JIVE/JIVE2/MEHRLIN

Towards clean public transportation with fuel cell buses

JIVE User Group – 26th April 2023 – Coventry, UK

ZERO EMISSION

Presentation by Element Energy, an ERM Group company

Clean Hydrogen Partnership

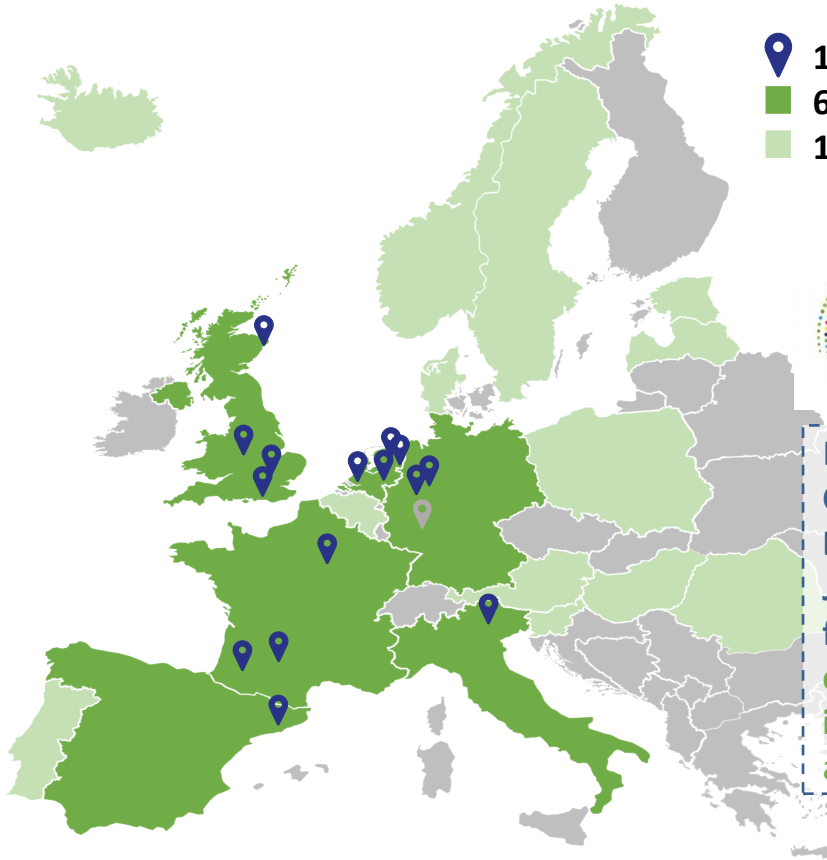
Co-funded by the European Union

The JIVE projects are the flagship fuel cell bus projects in Europe aiming to deploy around 300 buses by the end of 2022

Objectives:

- ❑ **Deploy 298 buses** across 16 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 18 Hydrogen Refuelling Stations
- ☑ **Enable new cities and regions to trial hydrogen technologies**
- ❑ Demonstrate routes to **low cost renewable H2**
- ☑ Stimulate further large-scale uptake of fuel cell vehicles



16 Sites
6 Deployment Countries
14 Observer Regions

Clean Hydrogen Partnership

CINEA

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.

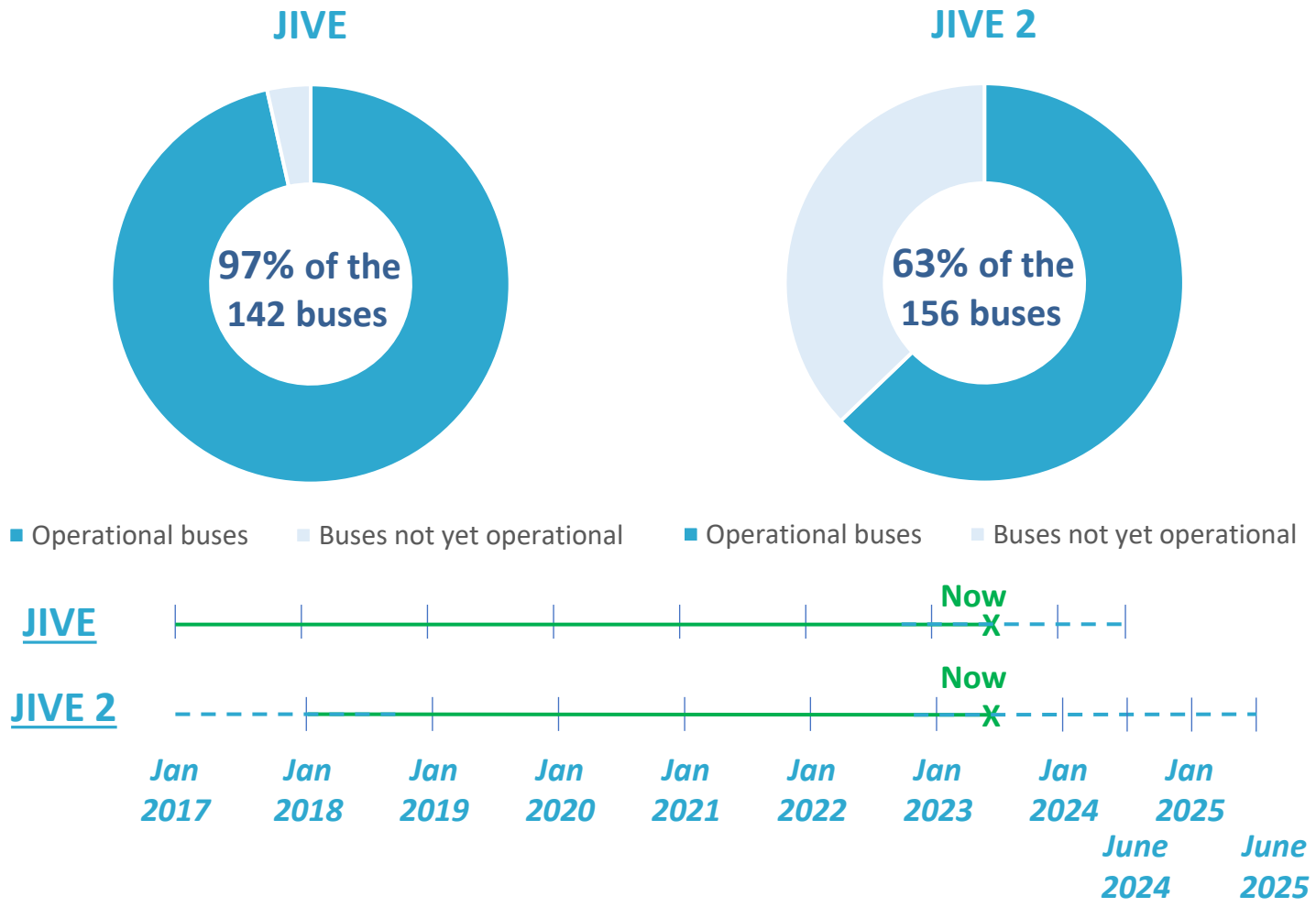






Current Status: Fuel Cell Buses

As of December 2022, **~77% of the buses have entered into operation*** (i.e., 230 buses), and **more than 9M km** have been driven cumulatively.



- 5 European OEMs

CaetanoBus VANHOOL SOLARIS WRIGHTBUS SAFRA Accélérateur de mobilité décarbonée

- Single deck (~67%) and double deck (~33%) buses
- Fleets from 5 to 50+ buses







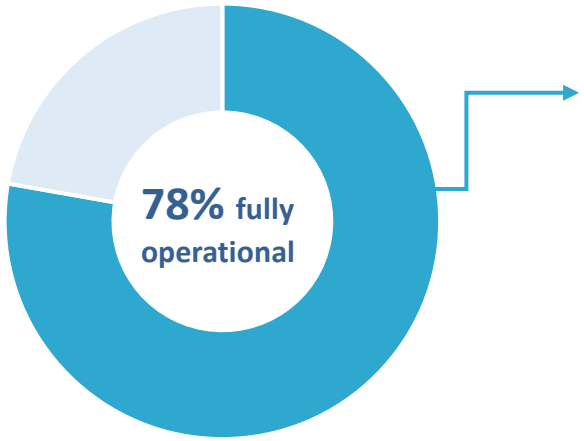

*Several sites are still at the beginning of their operational phase and therefore are experiencing issues (bus or hydrogen supply related) which can lead to longer downtimes for their buses.

Current Status: Hydrogen Refuelling Stations

There are **14 HRS fully operational**, most delivering green hydrogen to the vehicles. More **than 777,000 kg hydrogen dispensed** as of December 2022.

- **Seven** hydrogen refuelling stations used by the JIVE and JIVE 2 buses are financed through the MEHRLIN project (CINEA).
- Several operators use, or plan to use, other existing local HRS / **mobile HRS configurations** to allow buses to start operating before HRS commissioning.

Hydrogen refuelling stations (JIVE/JIVE2/MEHRLIN)



- **13** of the 14 operational HRS dispensing **green hydrogen*** – Once all stations will be online, ~90% of them will be dispensing green hydrogen.
- Sites with currently blue or by-product hydrogen have plans to move to green hydrogen.
- Across the project, **almost half of the sites are producing hydrogen on-site with electrolysers**

*included are sites which have green hydrogen certifications








The projects are yet to be finished; 1st findings show general target feasibility but also highlight room for improvement

Bus Performance

Distance travelled 
JIVE: min. 132,000km/bus in 3 years
JIVE 2: min. 150,000km/bus in 3 years

Availability of Buses 
>90%

Specific Fuel Consumption 
<9kg/100km (standard buses)
<14kg/100km (articulated buses)

HRS Performance

Availability of Station Unit 
>98%

Amount of Hydrogen Dispensed 
JIVE: >4,500kg/bus/year

- **Comparison with past projects** – Buses and refuelling stations in JIVE/JIVE 2 have, overall, the potential to outperform their counterparts or have already done so.
- **Teething periods** – JIVE/JIVE 2 local bus fleets did not exhibit pronounced teething periods, unlike in earlier projects.
- JIVE/JIVE2 local fleet are no longer considered a potential “add on” to normal operations by operators but **part of day-to-day-service**.

Target feasibility

- Target achieved at present
- Room for improvement – several sites are already close to reaching this target

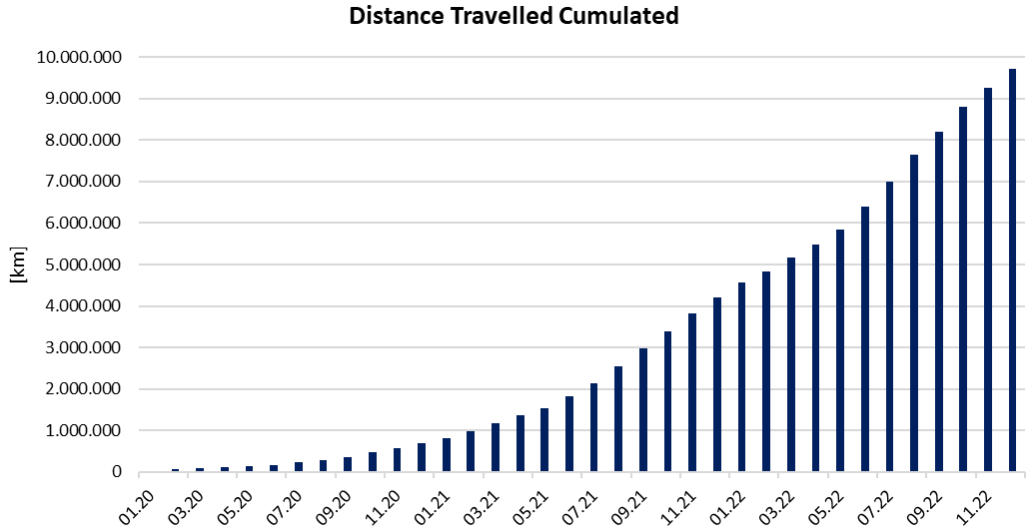
Performance analysis was conducted by Sphera and PLANET

Performance of the Buses (Distance) – Significant increase in monthly distance can be expected as site leave the teething phase

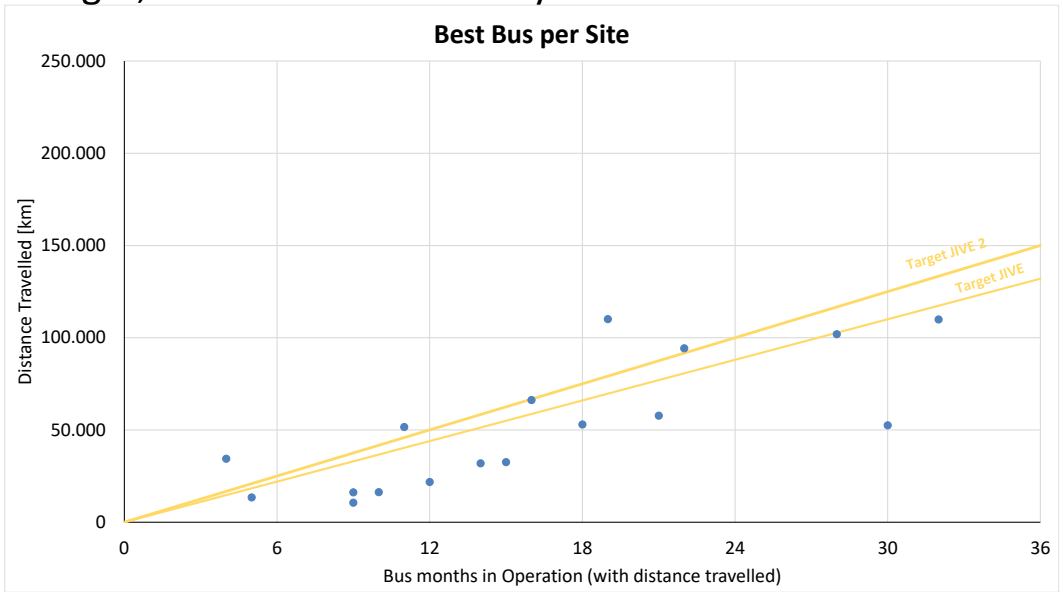
Distance Travelled

JIVE 1: min. 132,000 km/bus in 3 years
JIVE 2: min. 150,000km/bus in 3 years

- **>9M km** have been driven cumulatively as of December 2022. **Monthly distance driven up to 620,000km**.
- Local circumstances + External factors (e.g., Covid-19) had an **adverse effect on achieving the foreseen mileage**.
- However, 1.5 and 2.5 years are left before the end of JIVE and JIVE 2. Several sites only started operations in 2022 and others are not yet operational.



- However, at **almost all sites and with all bus brands the target was surpassed (for single buses in some months) during part of the reporting period**, sometimes even by a factor of two. That **proves that the buses are able of performing as expected**.
- Five sites have their best performing bus already above target; several others are very close.



NB: Data from individual buses and/or months may be missing.

Performance of the Buses (Fuel Consumption) – Buses are outperforming the project objectives

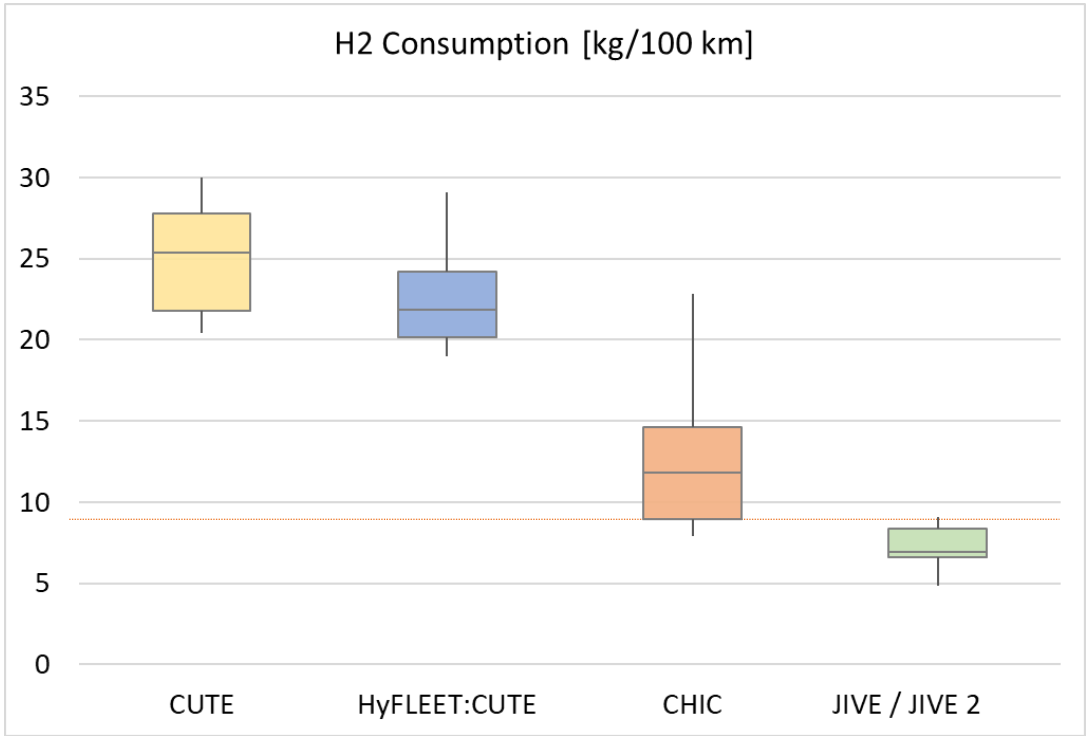
Specific Fuel Consumption

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

✓ *Target achieved at present*

- Excellent fuel efficiency with consumptions currently between **6.3 and 9 kg of hydrogen per 100 km for 12 m and double decker buses** (equivalent to between 20 and 23 litres of diesel) and **less than 9 kg per 100 km for 18 m articulated buses** (equivalent to less than 30 litres of diesel).
  - **Buses are outperforming the objectives**.

- **Significant reduction in fuel consumption over the projects** (incl. for the 18 m FCBs) with values **as low as 6.5 kg/100 km** achieved. Buses with external battery recharging are even lower.



Total numbers deployed / to be deployed in the projects

27 FCBS	47 FCBS	54 FCBS	298 FCBS

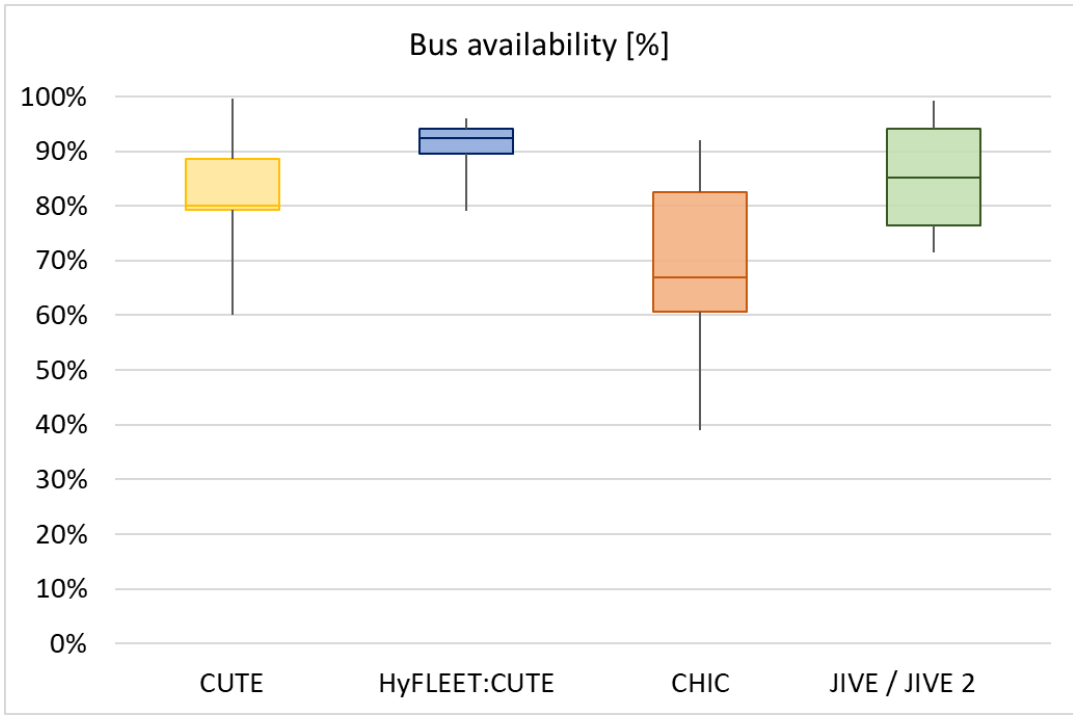
** Data up to 2022. The JIVE and JIVE 2 projects will run until June 2024 and June 2025 respectively; not all buses are therefore yet operational.*

Performance of the Buses (Availability) – Good performance in general

Availability

>90%

- **Buses from all manufacturers** represented in the projects have **proven the capability to surpass the 90% target during some parts of the reporting period**. The fleet averages at five sites are higher than 90%.
- **Single sites have reached 99% availability**.
- **Average availability** across all JIVE sites **~85 % at the end of Q4 2022**.
- Analysis shows that often non-hydrogen related components cause more than half of the downtimes



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27 FCBS	47 FCBS	54 FCBS	298 FCBS

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Performance of the HRS (Availability) – Good performance in general

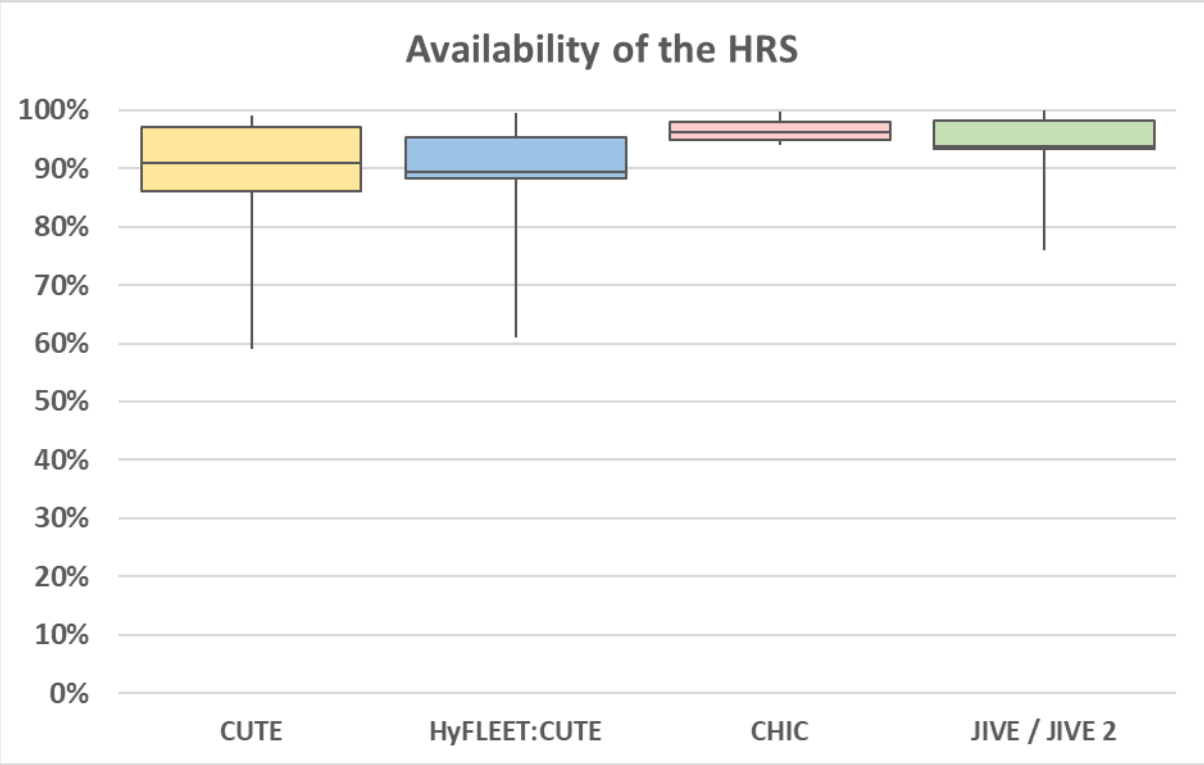
Availability of Station Unit

>98% (with aspiration >99%)

- **Performance in general is good**; however, some major issues have led to longer downtimes at some sites.

- **3 stations are already meeting the objective** (*out of the 10 studied here*) **– most of the others reached the target during part of the reporting period.**

- With regards to the best monthly values site by site: **Each of the studied stations have proven their capability to surpass the 98% target**.



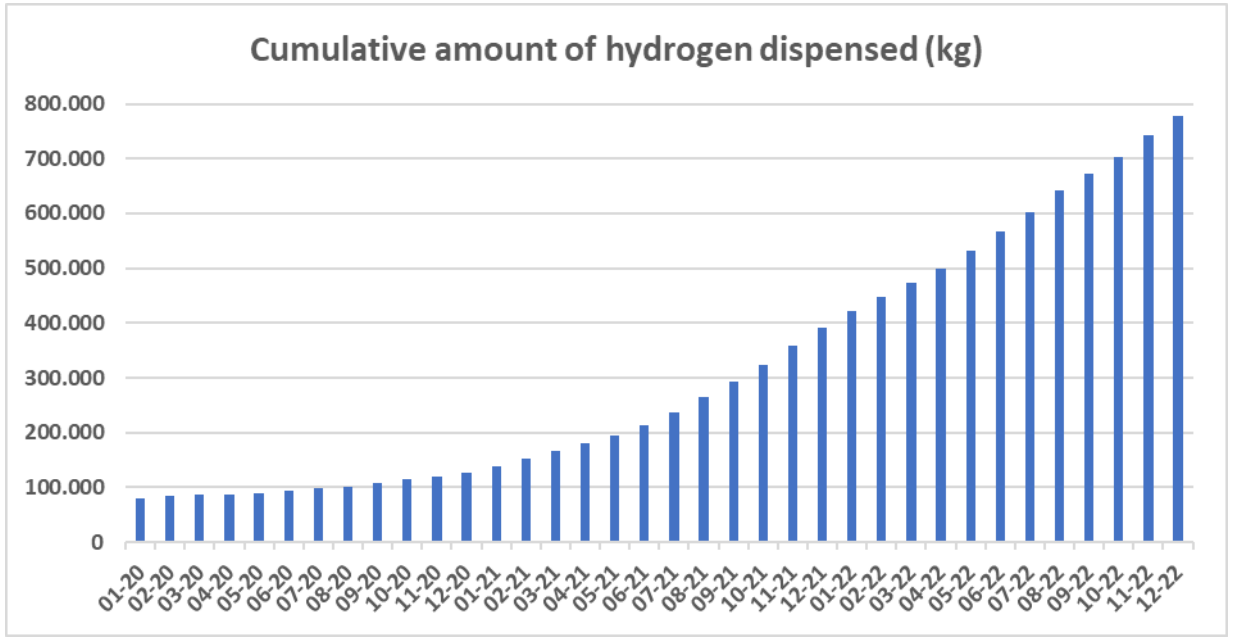
NB: Since JIVE/JIVE 2 are not complete, all analysis is ongoing and preliminary

Performance of the HRS (Amount of Hydrogen Dispensed) - gradually increasing

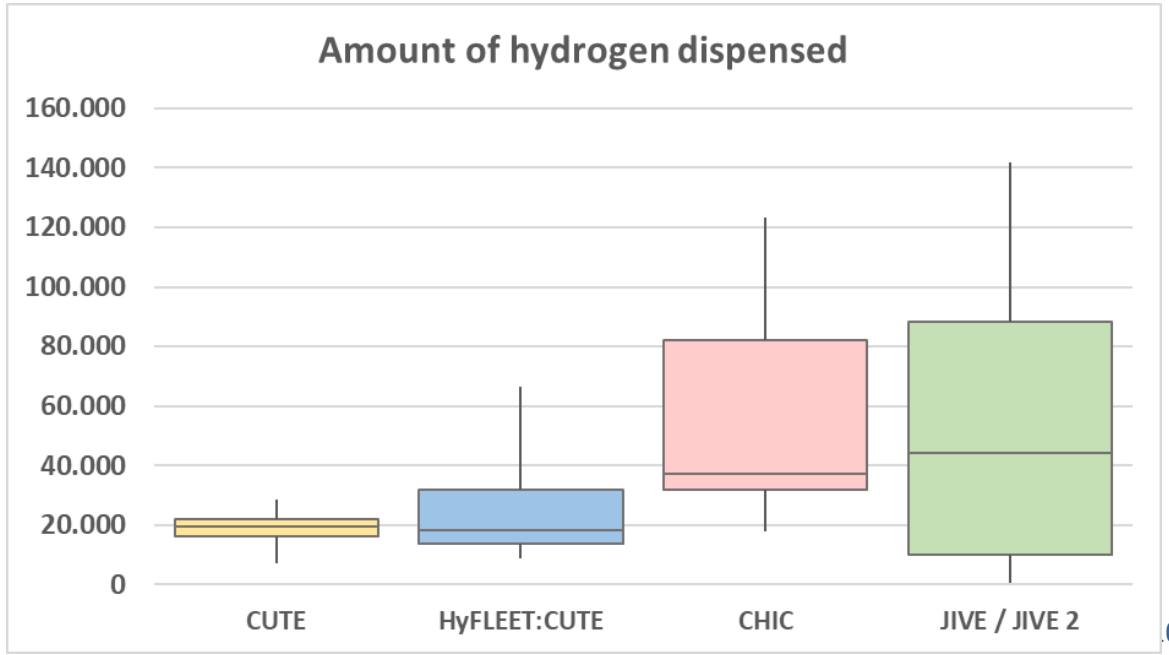
Amount of Hydrogen Dispensed

JIVE: >4,500kg/bus/year

- The amount of hydrogen dispensed has **gradually increased as the number of buses operating grew** (mid-2021). By end of December 2022, **more than 0.77M kg of hydrogen was dispensed to JIVE/JIVE 2 buses**.
- Given the larger bus fleet deployed, the **amount of hydrogen dispensed is higher than previous projects** (to be noted that 1.5 and 2.5 years are left for JIVE and JIVE 2 respectively).
- However, the **project target (JIVE) of 375 kg of H2 dispensed/bus/month is not yet reached**. This needs to be cautiously assessed, in the context of generally smaller distances travelled than foreseen and the **significant improved fuel economies** rather than assuming that the stations are not capable of providing more/enough fuel.



NB: Data from various sites is still missing.



Essential existing resource from the project – The 2022 Best Practice Report

JIVE/JIVE2/MEHRLIN Best Practice report

- Available on the project website (here) – 100 page document with all the learnings of the projects divided in the project life phases:

1) Stage 1 – Project Conceptualisation
2) Stage 2 – Financing and Planning
3) Stage 3 – Procurement
4) Stage 4 – Deployment and Operations

A Case Study was developed (section “Bringing it all Together”) with info boxes that summarise the essentials for a successful FCEB deployment project

Keys to success within the JIVE and JIVE 2 have been project sites that …

- Establish and communicate realistic project expectations
- Pick up learnings from earlier and ongoing FC Bus activities
- Have the ‘right’ people – champions for the technology, expert planners etc.
- Form part of a plan for a broader ‘clean’ energy system involving hydrogen

What's next ?

The **last buses and HRS are expected to go live** in the next couple of months – all should be operational by end Q2 2023.

Data will continue to be gathered to **provide further knowledge and insights on the performance** of the buses and HRS

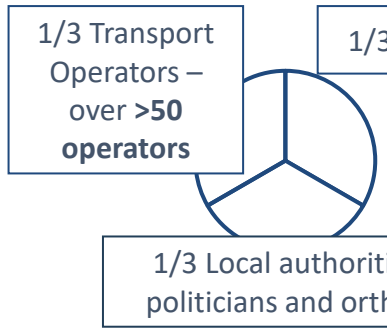
Dissemination and communication activities will be pursued.

Continue discussions with partners and the industry on the **post-JIVE FCB sector**.

ZEB 2023, a content-driven conference focused on deploying ZE Fleet at scale. New in this edition will be the special attention for ZE coaches.

- **The European ZEB (Zero Emission Bus) Conference 2023** will take place on the **9th-12th October 2023** in Brussels alongside Busworld Europe. A regular ticket includes **four half days of conference** and **access to the Busworld exhibition – day tickets are also available. Early bird** available until **11th June 2023.**
- The conference focuses on **technology**, **economy** and **policy-related** topics affecting zero-emissions buses and coaches. Full agenda and further information is available on the conference website - https://zebconference.eu/

What to expect from ZEB 2023:



>400 attendees

50 – 60 speakers

busworld EUROPE BRUSSELS 7-12 OCT 2023

500 exhibitors amongst which the 80 biggest bus manufacturers.

Free access to the Busworld exhibition

Free Public Transportation

Networking Opportunities including a networking dinner

EUROPEAN ZERO EMISSION BUS CONFERENCE 9th - 12th Oct 2023 @ Busworld Europe Brussels

European ZEB Conference @EUZEBconference

ZERO EMISSION

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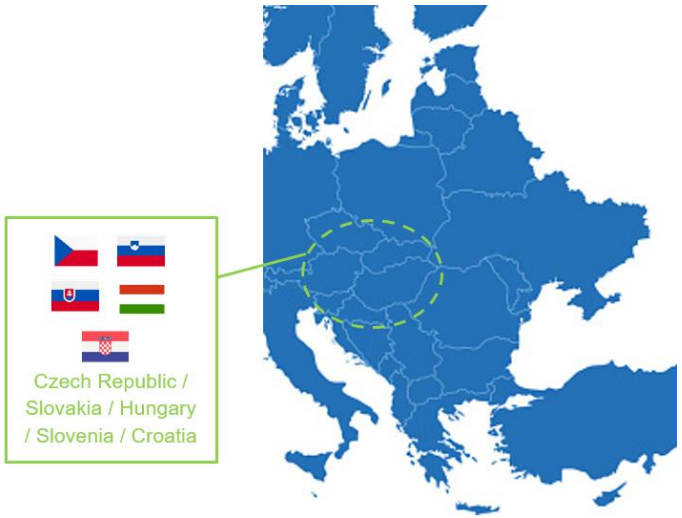
Pictures from previous editions

Partners of the 2023 edition

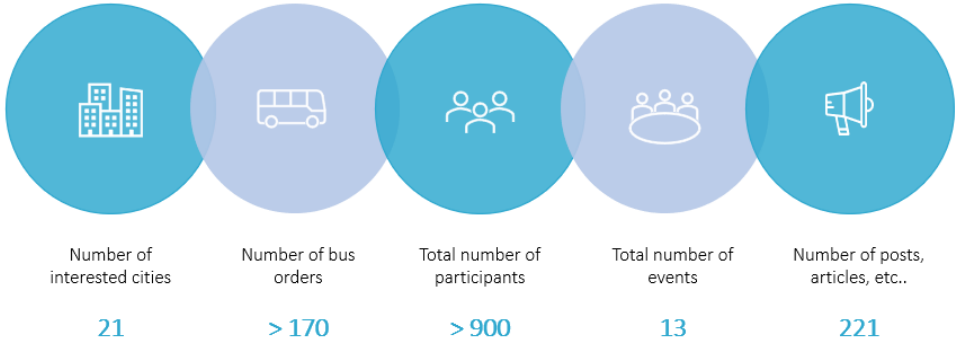
Clean Hydrogen Partnership Co-funded by the European Union MIVB STIB Sustainable BUS FLIX RATP IRU AVERE UIP Medlem Sveriges Bussföretag

1st JIVE 2 CEE (Central Eastern European) Roadshow



Countries from the 1St JIVE 2 roadshow

The bus drove across 5 countries (with 9 cities that trialed the technology) – from mid-November 2022 to mid- January 2023 (*1 month break between*) – traveling a total distance of **1 641 km** and consuming approximatively **125 kg of H2**, resulting in an average consumption of **7,6 kg/100km**



Key KPIs from the 1St JIVE 2 roadshow

- The roadshow included a total of **13 events** that reached out to a wide range of stakeholders, including government representatives, operators and local authorities, students, and members of the academic world
- Extensive media coverage including physical and digital newspapers, TV, radio, and social media allowed to reach over **2.5 million people**. This has allowed to disseminate knowledge and increase public awareness about hydrogen in transports.

Key impacts

- **90% of the cities** that trialed the technology have **announced a formal interest in deploying FCBs following the roadshow**. In total, **over 150 hydrogen buses** will be deployed in the region over the next years
- Messer/Caetano/Toyota are offering a “full package “ solution to cities that trialed the technology

Key barriers

- Price of the bus and H2, lack of public funding - insufficient support for FCB on a national level, lack of hydrogen ecosystem and pilot projects, regulatory framework for the whole system, etc.

QUESTIONS?

For further information, please don't hesitate to contact: eva.baker@element-energy.co.uk, magali.senaux@element-energy.eu

https://www.fuelcellbuses.eu/ @fuelcellbus @fuelcellbus @fuelcellbus

Project coordination

elementenergy

an ERM Group company

Project dissemination

Hydrogen Europe

The JIVE and JIVE2 projects have received funding from the Clean Hydrogen Partnership under Grant Agreements No 735582 and 779563.

This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe Research.

The MEHRLIN project is co-financed by the European Union's Connecting Europe Facility.

If you have any questions, please don't hesitate to contact:
magali.senaux@element-energy.eu, eva.baker@element-energy.co.uk

Clean Hydrogen Partnership

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