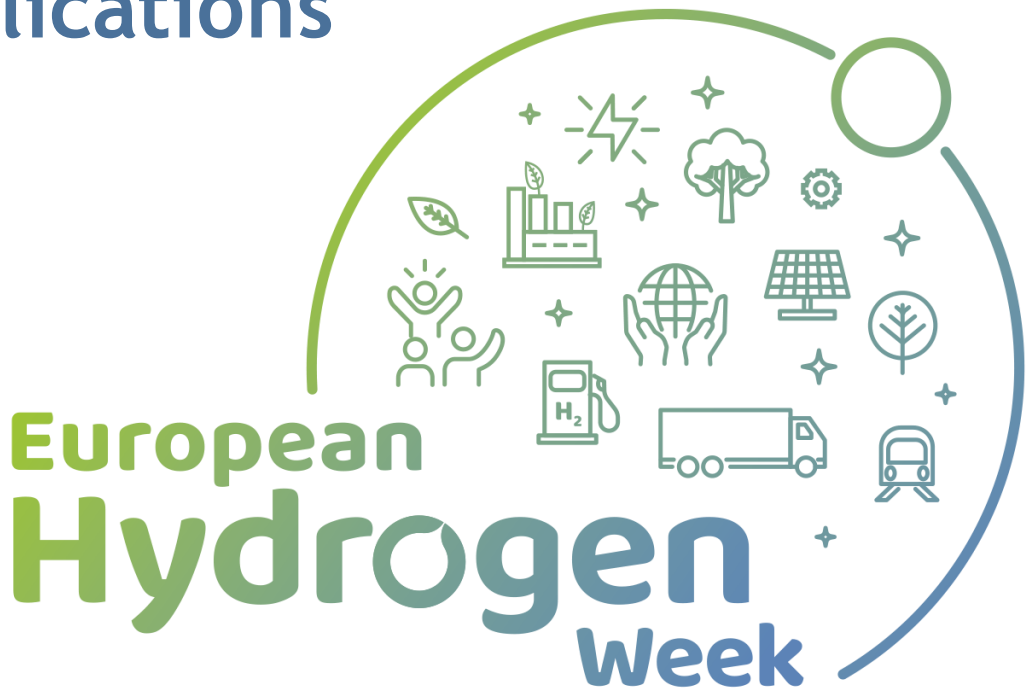
Transport Applications



L. Boillot
E. Giron
P. Caloprisco
C. Pavel

Project Officers

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PRD parallel sessions on transport

23rd Nov. 11:00 - 12:20

Bus, light duty vehicles and refuelling infrastructure

23rd Nov. 12:20 - 13:50

Heavy Duty Transport Application

23rd Nov. 14:00 - 15:20

Fuel Cell Technology for Transport Application

24th Nov. 09:30 - 10:50

Hydrogen for sectoral integration

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HRS development

Addressing the main challenges to expand the H_2 infrastructure

Building blocks

Grid balancing services analysis

HRS Scale up

Innovative compression technologies

HD adaptation

Fast refuelling FCH HD trucks

PRHYDE – Protocol for heavy-duty Hydrogen refuelling

360° approach

Customer experience

European HRS Availability System

https://h2-map.eu/

Trials and business models

H2ME and H2ME 2

Hydrogen Mobility Europe

ZEFER: Taxi fleets

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Innovative compression technologies for HRS

Targeting the heart of the HRS: efficiency, reliability and cost

Accumulator and bladder

- Resistant bladder material
- CBM design and validation

Metal hydride and mechanical hybrid compression

- Compression at 430 bar reached via metal alloys without rare earth
- Peak demand: 4kgH_2/h

Large scale demonstration

- Capacity: 1 t H_2 per day at 240kgH_2/h peak demand
- Energy efficiency: + 20%

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HRS for transport: historical progress

Operation confirming HRS robustness

CUTE
3 FCB / HRS

CHIC
3-8 FCB / HRS

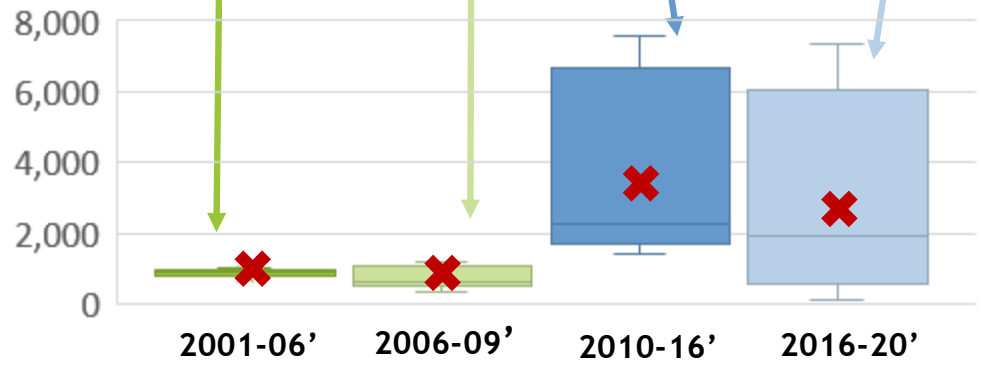
HyFLEET:CUTE
2-4 FCB / HRS

HighVLOCity
HYTRANSIT
3Emotion
3-10 FCB / HRS

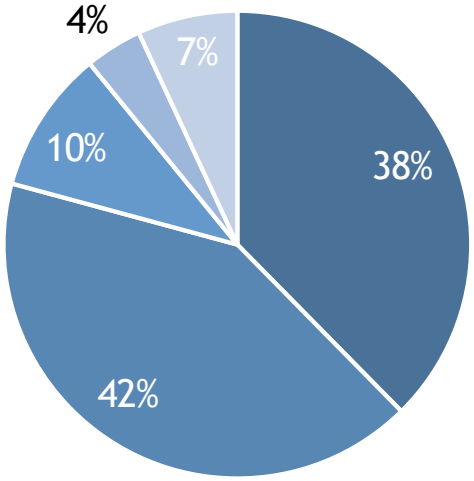
Challenges

- Full service for H_2 management (production, distribution and maintenance)
- HRS standardisation

Number of refills per HRS

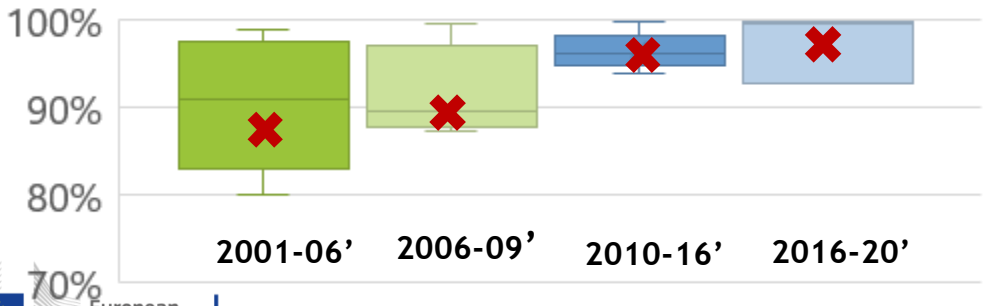


HRS downtime causes



- A - Dispenser
- B - Compressor
- C - H2 storage
- D - Electrical components
- E - Other equipments

HRS availbility



HRS availability > 95%

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Light duty vehicle demonstration

Fleets are bringing the mileage with 100% FC availability

New models coming into the projects:




Achievements

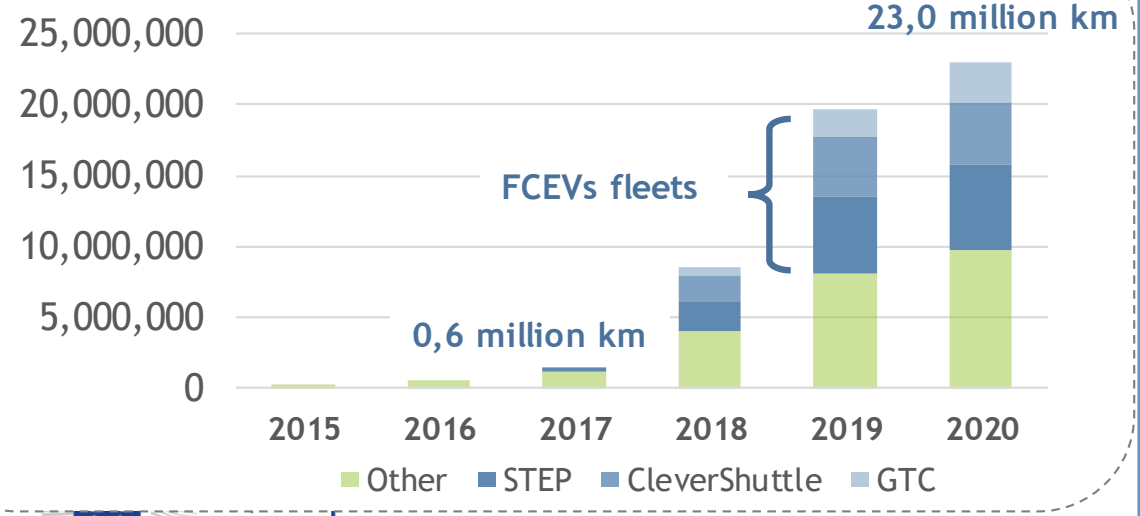
- 1,860 cars funded / 963 cars deployed
- 378,595 h of operation / 1,072 t H_2 consumed
- 1,700 tCO2 avoided

86% of the vehicles in fleets: Confirming the business model

Hydrogen:

- 85% low carbon H_2, out of which 21% renewable H_2

FCEVs cumulative distance driven



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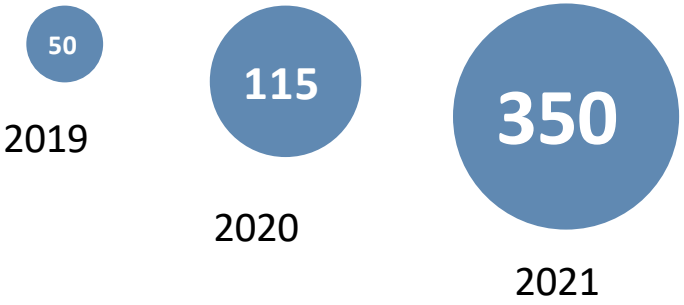
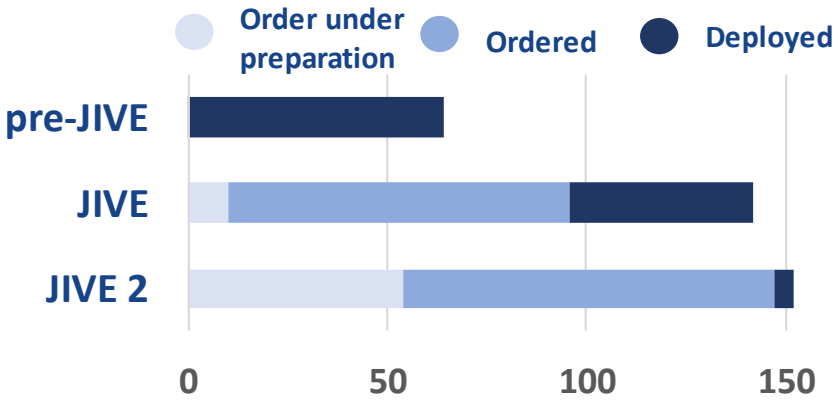
Fuel Cell Buses

Prepare for your next ride on-board a hydrogen bus

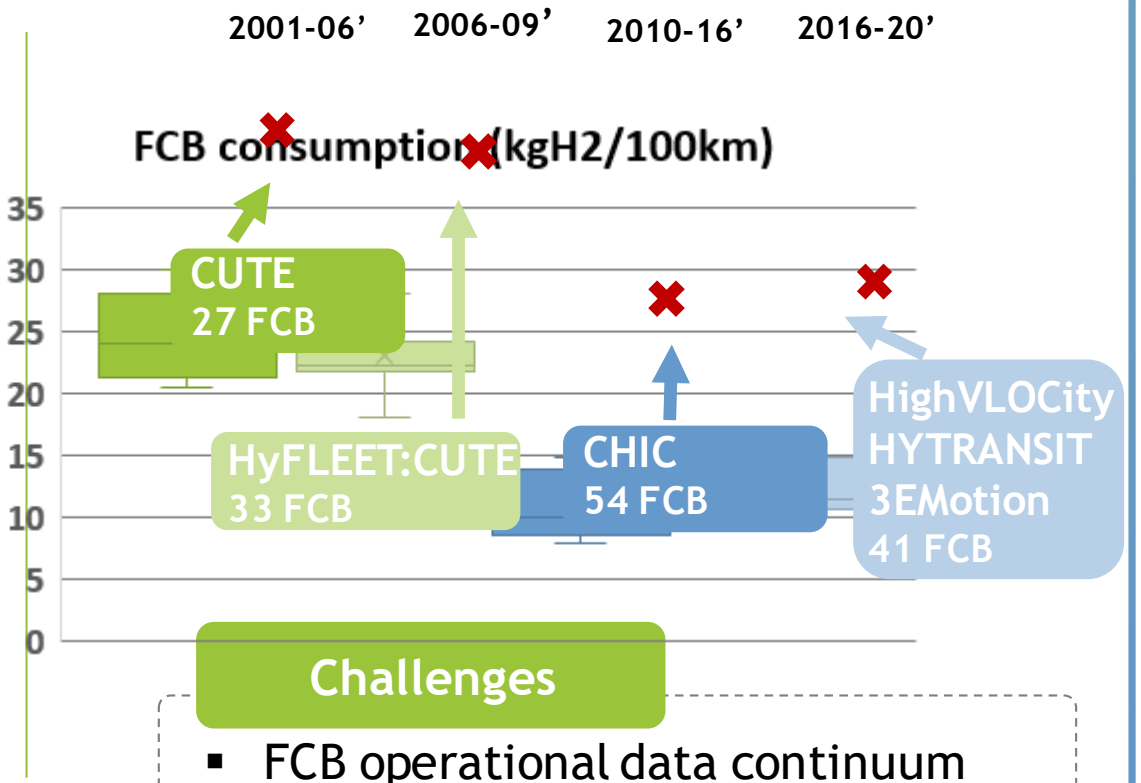
Evolution of FCB in operation in EU



Buses deployment status



FCB consumption (kgH_2/100km) - Pre-JIVE



Challenges

- FCB operational data continuum (JIVE and JIVE will report from 2021)
- Secure robust plans for FCB support

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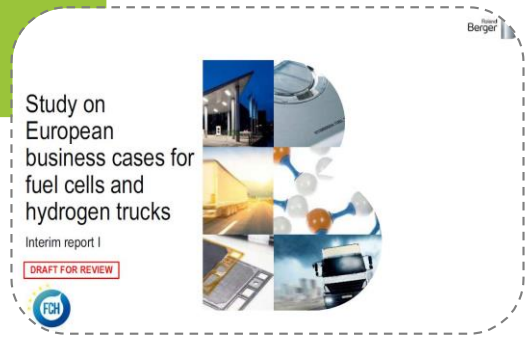
FCH JU support HD road transport

Addressing the CO2 challenge of the heavy duty

Business models



Building blocks

STACKS
Durability

TANKS
LH_2 storage

Standardisation

HRS
Scale up

360° approach

Trials

REVIVE H_2

H2HAUL

15 refuse trucks
8 sites
4 countries

15 HD trucks
5 sites
4 countries

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Ships and ports decarbonisation

Matching the appropriate solutions for waterborne applications

2020 – LH_2 vessel — LH_2 PEM — 3 MW

2019 – sea-going vessel — NH_3 SOFC — 2 MW

2018 – ferry + barge pusher — CH_2 PEM — 1 MW

2017 – research vessel — CH_2 PEM — 0,16 MW

2013 - APU for yachts — LPG HT PEM — 0,05 MW

Heavy machinery for port operations

Challenges

R&D in the area's of LH_2 storage (bunkering), MW scale Fuel Cells, carriers,…

Key considerations

- Importance of regulatory aspects (IMO and CESNI)
- Crucial need for international cooperation
- FC for hotel load as clean on-shore power
- Ports as hydrogen « coastal hubs »

Aeronautic applications

Taking the steps to zero emission aviation

From APU

To aircraft propulsion

2012 - APU for secondary electrical system

2017 - FC for emergency operation

2018 - Aircraft propulsion

Challenges

- Specific safety measures
- Liquid hydrogen storage: volumetric & gravimetric density
- 1.5+MW fuel cell
- Liquid hydrogen infrastructure

Hydrogen-powered aviation- Joint Study Clean Sky 2 JU – FCH 2 JU: key take aways

Technology

Hydrogen is a compelling option

Research & Innovation

Demonstrator by 2028

Economics

Less than 18 EUR per PAX

Climate impact

Zero CO_2 and 70% total climate impact reduction

Rail applications

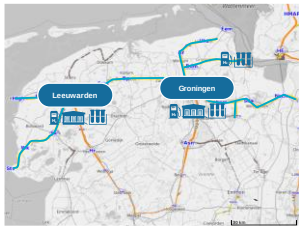
Eliminating the last non-electrified rolling stock

« Study on the use of fuel cell hydrogen in railway environment »

Groningen & Friesland, Netherlands

Riga Node, Latvia

Kalmar – Linköping, Sweden



At specific circunstances H_2 is already competitive or the most economic zero emission solution

Challenges

- Rail vehicle design & powertrain system
  - Standard scalable design
  - FC bi-mode design and operation
- H_2 storage
- FC operational hours
- HRS
  - Design for fast fuelling
  - Density of the network
- Homologation

Call 2020: train project

Under negotiation

- By-mode multiple unit
- Homologation in three countries

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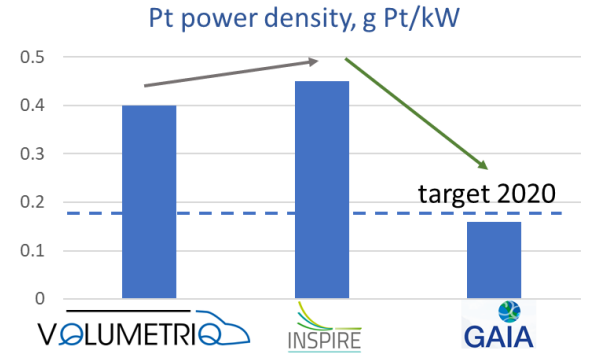
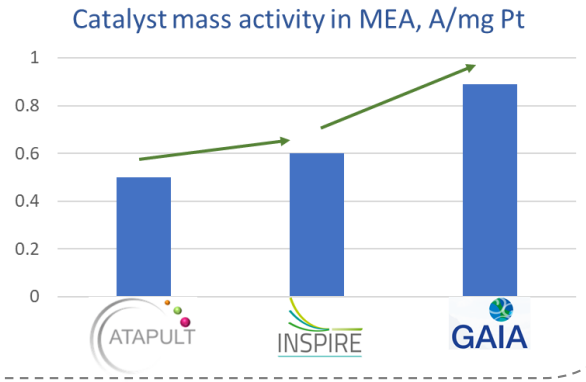
MEAs development

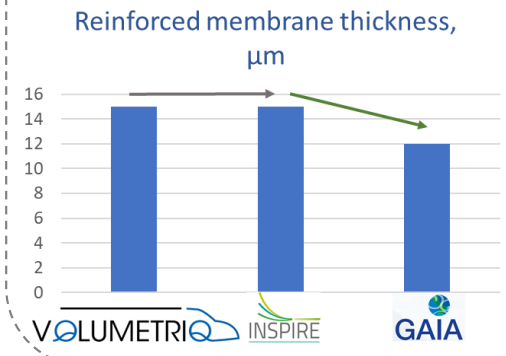
Towards more affordable and competitive fuel cells

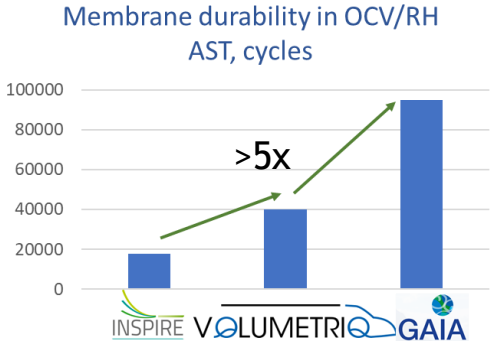
- 2020 target of PGM loading catalyst reached at cell level
- Mass activity of Pt catalyst almost doubled in the last 7y

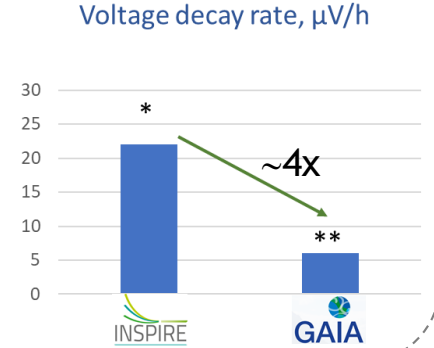




- 5x better stability of membranes and ~4x decay reduction







CATAPULT novel catalyst structure 2012

VOLUMETRIQ making key components 2014

INSPIRE critical stack components 2015

CRESCENDO non-PGM catalysts 2017

PEGASUS Pt-free cathodes 2017

GAIA next generation MEA 2018

Challenges

- Improve the performance and stability of PGM-free catalysts in PEMFC MEAs

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* Short stack, drive cycle 1, standard membrane reinforcement
** 200 cm² single cell, drive cycle 2, nanofiber membrane reinforcement

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Improved manufacturing

Bringing cost down, quality up, and approaching mass production

Fuel Cells

DigiMan

Big data to determine cause and effect for GDL imperfections

FIT-4-AMANDA

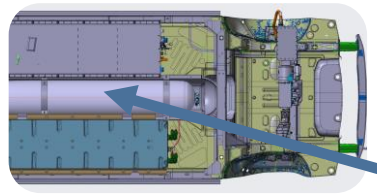
Automation of the stack assembly process

INLINE

From a 100 fuel cell production line to 50.000 fuel cells pa

H_2 tanks

TAHYA
TANK HYDROGEN AUTOMOTIVE



Achievements

- 50% cost reduction for on-board hydrogen storage from SoA to ~500€/kgH_2
- 18% increased gravimetric efficiency from SoA to 6.5%
- RCS contribution “safety vs. costs”

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Conclusions

- Heavy-duty: addressing different hydrogen carriers and studying LH_2
- Preparing for heavy duty segment: infrastructure and technology building blocks
- Supporting high-quality manufacturing to deliver volumes
- Improve the performance and stability towards PGM-free catalysts in PEMFC MEAs