JIVE/JIVE2/MEHRLIN

Towards clean public transportation with fuel cell buses

JIVE/JIVE 2 project results

9th May 2024

Presentation by ERM

ZERO EMISSION



Clean Hydrogen Partnership

Co-funded by the European Union

ERM's Hydrogen Expertise

- **Concept development of hydrogen projects** including technology selection, financial modelling, hydrogen demand and off-take scenarios.
- **Strategy Advisory** including development and analysis of strategic responses to climate change and the low carbon energy transition for **industry** and **Government**.
- Hydrogen **hazard assessment and risk assessment including** hydrogen production facilities, storage and pipelines.
- **Techno-economic feasibility** including detailed cost estimates, financial modelling, and technical options evaluation for new projects.
- **Communication and stakeholder engagement** (technical and non-technical).
- **Safety & environmental consent** delivery for projects (Planning, EIA, Seveso III, Permitting, etc.).
- **Lifecycle assessment**

Other core services: funding acquisition, funded project management/consortium coordination

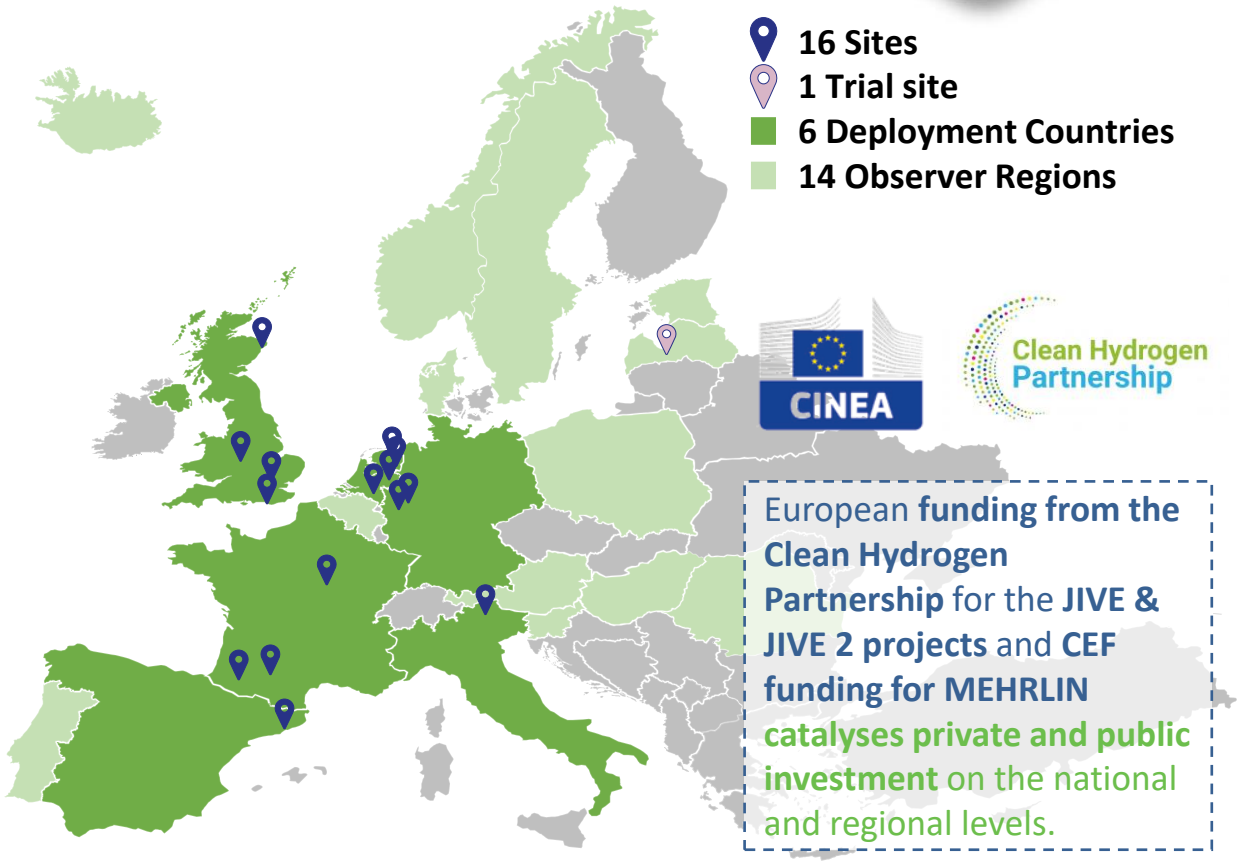
contact: eva.baker@erm.com

The JIVE, JIVE 2 and MEHRLIN projects are the flagship fuel cell bus projects in Europe aiming to deploy c. 300 buses and 17 HRSs by 2025

Objectives:

- **Deploy ~300 buses** across 15 European cities and regions in **6 countries** – the **largest deployment attempted to date**
- Validate large scale fleets in operation
- Stimulate the FCB market
- **Achieve a maximum price of €650k (JIVE) and €625k (JIVE 2)** for a standard fuel cell bus
- Trial joint procurement methods to **access economies of scale**

- **Deploy 17 Hydrogen Refuelling Stations (HRSs)**
- **Enable new cities and regions to trial hydrogen technologies**
- Demonstrate routes to **low cost renewable H_2**
- Analyse the **technical and economic performance of HRSs** under real conditions



European **funding from the Clean Hydrogen Partnership** for the **JIVE & JIVE 2 projects** and **CEF funding for MEHRLIN catalyses private and public investment** on the national and regional levels.

Timeline of the 3 projects (JIVE/JIVE2/MEHRLIN)



Overview of the current status of the project and its key activities

Deployment of buses and refuelling stations

- **83% buses are operational** (out of the 290 JIVE/JIVE 2 buses). As of end of December 2023, **>17M km** have been driven cumulatively
- **94% hydrogen refuelling stations are operational** (16 out of the 17 JIVE/JIVE2/MEHRLIN stations). As of end of December 2023, **>1.3 million kg of hydrogen were dispensed**



- 5 European OEMs

SAFRA Accélérateur de mobilité décarbonée · CaetanoBus · VANHOOL · WRIGHTBUS · SOLARIS

- Single deck (~68% including 2% 18m) and double deck (~33%) buses
- Fleets from 5 to 50+ buses

Organisation of hydrogen bus roadshows

- **Two hydrogen bus roadshows** across 9 Eastern European countries - including 32 events, engaging over **1,700 participants**.

1st roadshow

2nd roadshow

- **>90%** of the cities that trialed the technology **announced formal interest in deploying FCBs**.



3rd Roadshow

- The 3rd roadshow will be stopping in Romania, Greece, Bosnia-Herzegovina and Bulgaria through a **total of 9 cities**.

Fuel cell buses offer several advantages over conventional and other zero emission technologies, proven by the successful outcomes of JIVE

High daily range

Satisfies the longest routes and provides **operational resilience**

Project results

500 km/day without refuelling can be travelled with an FCB demonstrated by project partners as well as during roadshows

→ **Buses meet the expectations of the operators**

Increased passenger capacity

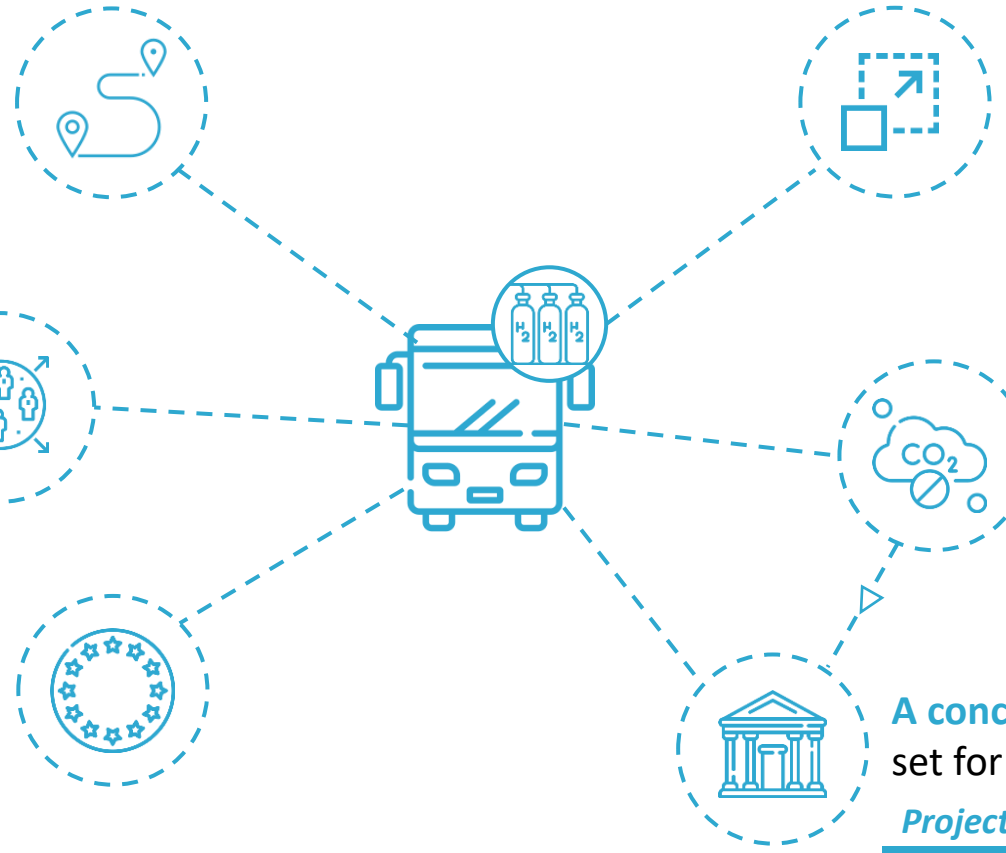
18 m and **double decker** models now widely available

Enhance European competitiveness

Due to the European manufacturing base and the supply chain

Project results

Now products available from >10 different European Manufacturers covering multiple models



Scalability

The refuelling infrastructure can be **scaled up** to accommodate **growing fleets**

Project results

Most of the transport operators within the project have already ordered further fuel cell buses or are aiming to increase their fuel cell bus fleet in the next years – in some cases this requires little to no station update

Zero tailpipe emissions

As fuel cell buses **operate locally emission free**, of a pure fuel cell bus fleet would result in the **complete avoidance of combustion nitrogen oxides** and **particulate matter emissions**

A concrete answer to ambitious policy targets set for transport decarbonisation

Project results

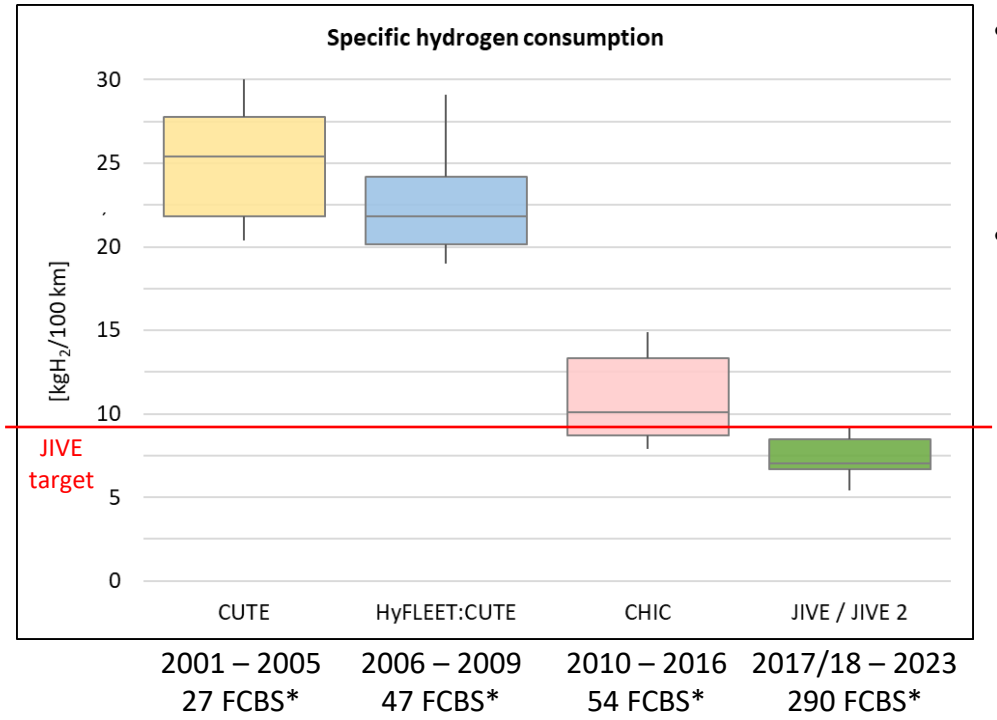
*With hydrogen from electrolysis using electricity from wind power throughout the JIVE sites, **an overall Global Warming Potential reduction of 82% can be achieved****

**Environmental Impacts and External Costs Benefits of FCBs – Comp. of FCBs with BEBs (Sphera) – JIVE (D3.22) / JIVE 2 (D3.6/D4.3)*

Buses perform better than in past projects with significantly improved fuel consumption

Specific Fuel Consumption

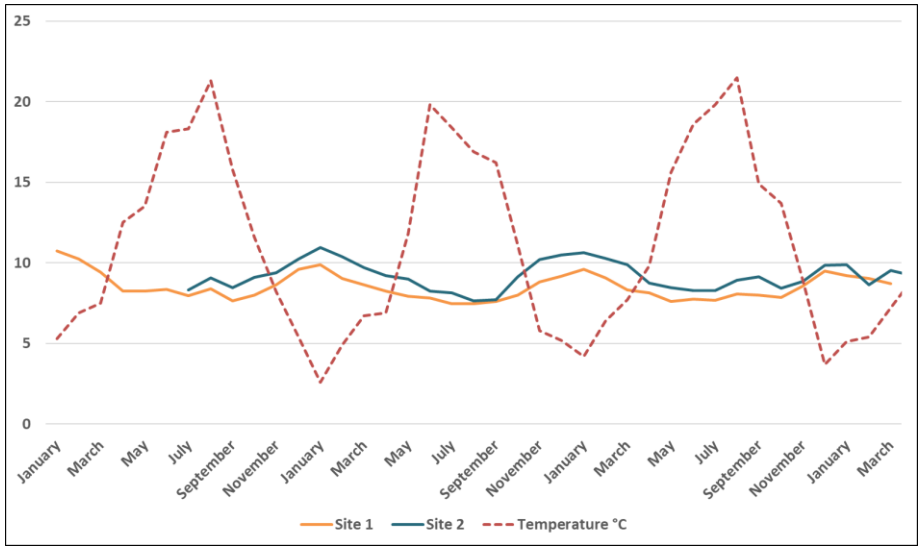
Target: <9 kg/100 km (standard buses) / <14 kg /100 km (articulated buses)



Total numbers deployed / to be deployed in the projects

- Excellent fuel efficiency with consumptions currently between **6.3-9 kg/100km for 12 m** (equivalent to between 20 and 23 litres of diesel) and **< 9 kg/100 km for 18 m buses** (< 30 litres of diesel).
- **1st and 2nd roadshow:** Average consumption of **5.7 kg/100km**

Ambient temperature influences hydrogen consumption
(± 1 – 2 kg / ± 15 – 20%)



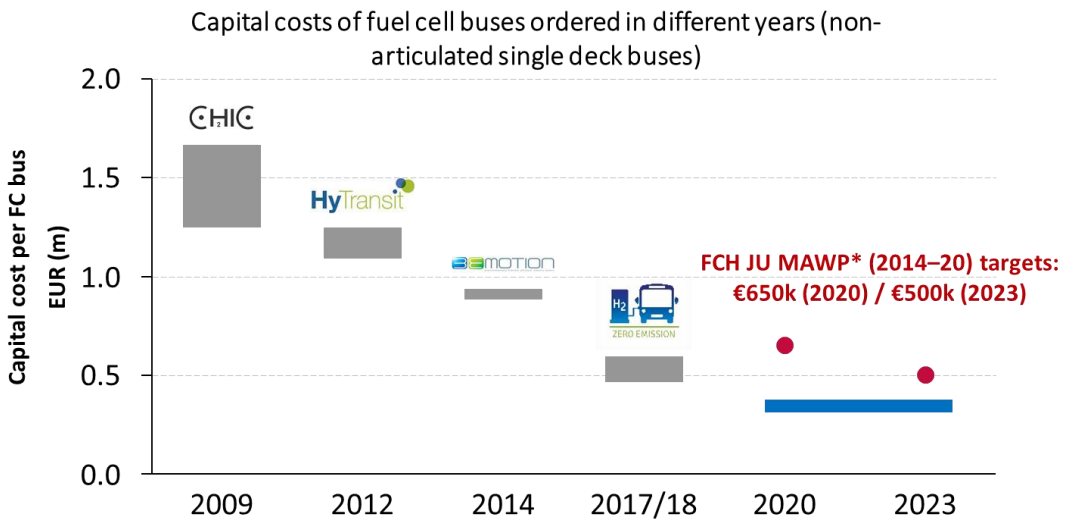
Availability

Target: >90%

- Much better performance than in CHIC
- As of Q3 2023, **median availability rate very close to the target (90%)** with several sites reaching 99%
- Downtime typically not cause by FC drivetrain (e.g. – mechanical issues, HVAC, etc.)

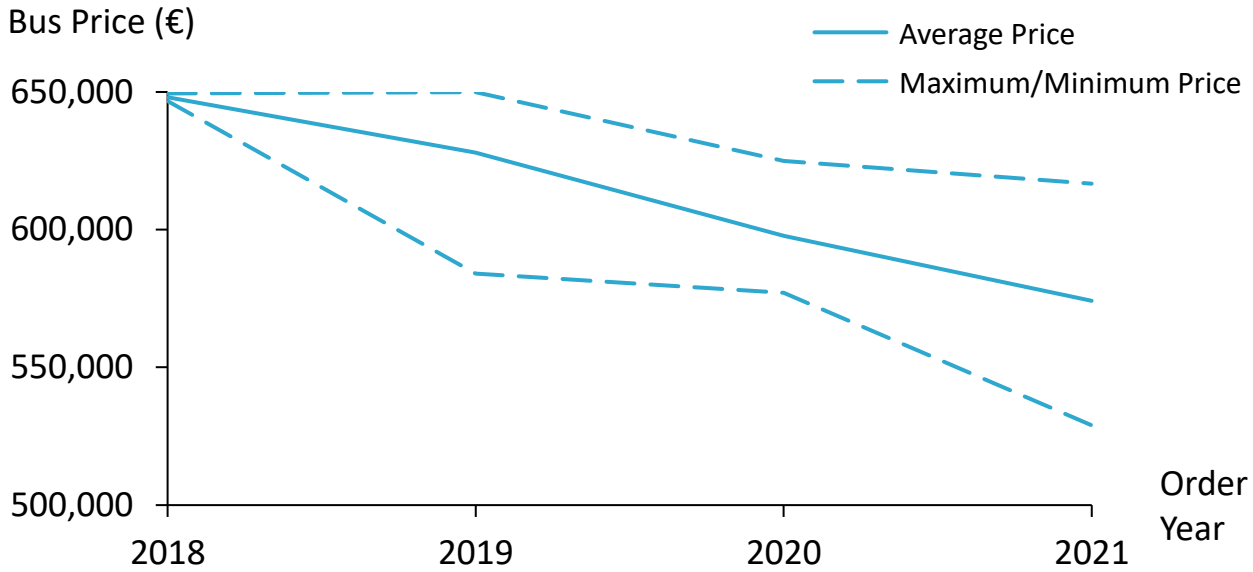
Drop in bus prices (CAPEX) compared to previous FCB projects and within the JIVE projects

Actual bus capex – historic FCB projects



- **Prices have significantly decreased since the first funded FCB projects**, a success of the increasing scale of the JIVE deployments.
- **The JIVE** (650K€) **and JIVE 2** (625K€) **targets have been achieved. The Clean Hydrogen Partnership 2020 target was achieved early in 2018.**
- While fuel cell bus costs have fallen significantly, further reductions will be needed for commercially viable offers.

JIVE & JIVE 2 combined average bus price*



- Since 2018, there has been a **12.9% decrease in the average bus price**
- **Minimum costs are accessible for vehicle orders of >10 vehicles**
- **The size of an order has an impact** – Amongst the lower prices approx. 80% of them were for orders of min. 15 buses.

**Assessment on 19 orders (259 buses) out of the 21 orders made within the JIVE projects. Prices shown are the base bus prices which excludes add-ons such as USB ports, WiFi, lighting, etc.*

Best practices from JIVE projects

Development, financing, and permitting

- **Rigorous planning** will avoid or mitigate most of the typical challenges experienced in the deployment and operations phase.
- **Financing models:** New financing models are under development to address the challenges of large orders without having full certainty of the lifetime costs.
- **Engage with key stakeholders early and often:** connecting all involved (drivers, operators, local groups, local governments) ensures all are committed to the successful delivery of a new technology.

Procurement

- **HRS, hydrogen supply, and buses should be procured in parallel:** If not, the risk is that the buses stay idle with risk of component damage.
- **Hydrogen supply:** Diversifying and securing backup hydrogen supply is key.
- **Conduct a market review:** Determine which manufacturers of HRS and FCB are willing and able to deliver. Consider RFIs to test the market
- **Negotiate for scalability:** ensure the proposed solutions can incorporate scaling and address potential reliability issues.
- **Engage with existing sites:** those with experience of HRS and FCB operations can advise on key points for reliability/innovation/scaling.

Deployment and Operation – FCB experiences

- Be “hands on” with the buses, **work collaboratively with the OEMs** and have a plan to wean off the OEM technicians
- **Use peer group support** – within the bus operator organisation and outside with experienced other sites
- **Facilitate discussions between Bus OEMs with HRS OEMs**

Deployment and Operation - Refuelling Experiences

- **Backup refuelling essential**: can be in the form of trailers, redundancies in the HRS or multiple stations; trucked in H2 must be available 24/7
- **Technical support from OEM in early stages should be onsite** and **critical spare parts kept in stock**
- **Communications with OEMS and safety authorities early and often**

ZEB 2025 – Join us at the Zero Emission Bus Conference @Busworld Europe in Brussels

EUROPEAN ZERO EMISSION BUS CONFERENCE 7th - 9th Oct 2025 @ Busworld Europe Brussels

7th – 9th Oct. 2025: Save the date !

- **European ZEB conference is back for a 6th edition**! Following the successful 2023 edition at @Busworld Europe, ZEB will take place alongside @Busworld Europe 2025.

- Valuable feedback from the 2023 edition has been incorporated to make **ZEB 2025 better than ever**. You can expect: a more dynamic format with 2.5-day conference, featuring new breakout sessions for in-depth discussions, enhanced synergies with the Busworld exhibition, excellent networking opportunities and more await ...

- Sponsorship opportunities are opened with early-bird rates (15% discount) **before September 20th, 2024**

Interested in sponsoring the event ? Contact us directly at zebconference.eu@erm.com

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Picture from ZEB Conference 2023 at Busworld Europe (8th – 12th October 2023)



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https://www.fuelcellbuses.eu/

Best Practice report *available on the project website (here)*

@fuelcellbus













Stay in the loop with the latest development of fuel cell buses by joining the JIVE User Group !

Exchange feedback and discuss operational assessment from the point of view of external PTO/PTAs to JIVE deployments sites – 2 meetings/year.

Thank you for your attention

Project coordination:

ERM

Project dissemination:

Hydrogen Europe

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If you have any questions, please don't hesitate to contact:
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