ETF BE-HyFE Project

Fuel Cell Buses for Public Transportation

Insights by Van Hool

By Geert Van Hecke

Head of Sales Public Transport Van Hool

Oktober 2021

PRODUCT PORTFOLIO

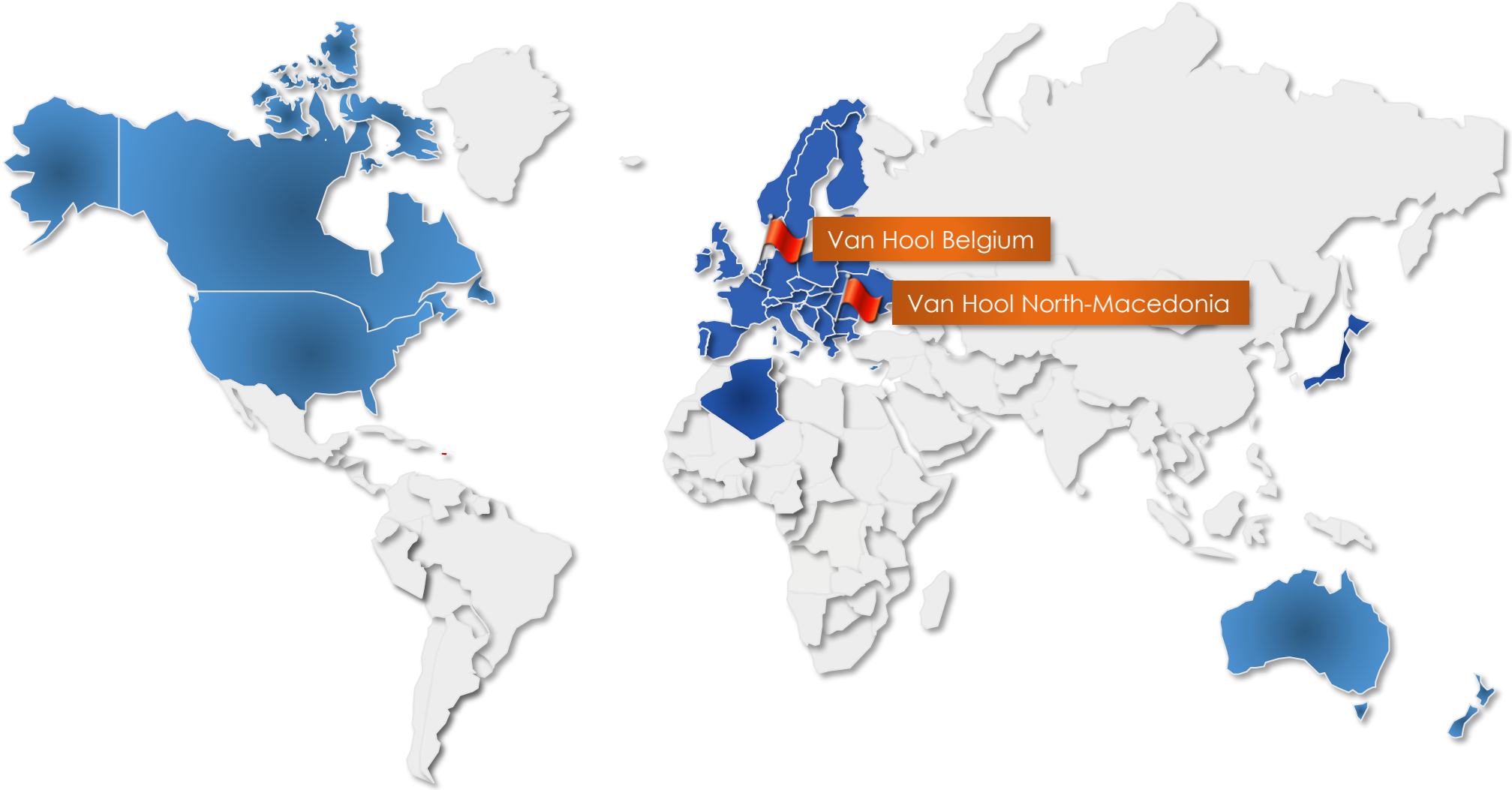
- **Bus and Coach**
- **Industrial Vehicles** : Trailers, semi-trailers and tank containers for road transport & the container sector.

Coaches

Public transport

Industrial Vehicles

Bus & Coach markets and assembly plants



VAN HOOL BELGIUM, KONINGSHOOIKT

Coach, Bus and Industrial Vehicles

Assembly and Parts Production

Area:	465.000 m²
Building :	220.000 m²
Capacity B&C :	400-1200 Units/Year
Capacity IV:	3000-4000 Units/year

VAN HOOL North-Macedonia, SKOPJE

Coach and Bus

Focus on Series Production

8 Productionslines, Assembly

Area:	170.000 m²
Building :	72.600 m²
Capacity:	1000 Units/Year
Personnel:	1000 Employees

Van Hool company introduction

- 75 years of experience in tailor made bus solutions with electrical driveline

- **Hybride**
- **Trolley**
- **Fuel-Cell**

Belfast
Trondheim
Barcelona
Pau
Aberdeen
VVM
Londen
Versailles
US
Quebec
Martinique
Keulen
Malmö
Luxemburg
Monaco
Metz
Oslo
…

building on experience – F-cell buses

Key facts :

162 F-cell buses sold

+ 10 million driven kilometers in several projects

Follow-on orders of main customers

QBuzz Groningen 2 (2017)+ 30 (2020)

RVK Cologne 2 (2014)+ 35 (2019)

Van Hool BRT solutions

More than 300 vehicles delivered creating iconic milestone projects in 17 cities.

Linz : 20 vehicles Exqui.City Trolley electric with battery IMC

Trondheim : 58 vehicles Exqui.City HVO Diesel hybrid

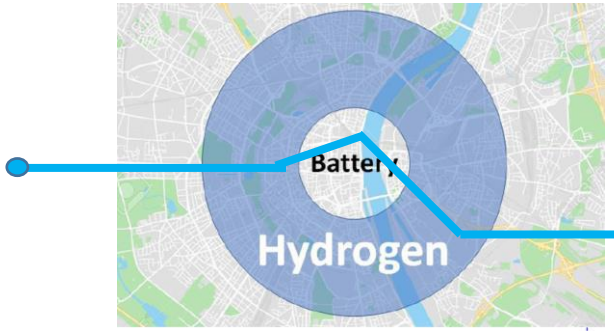
Nîmes : 13 vehicles Exqui.City Biogas hybrid with start-stop

Pau project : 8 vehicles Exqui.City electric with fuel cell

building on experience – F-cell buses for BRT

<u>Hydrogen will also become a solution for flexible BRT systems:</u>

- Project Pau, France
- In service since dec. 2019
- 8 articulated Tramlook buses
- No catenary wiring, no rails.
- + 300 km autonomy per day



building on experience – F-cell buses

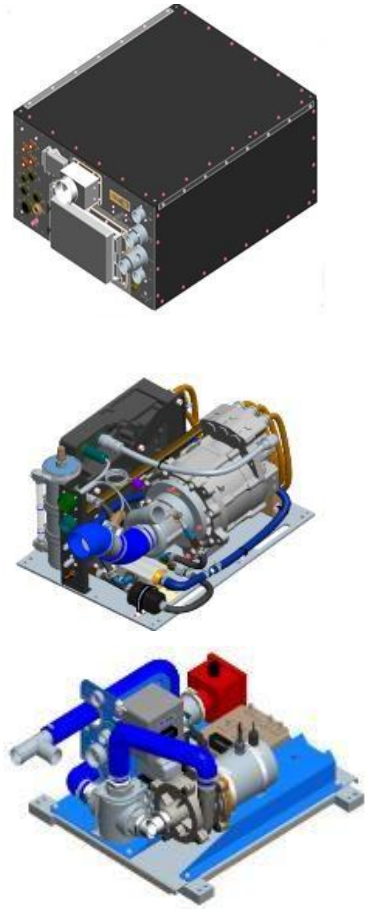
As of 2022 Van Hool starts with the series deliveries of the 4th generation of F-cell buses.

Time >	2005 - 06	2007	2008-09	2011	2012-15	2016+
Series				CHIC	High VLOCity HyTransit Cologne	3EMotion JIVE
1	1. gen. USA 2 axle					
2		1. gen. EU 3 axle				
3			2. gen USA 2 axle			
4				2. gen EU 3 axle		
5					3. gen EU 3 axle	
6						3. gen EU 2 axle
Nr. Buses	5	16	1	5	22	93

Official launch will follow.

Fourth generation fuel cell buses with newest fuel cell

Ballard FCVelocity



Ballard FC MOVE

- Integration of Fuel Cell, compressor and cooling/heating in one module.
- Cheaper in price and maintenance
- Better energy efficiencyenz

Why do customers buy F-cell buses ?

5 main reasons :

1. Range

x 1,5

Battery Bus 400 kWh
versus
Fuel cell bus with 600 kWh usable energy

2. Time to charge

x 6/ x 30

Battery Bus 1 hour@400kW (fast charge)
Battery Bus 5 hours@80kW (depot charge)
versus
Fuel cell bus in 8 to10 minutes

3. Operational flexibility

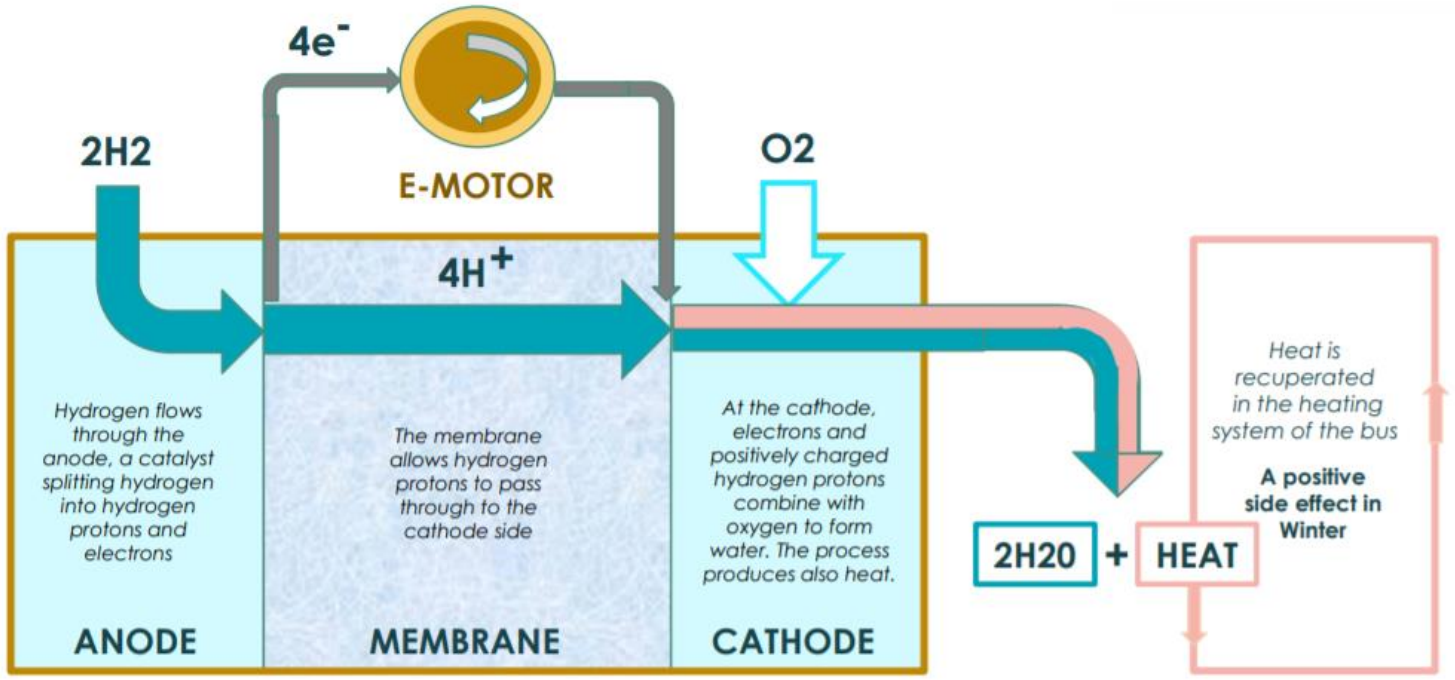
Depot & charging station centralised at one location.
100% flexibility on the road.
Growing importance for large scale project.

Picture : fuel cell bus in Versailles

Why do customers buy F-cell buses ?

5 main reasons

4. Efficiencies in cold weather conditions



THE FUEL CELL (the chemical factory inside the bus)

Why do customers buy F-cell buses ?

5 main reasons

5. Political choices (development of hydrogen supply chain ; urban integration)

Total system approach

What is the expected role for the F-cell bus manufacturer ?

Shift in focus during the last 5 years

	Focus during conferences 2016-2022 BUS	New Focus 2021-… PROJECT
1	Does the F-cell techology work ?	How to make a F-cell bus project work (safely)?
2	What is the cost of the F-cell bus ?	What is the TCO of a F-cell bus project ?
3	What is the best bus ? F-cell bus versus Battery bus.	Multi modal strategy with clear choices
4	How/when can F-cell buses be delivered ?	How to deliver a total F-cell bus project ? How fast can F-cell knowledge be transferred ?
5	What is the efficiency of the F-cell stack ?	What is the efficiency in the F-cell bus project ?

Clear choices for the 4th Generation F-cell bus

Fourth Generation key technical improvements :

1. **Flexibility for Tankprotocol Harting, IR and Fill'n Drive**

3 Possibilities :

- **With Harting Plug and Cable**
- **With IR-Protocol**
- **With Bluetooth Fill'n Drive-Protocol**

Clear choices for the 4th Generation F-cell bus

Fourth Generation key technical improvements :

1. Flexibility for Tankprotocol Harting, IR and Fill'n Drive
2. **Flexibility with regard to type of hydrogen tank**

Van Hool offers both Type 3 and Type 4 :

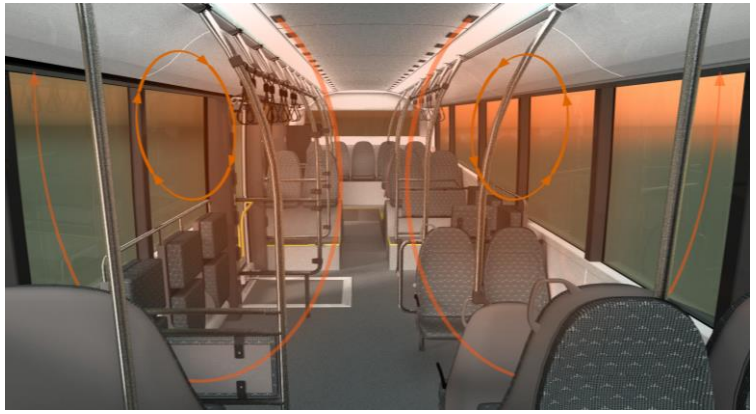
Type 3: glas fiber reinforced Alu-Container
Type 4: glas fiber reinforced Composite Container

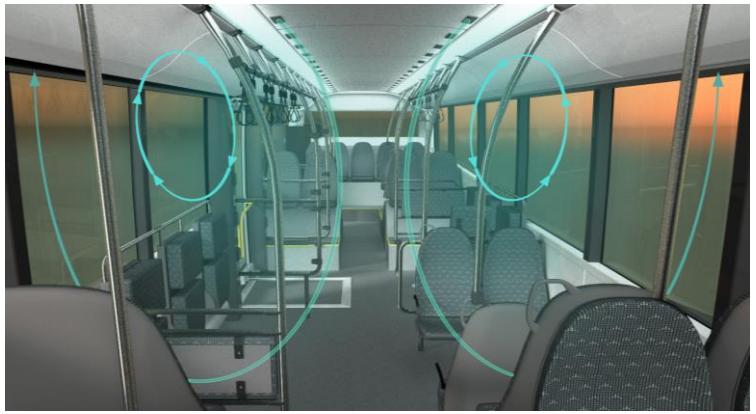
+/-	Type 3	Type 4
Weight	basis	+ 1 up to 2 Persons passengercapacity
Time to fill	basis	15 to 20% slower fill rate
Price	basis	basis

Clear choices for the 4th Generation F-cell bus

Fourth Generation key technical improvements :

1. Flexibility for Tankprotocol Harting, IR and Fill'n Drive
2. Flexibility with regard to type of H2 tank
3. **Optimised hydrogen consumption through integrated heating and cooling concept**





Patented air distribution

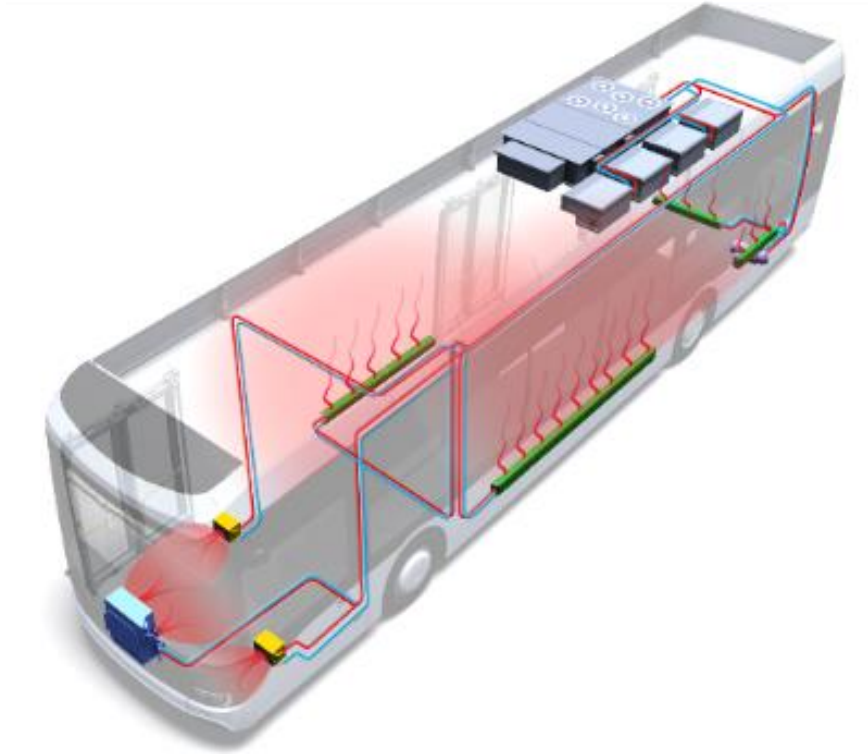
Clear choices for the 4th Generation F-cell bus

Fourth Generation key technical improvements :

1. Flexibility for Tankprotocol Harting, IR and Fill'n Drive
2. Flexibility with regard to type of H2 tank
3. **Optimised hydrogen consumption through integrated heating and cooling concept**

Completely integrated system
for driver's cab and passenger compartment
(including side wall convectors)

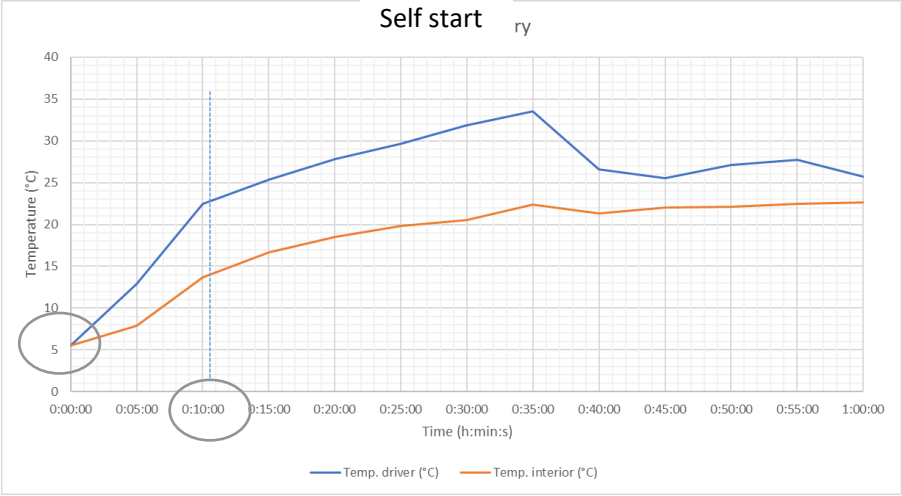
Recovery of waste heat
from the drive train and the fuel cell.



Clear choices for the 4th Generation F-cell bus

Fourth Generation key technical improvements :

1. Flexibility for Tankprotocol Harting, IR and Fill'n Drive
2. Flexibility with regard to type of H2 tank
3. Optimised hydrogen consumption through integrated heating and cooling concept
4. **Flexibility with regard to pre-conditioning**



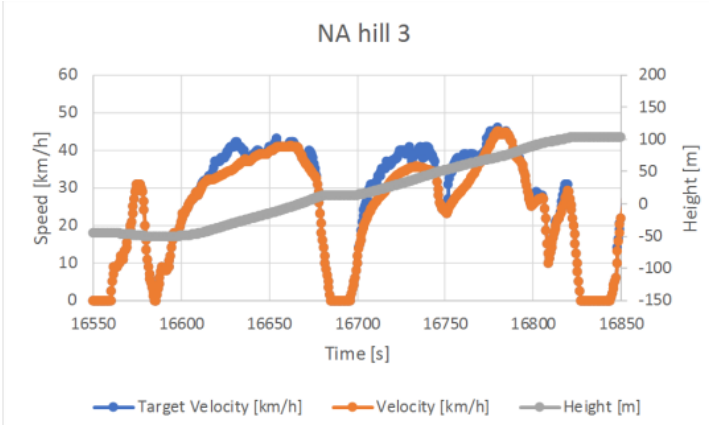
2 Possibilities :

- **Self start (without cable)**
- **Combo Charging Plug (1 @ the front right)**

Providing full project support

Analysis with Geo-Tracker

Routes & Velocities



Optimal Definition of the drive train

Additional Information / Sensitivity analysis

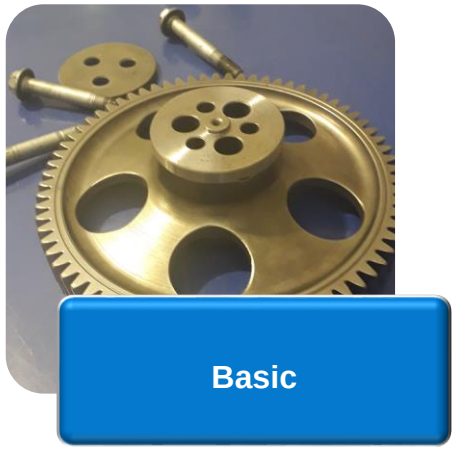
- HVAC (Influence of Winter and Summer)
- Pre-conditioning
- Desired top speed
- Desired performance driving uphill

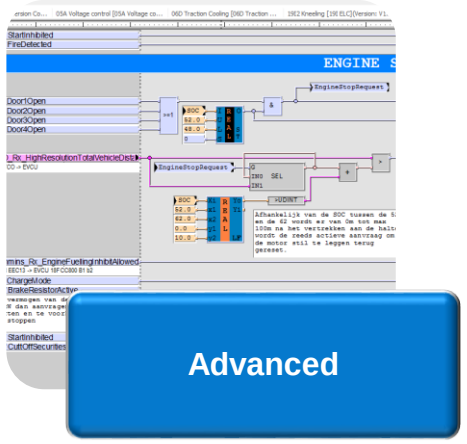
A joint assessment leads to the most suitable definition of the fuel cell bus.

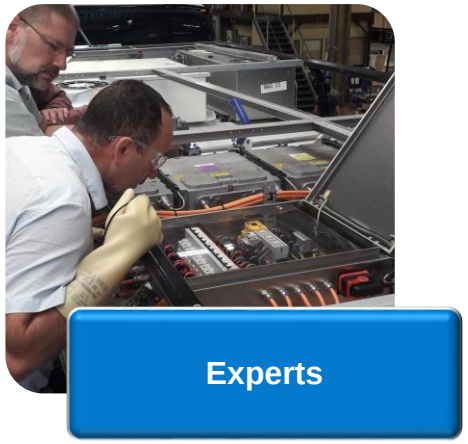
Providing full project support

Learning organisation and knowledge transfer :

VANHOOL Academy







A consistent approach towards safety

Safety measures on the bus

DETECT

Hydrogen sensors on the bus

GUIDE/EVACUATE

Bus design to guide potential hydrogen leak outwards towards sensors

STOP POTENTIAL SOURCES OF FIRE

Potential sourse of fire detected and extinguished by automatic Kidde system

Safety measures in the workshop

DETECT

Hydrogen sensors at the roof of the workshop

GUIDE/EVACUATE

Automatic opening of gates to create air circulation
Automatic opening of roof hatches

STOP POTENTIAL SOURCES OF FIRE

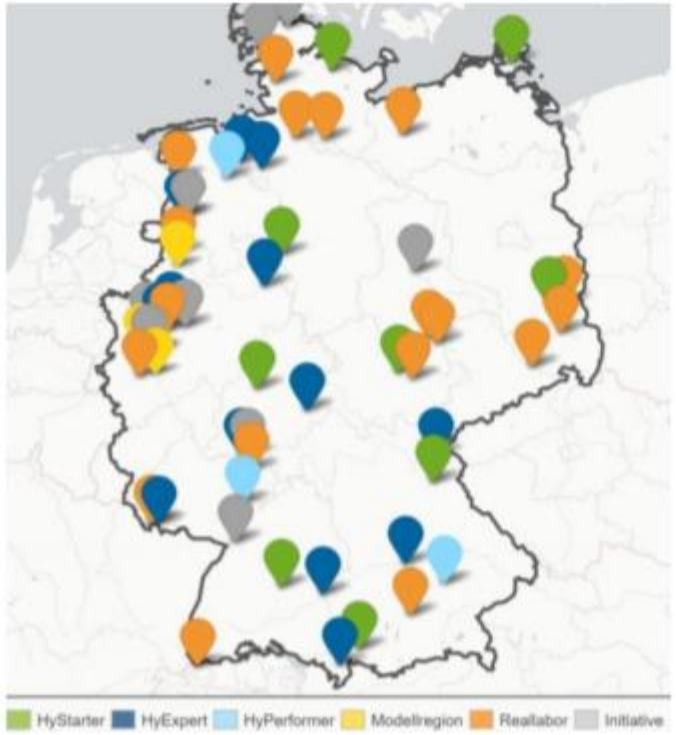
Workshop specific safety drills

Market expectations for fuel cell buses

Upward trend : Germany, France, Netherlands, UKK, Belgium (MIVB)

Example Germany :

- Structured and systematic approach to develop the hydrogen ECO-system
- Development of hydrogen ECO-System considered of strategic importance in the country.
- Commercial initiatives starting to take over.



H2Live : available H2 tankstations

Inauguration Stockholm in 2019 :
The key of the first bus of the biggest EU hydrogen fleet (35 FC buses) is handed over by Jan Van Hool to RVK Köln.

20 F-cell buses of fourth generation sold tot date

Q & A