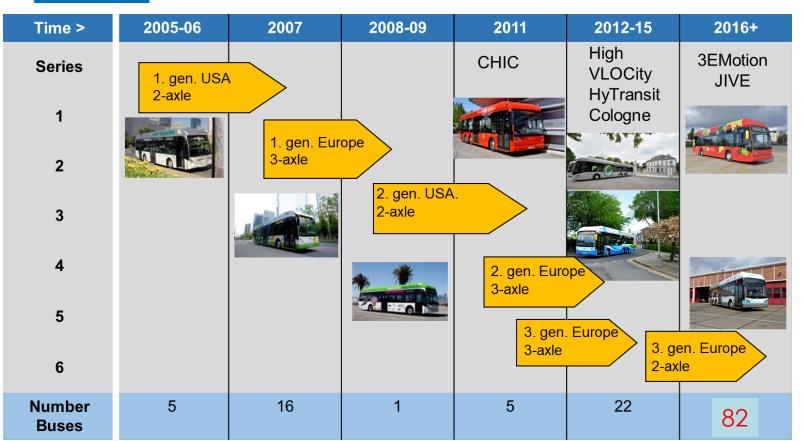
Hydrogen has the potential to become the most disruptive technology being accepted by society.

WHY? It's habits will be "driving" the acceptance of the solution!





FUEL CELL BUS DEVELOPMENT ROADMAP



- 13 years of building experience
- Running over several development phases
- Small scale projects
- Higly 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.





STRATEGIC DEVELOPMENT FUEL CELL BUS

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 / ...

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 /

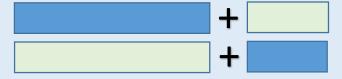
The importance of Hydrogen will grow over the coming years

Top-down analysis Efficiency @ "Big system" level Efficiency @ operator level Fuel cell electric 125 miles/ Bus/day Battery 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.



Q&A





Thank you, Just think......

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