

VAN HOOOL | Fuel Cell

**Fuel cell Electric Bus :
It works and it's ready !**



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Congres WaterstofNet 's-Hertogenbosch, november 14, 2019

INTRODUCTION VAN HOOL

- 70 Years Bus Experience (design, production, service)
- Family owned and managed
- 90% Exports Worldwide
- 4.900 Employees in two production facilities
- 1.200 Output Buses and Coaches yearly
- 4.000 Industrial vehicles yearly
- Flexibility in Design and Market requirements
- Innovator in technologies



ZERO EMISSION SOLUTIONS

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

Trolley solutions (IMC battery)



Battery electric solutions



Fuel cell electric solutions





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

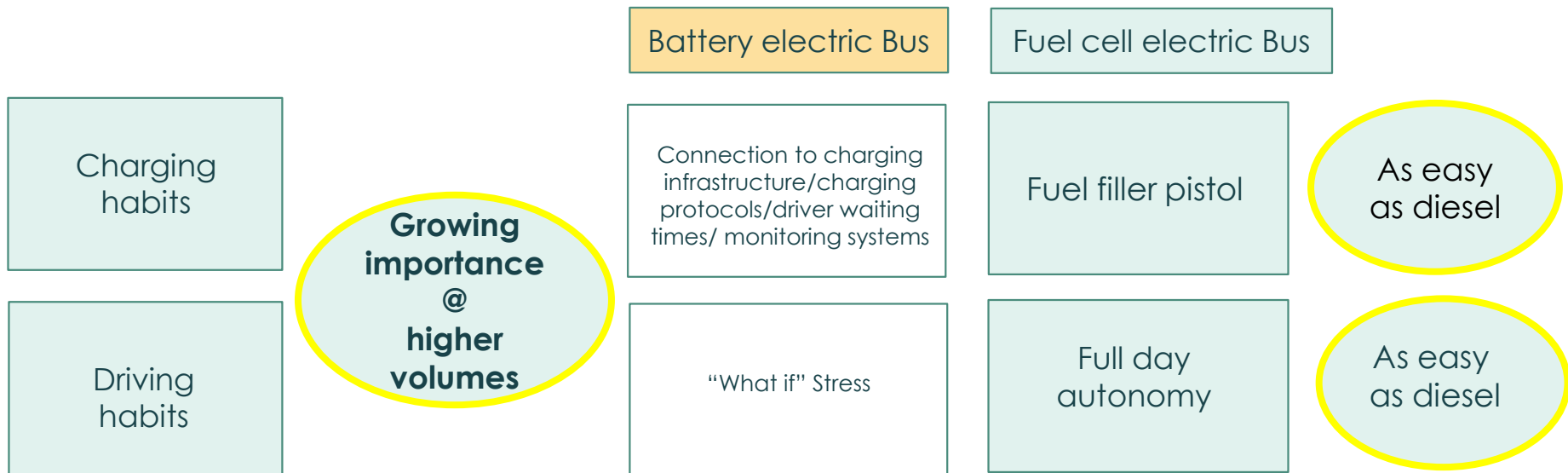
| | | Battery electric Bus | Fuel cell electric Bus | |
|--------------------------|-------------------------------|---|--|--------------|
| Usable energy on the bus | Energy density H2 = 33 kWh/kg | 250 kWh | 600 kWh Assumed 5 stacks H2:(36 kg usable H2 or 1.200 kWh) x 50% efficiency | X 2,4 MORE |
| Time to charge | H2 = Gaz/liquid | 1 hour Assumed 250 kW charging power | 7 minutes Standard filling process | X 8,5 FASTER |














HABITS DRIVING THE ACCEPTANCE

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

It is habits driving the acceptance (of the solution)



FUEL CELL BUS DEVELOPMENT ROADMAP

| Time > | 2005-06 | 2007 | 2008-09 | 2011 | 2012-15 | 2016+ |
|---------------------|---|---|---|--|---|---|
| Series | | | | CHIC | High VLOCity HyTransit Cologne | 3EMotion JIVE |
| 1 |  | | |  | |  |
| 2 | |  | | |  | |
| 3 | | |  | |  | |
| 4 | | | |  | |  |
| 5 | | | | |  | |
| 6 | | | | | |  |
| Number Buses | 5 | 16 | 1 | 5 | 22 | 82 |

- 13 years of building experience
- Running over several development phases
- Small scale projects
- Highly supported by FCH JU

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 of the first fuel cell bus for
RVK Cologne

First fuel cell bus of a lot of 35 buses

First bus produced in a standardised
series production @ Van Hool

Current capacity of fuel cell bus
production line : 2,5 buses/week.



FOLLOW-ON ORDER IN THE NETHERLANDS

Follow-on order of Qbuzz (operator in the Netherlands) after first successful experience with 2 hydrogen buses of Van Hool (photo)



PERSBERICHT

datum 25 juli 2019

Waterstoftankstation en 20 waterstof bussen voor busconcessie Groningen Drenthe

Nieuwe fase in gebruik waterstof als voertuigbrandstof



REFERENCES TRAMBUS VAN HOOL

EXQUI.CITY

174 x ExQui.City 24m



3 # to TMB Barcelona, Spain

24 m Electric Hybrid Diesel

27 # to Metz Métropole, France

24 m Electric Hybrid Diesel

5 # to Luxemburg, Luxemburg

24 m Electric Hybrid Diesel

15 # to Nobina Malmö, Sweden

24 m Electric Hybrid CNG

2 # to SKYSS Bergen, Norway

24 m Electric Hybrid CNG

14 # to Martinique, French Antilles

24 m Electric Hybrid Diesel

20 # to Linz, Austria

24 m Trolley Hybrid Battery

58 # to Trondheim

24 m Electric Hybrid Diesel

16 # Nîmes

24 m Electric Hybrid CNG

14 # Brussels

24 m Electric Hybrid Diesel

First BRT system in Europe running on hydrogen

Launch end of 2019 in Pau, France

8 Vehicles type Van Hool Exqui.City 18 FC

- Full day autonomy
- No catenary wiring, no rails
- Smooth and silent
- Zero emission without compromises

Tender won in consortium with Engie and ITM

- Bus and infrastructure in one package



Film Pau Project :
First drive with customer



Inauguration
in Pau
&
start of service
December 17



CHALLENGES FOR FUEL CELL BUSES

Hydrogen buses have many advantages (e.g. operation comparable to diesel buses), but have **2 main challenges** as well :

| | Today | Trend | Future |
|------------|---|--|---|
| TCO | <ul style="list-style-type: none"> + 20% compared to battery electric ... but no spare buses needed | <ul style="list-style-type: none"> Growing competition among manufacturers & suppliers Carry-over effects with hydrogen trucks, .. Availability of infrastructure | <p>On par or better than battery electric projects if</p> <ul style="list-style-type: none"> Large scale Long distance |
| Efficiency | <ul style="list-style-type: none"> Efficiency loss due to electrolyses (production of green hydrogen) E-loss due to reverse electrolysis on the bus (production of electricity) | <ul style="list-style-type: none"> Battery electric for the inner cities if daily autonomy less than 250 km. Plug-in solutions preferred. | <p>Development of new range of hydrogen products focused on the long distance :</p> <ul style="list-style-type: none"> Regional FC Bus FC Coach |





Thank you for your attention

(during this presentation 2 fuel cell buses have been refuelled !)