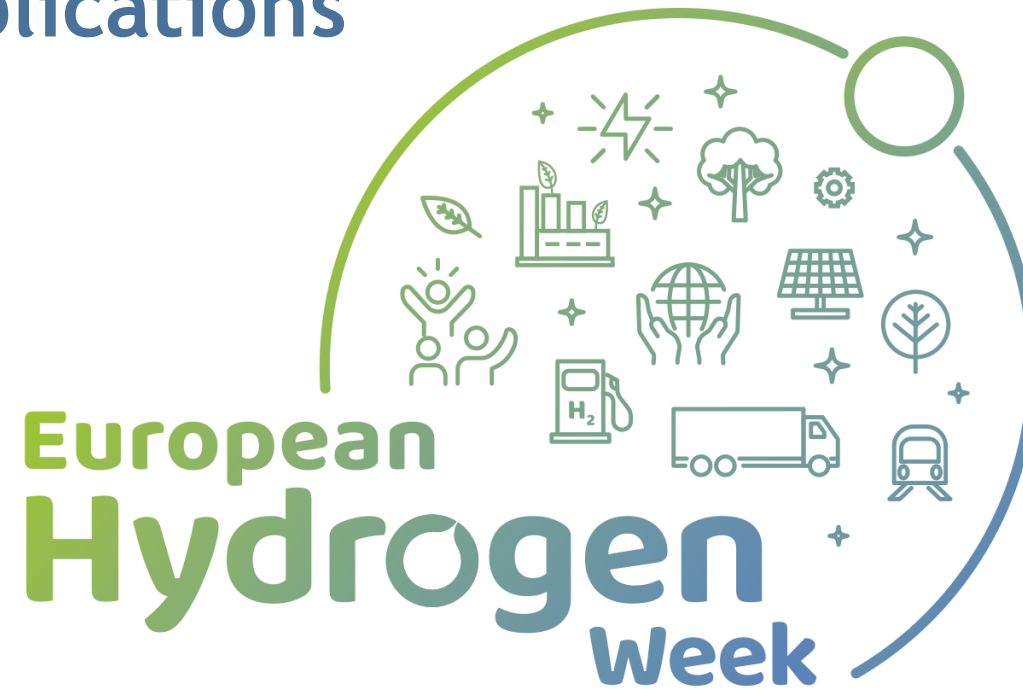


Transport Applications



L. Boillot
P. Caloprisco
C. Pavel

Project Officers

#PRD2021
#CleanHydrogen



PRD parallel sessions on transport

2nd Dec. 11:00 - 12:20



Transport Applications and
Refuelling Infrastructure

2nd Dec. 13:00 - 14:20



Heavy Duty Transport
Application

2nd Dec. 14:30 - 15:50



Building Blocks for Heavy
Duty Transportation
(Tanks/Compressors/FC)

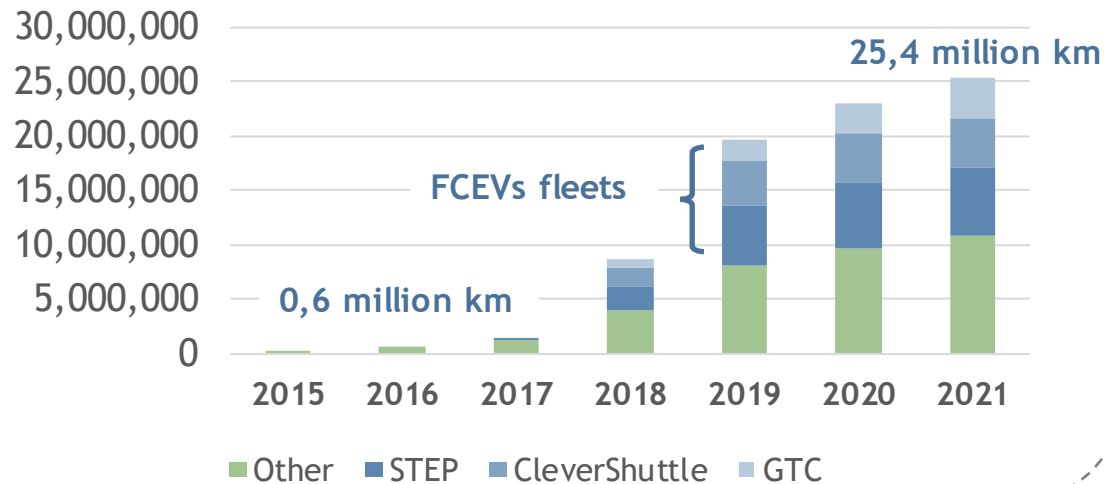
Light duty vehicle demonstration

Fleets are bringing the mileage with > 99% vehicle availability

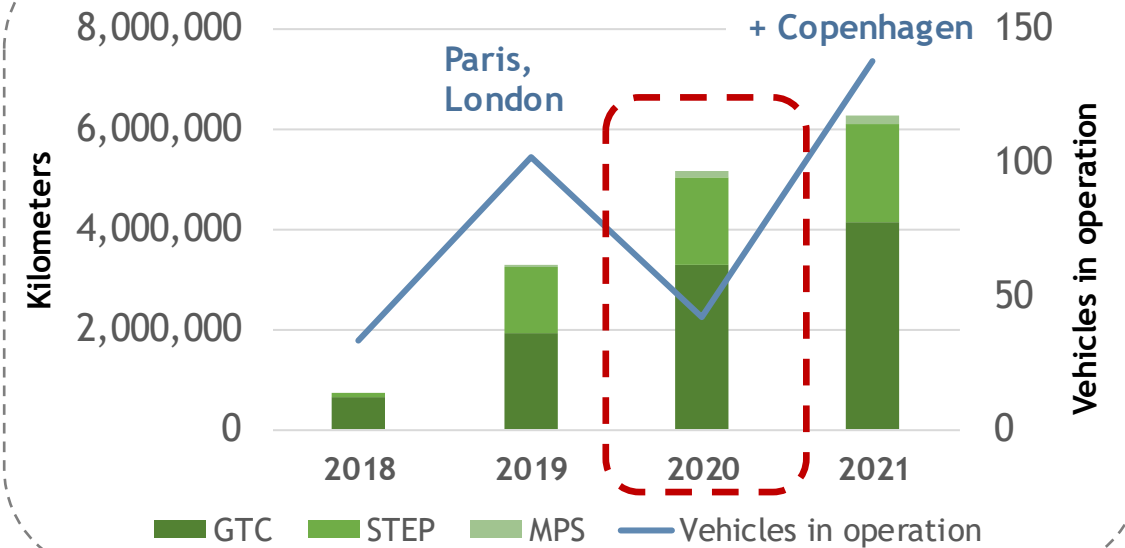
Achievements (until 1st Jan. 2021)

- 1.610 cars funded / 1.064 cars deployed
- 920.000 h of operation / 224 tH₂ consumed
- 6.250 tCO₂ avoided

FCEVs cumulative distance driven



Covid-19 impact on taxi operations



Nearly all vehicles deployed in 2021 are in fleets, confirming the business model



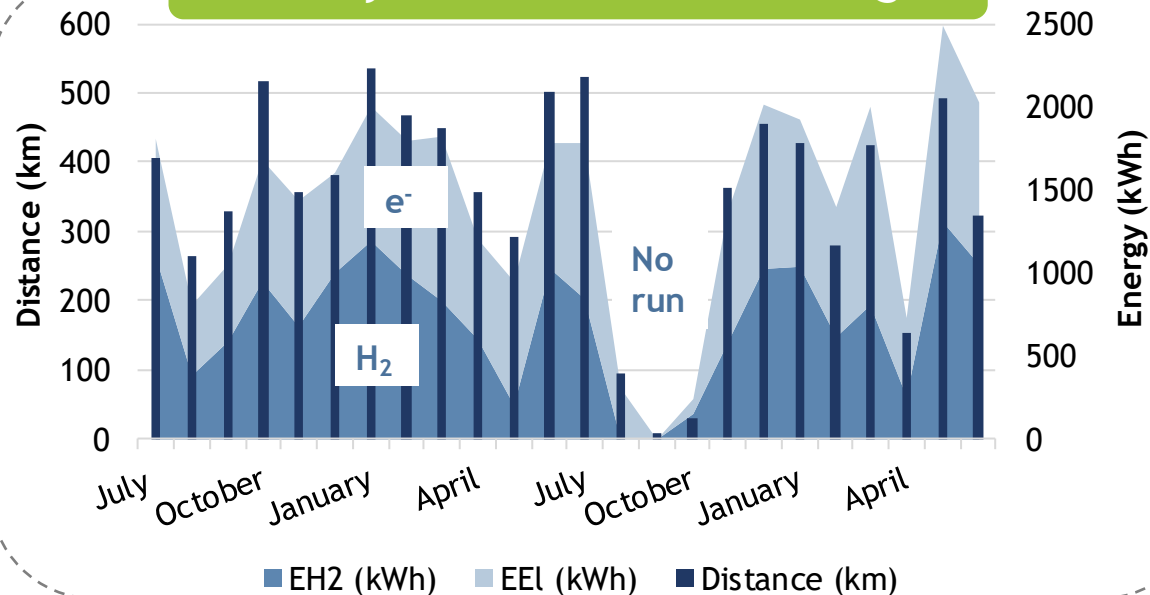
Experience from functional fleet of small vans

A fleet of 50 HyKangoos is operated since May 2018



- End user = ENGIE-Cofely, utility company
- Vehicles leased
- H2 as a range extender to the battery

Monthly distance and refuelling



Analysis of a single small van operation

- Distance driven: 35.117 km
- Average daily distance: 37 km
- Maximum daily distance: 286 km
- **Battery-only range** 85 km
- % days over 85km: 23%
- **% H2 used:** 53%
- % days H2 refuelled: 44%
- % days recharged: 75%

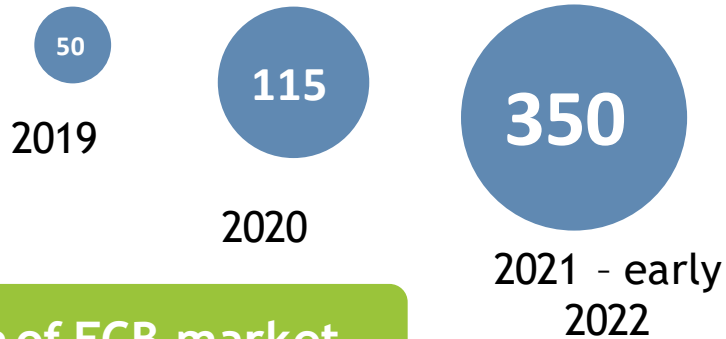
Drivers refuel equally hydrogen and electricity, especially when longer range is required and not achievable on the battery alone (> 85km battery autonomy)

Fuel Cell Buses

Prepare for your next ride on-board a hydrogen bus



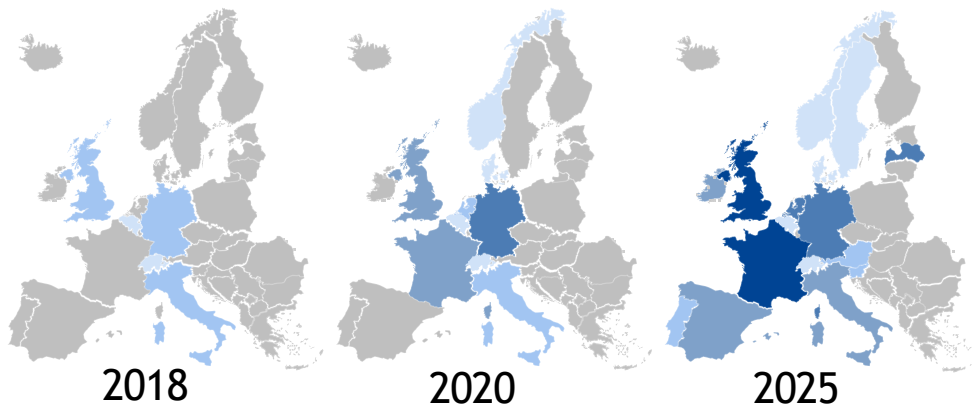
Evolution of FCB in operation in EU



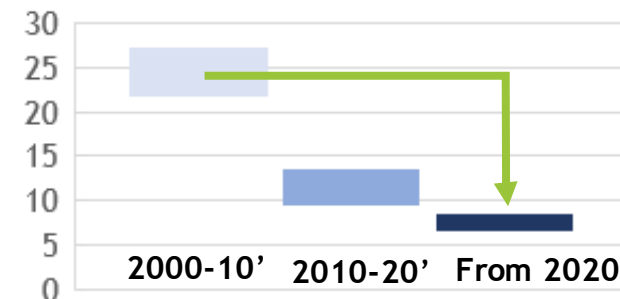
Expected growth of FCB market

No. of buses

- 1-5
- 6-20
- 21-50
- 51-250
- 251 +



FCB consumption (kgH₂/100km)



68% more efficient buses

Increasing market and awareness

- 7 bus suppliers and 3 FC suppliers
- Cities expanding of their current fleets
- Demand for coaches and 18m buses
- Project development assistance by FCH
- One-stop website www.fuelcellbuses.eu

Heavy-duty applications starting real-life conditions

Scalable solutions for all use cases

Long haul trucks



- Trucks and HRS: technical specs agreed
- First HRS commissioned
- Deployment of trucks to start in 2022
- Several use cases tested - mileage, payload, distance, type of good
- Logistics, retail and H2 distribution
- Different configurations (26t rigid and 40t tractor trucks)

29 trucks and bin lorries
13 sites
7 countries
5 FC suppliers



Urban bin lorries



- 14 bin lorries ordered with several truck configurations
- 3 bin lorries collecting garbage in NL
- Better working conditions of workers
- MoU with Hector and Life 'N Grab Hy

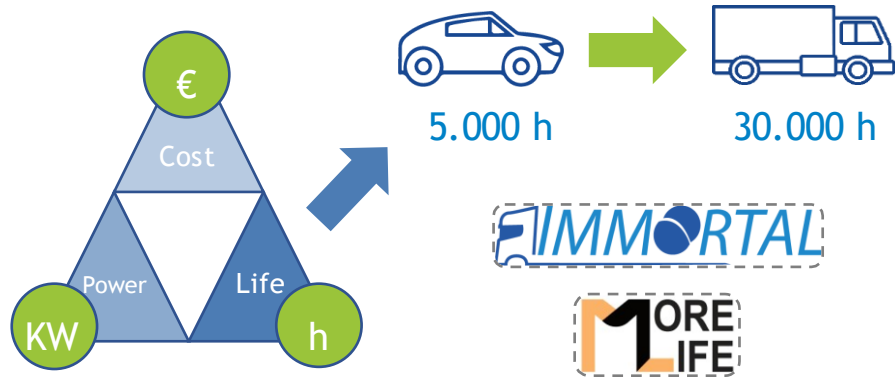


- Trucks and Bin lorries (BE)
- Bin lorries
- Trucks

Next generation components for HD applications

Meeting users 'needs

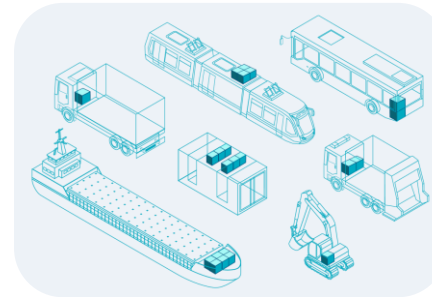
Long lifetime fuel cells



- Study of degradation mechanisms
- Optimised management for HD cycle
- Building on past FCH JU projects (Giantleap, ID-FAST)

Standardised FC modules

STASH



- Plug and play concept
- No lock in
- Market aggregation
- Lower development costs
- Lower TCO for users
- Strong industrial cooperation: 9 OEMs, 11 FC suppliers

Fast refuelling protocols



- Beyond the SAE J2601 protocol limitations
- Enable 80 kg in 10 minutes
- Open source protocol
- International cooperation



Ships: towards larger vessels and H₂ delivery by ships

Building the pilots and experiments to speed up standards for waterborne applications

2020 - Ro-Ro passengers and freight vessel - LH2 PEM



2019 - Platform vessel -NH₃ SOFC and inland barge - CH₂ PEM



2018 - Inland cargo - CH₂ PEM



2017 - R&D vessel - CH₂ PEM



Challenges

- Regulations
- Bunkering infrastructure and protocols
- Creation of hydrogen corridors
- International cooperation



Pre-Normative Research, codes and standards



- Hydrogen for passenger vessels

- Experimental data
- Guidelines for safe design for the new IGF chapter on hydrogen
- CEN/CENELEC SFEM WG on maritime

Ports as hydrogen « coastal hubs »

Pilots for clean port operations in container and ferry terminals

Pilots for ports operations

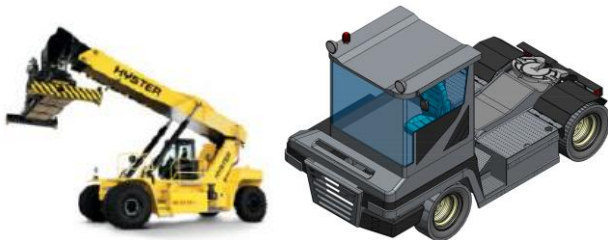


Heat and on-shore power for ferry terminals

- Port of Palma = 100kW
- Port of Orkney = 75 kW
- Port of Tenerife = 100kW



Heavy machinery for container handling



- Port of Valencia



Ports as hydrogen « coastal hubs »

- Creating / Serving H₂ demand locally for energy intensive industry (steel, chemicals, refineries, etc.)
- Integration of renewable electricity from offshore wind
- International trading routes for H₂
- Transport node / ecosystem with trains, trucks and inland navigation

Study on hydrogen in ports and industrial coastal areas

- European Hydrogen Ports Network
- Global Hydrogen Ports Coalition - CEM

Supporting the uptake of clean rail and aeronautic transports

Taking the steps towards zero-emission rail and aviation



Prototypes

- Innovative bi-mode fuel cell hybrid train
- Test, validate and carry out the homologation of the prototype

RCS

- Identify gaps normative framework
- Modifications of relevant standards and technical specifications for interoperability

#PRD2021
#CleanHydrogen



From APU to aircraft propulsion

2018 - Aircraft propulsion



2017 - FC for emergency operation



2012 - APU for secondary electrical system



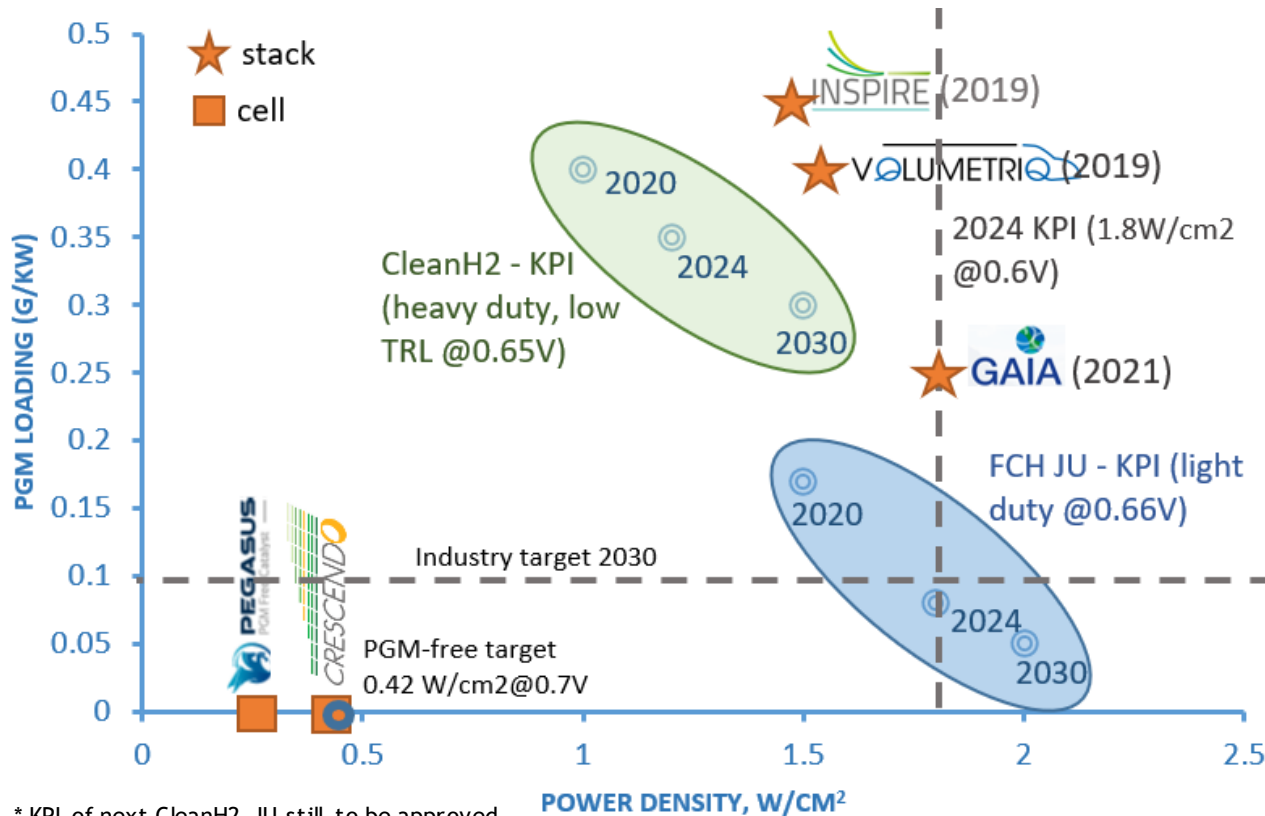
Challenges

- Specific safety measures
- Liquid hydrogen storage and infrastructure
- Fuel cell scale-up to 1.5+MW

Next generation of MEA with low/no Pt

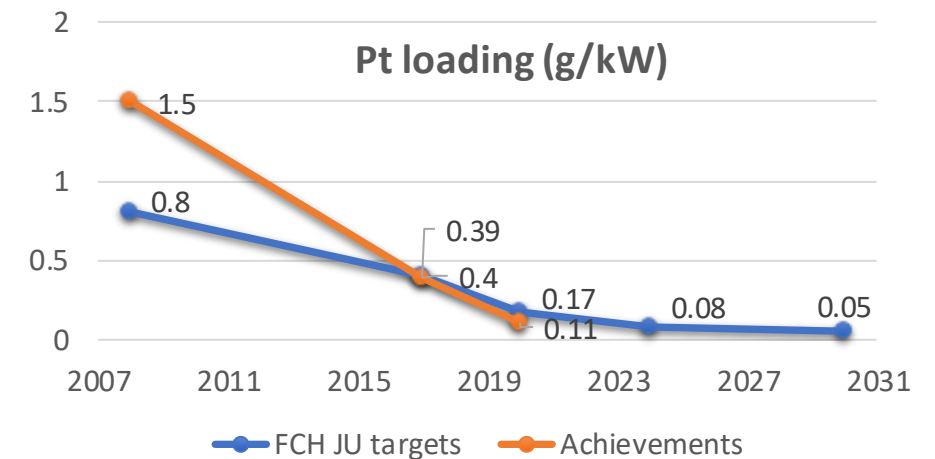
Increased competitiveness of the EU supply chain

Results vs. objectives



Achievements

- Pt loading reduced 10-fold from 1.5 g/kW in 2008 to 0.11 g/kW in 2020
- The MAWP 2024 target for LDV (1.8 W/cm²) already achieved (GAIA project)
- Target performance of non-PGM catalyst of 0.42 W/cm² (H₂/air) met (CRESCENDO project), but stack cost is 4 times above the target of 50 €/kW

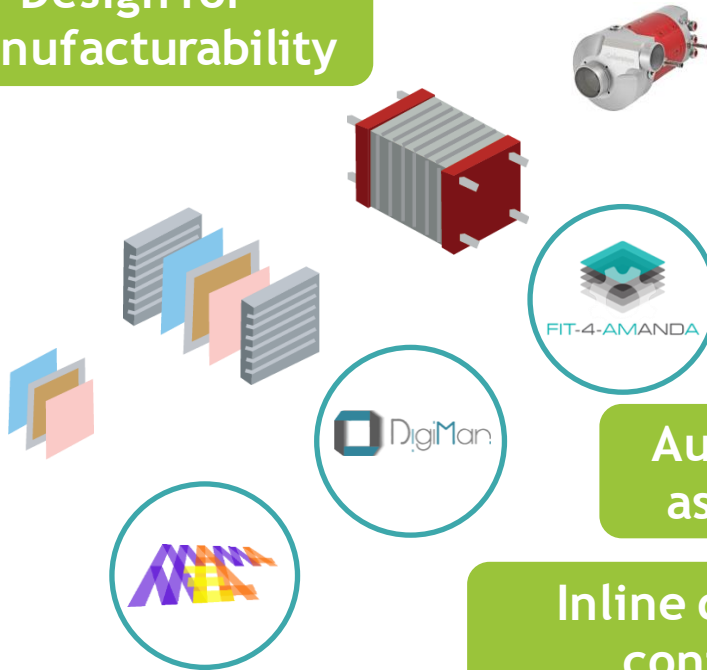


Manufacturing of fuel cells: scaling up capacity

More, faster, better at a lower cost and increasing competitiveness of the EU supply chain

Innovative manufacturing techniques

Design for
manufacturability



Automatic
assembly

Inline quality
control

Single production lines



Achievements

- Better GDL characterization methods
- Cell assembly time from 22 to 5 seconds
- Increased production capacity
 - CCM = 3 GW/line/y
 - Single stack = 50.000/line/y

HRS compression technology

Supporting the full innovation cycle

Concept

COSMHYC 
INNOVATIVE H2 COMPRESSION



- Hybrid compression: mechanic compression with rare-earth free metal hydride

2017

Validation

COSMHYC^{XL}



- Scale up of the technology and validation in prototypes

2019

Operation

COSMHYC^{DEMO}
INNOVATIVE H2 COMPRESSION



- Real operations with refuelling of a garbage truck

2021

Commercialisation

- Creation of a SME for the commercialisation of the technology  **EIFHYTEC**
European industry for Hydrogen technologies

Achievements

- TRL: from 3 to 7
- Baseload capacity: from 100 to 200 kg/day
- Electricity consumption: from 8 to 4 kWh/kg
- CAPEX: -55%

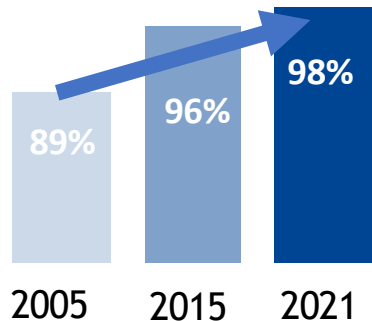
Witnessing the operation of the new generation HRS

Shifting from hundreds to tonnes of H₂ per year for large and solicited stations

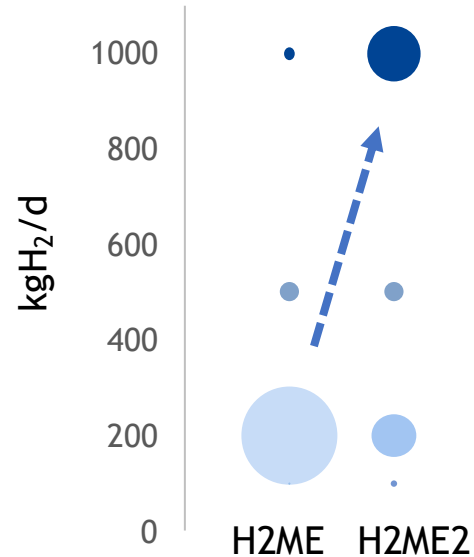
Robust HRS service

- Larger HRS sustaining fleets of buses or cars
- Increase of green H₂ production
- Operators handling a network of HRS
- Improved customers experience (payment system, back-to-back, multidispensers, etc.)

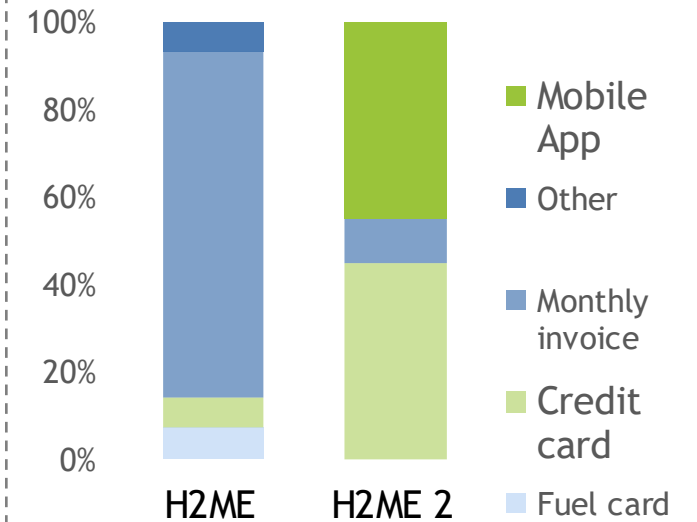
Average HRS availability (Bus)



Cumulative capacity of HRS by kgH₂/day



Payment system



European HRS Availability System

<https://h2-map.eu/>

Conclusions



Bus: Collecting data on TCO, environmental and operational benefits



Trucks, ships and heavy machinery: preparing the commercial products in the heavy duty segment



Manufacturing: gearing up for meeting the demand and setting up the basis for strengthening the EU supply chain



R&D Building blocks: improve the performance and stability towards PGM-free/low Pt catalysts in PEMFC MEAs