

MOVING TOWARDS CLEAN PUBLIC TRANSPORT WITH FUEL CELL BUSES: JIVE 2 PROJECT BRIEF

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INTRODUCTION

*In recent years, decarbonisation and clean technology policies have been driving markets and cities towards increased deployment of zero-emission buses. Fuel cell technology for urban buses has been gradually gaining traction as one of the multiple efficient solutions for decarbonising transport networks. **Hydrogen fuel cell buses (FCBs) offer an opportunity for operators and authorities to move away from fossil fuels and contribute to urban transport decarbonisation and the sustainable development of our cities.***

The Joint Initiative for hydrogen Vehicles across Europe programme, also known as the JIVE and JIVE 2 projects, was the biggest attempt to date to successfully deploy new fleets of FCBs and associated hydrogen refuelling infrastructure in cities and regions across Europe.

From 2017 to 2025, the combined JIVE & JIVE 2 projects deployed 290 FCBs in 15 cities and regions in seven countries across the United Kingdom (UK) and Europe. The objective of the projects was to demonstrate FCBs as a functional decarbonisation solution for public transport fleets. Together with the MEHRLIN project, 17 hydrogen refuelling stations (HRSs) were also deployed in 15

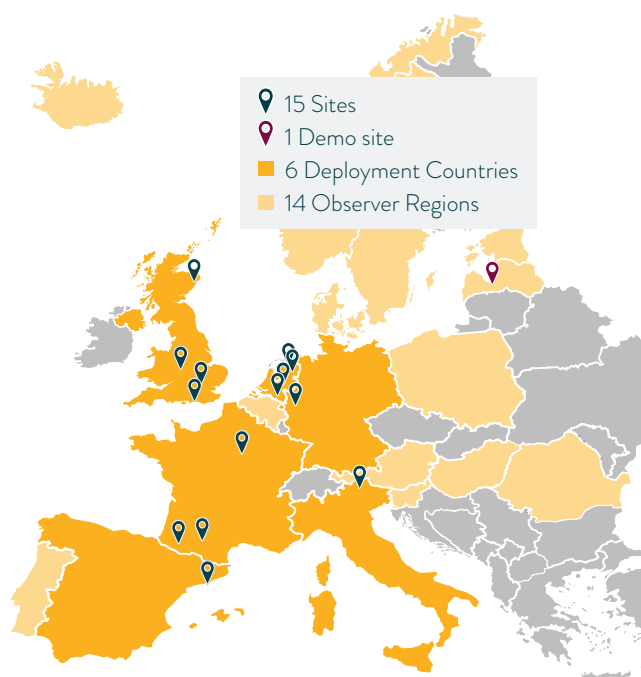
European cities across six countries. Coordinated by Environmental Resources Management (ERM) and co-funded by the European Climate, Infrastructure, and Environment Executive Agency (CINEA) and the Clean Hydrogen Partnership, JIVE and JIVE 2 played a critical role in advancing hydrogen mobility in Europe, showcasing how cross-border collaboration can drive the transition to cleaner urban transport.



PROJECT OBJECTIVES

The main purpose of the JIVE projects was to advance the commercialisation of FCBs through large-scale deployment. The **projects aimed at validating large-scale fleets in real commercial operations and stimulating the FCB market** by achieving a maximum standard bus price of €650,000 in JIVE and €625,000 in JIVE 2, which was successfully realised by all of the deployment partners. The JIVE projects enabled new cities and regions to test hydrogen technologies and, in some cases, joint procurement methods to achieve economies of scale. Across the cities, the bus deployment successfully proved the technical and commercial viability of FCBs for future large-scale rollout. The successful deployment of FCBs and related refuelling infrastructure was followed by a thorough analysis of their operational experience. The projects gathered a wide range of data on FCB performance, allowing project partners to analyse the technical and economic performance of buses and HRSs under real conditions over an extended time period.

DEPLOYMENT SITES AND BUS FLEETS



► Figure 1: Map of JIVE and JIVE 2 Deployment Sites, Countries, and Observer Regions

Through the JIVE projects, public transport operators (PTOs) and public transport authorities (PTAs) acquired extensive experience with FCBs in regular operations over many years. Up to 31 March 2025, the project buses cumulatively travelled more than 24 million kilo-

metres (km), providing key data on FCB operations and HRS performance. There were also differences between the bus fleets deployed that enabled comparison. Not only were the buses deployed in different locations, but the fleet characteristics also varied — the fleets deployed ranged from five buses to over 50 buses (fleets of over 50 buses were deployed in Crawley, UK and Cologne, Germany), some cities deployed articulated/18 metre (m) buses (a total of 10 articulated buses were deployed across Barcelona, Spain and Pau, France), and the UK sites deployed double-decker hydrogen buses. A diverse range of suppliers contributed to the MEHRLIN and JIVE projects, both by providing equipment (FCBs and HRSs) and the required hydrogen and by participating in exchanges with the consortium. One of the key achievements of the JIVE projects was that it helped the sector develop, from only a small FCB offering in 2017 — when few suppliers provided models — to multiple models from a variety of manufacturers now being available on the market.

THE IMPORTANCE OF KNOWLEDGE SHARING

The coordination between vehicle and infrastructure deployment was key in fostering the development of a hydrogen ecosystem. Across all the deployment sites, the JIVE projects demonstrated the importance of data and knowledge sharing, which was made possible by the collaboration of more than 35 partners across Europe. By combining their knowledge and competencies, from planning to implementation, partners engaged in frequent exchanges throughout the projects, providing opportunities to share insights, best practices, and learnings and jointly tackle the challenges of hydrogen mobility. UITP further contributed to this through the coordination of the work of the JIVE User Group, a group of public transport stakeholders, external to the JIVE deployment sites and cities, who were also interested in exploring the potential for future FCB deployment. The goal of the JIVE User Group was to exchange feedback and discuss operational assessments from the point of view of external PTOs and PTAs, in order to identify the different factors linked to acceptance of FCBs. The user group also played a crucial role in sharing the projects' key learnings with the wider bus sector and collaborating with the UITP Bus Committee and Bus Division. Moreover, the JIVE projects collaborated with several European Union (EU)-funded initiatives, fostering synergies and knowledge sharing. Launched in 2019, the [Clean Bus Europe Platform](#) (CBEP) is an initiative under the European Commission's Clean Bus Deployment Initiative that aims to support clean bus technology deployment across Europe. Strong links were created

between the platform and JIVE in the form of knowledge and content exchange, as well as participation in each other's events. Other synergies were exploited with the EU project [ASSURED](#), aimed at boosting the electrification of urban commercial vehicles and their integration with high-power fast charging infrastructure.

“The JIVE 2 project has been a great experience. Participation of PTOs from cities across the EU in open discussions and presentations on the same task opens the door for the best possible conclusions about the next steps in introducing hydrogen vehicles across Europe.”

*Dinko Butković, Bus Garage Manager,
Zagrebački električni tramvaj d.o.o.*

PROJECT ACHIEVEMENTS

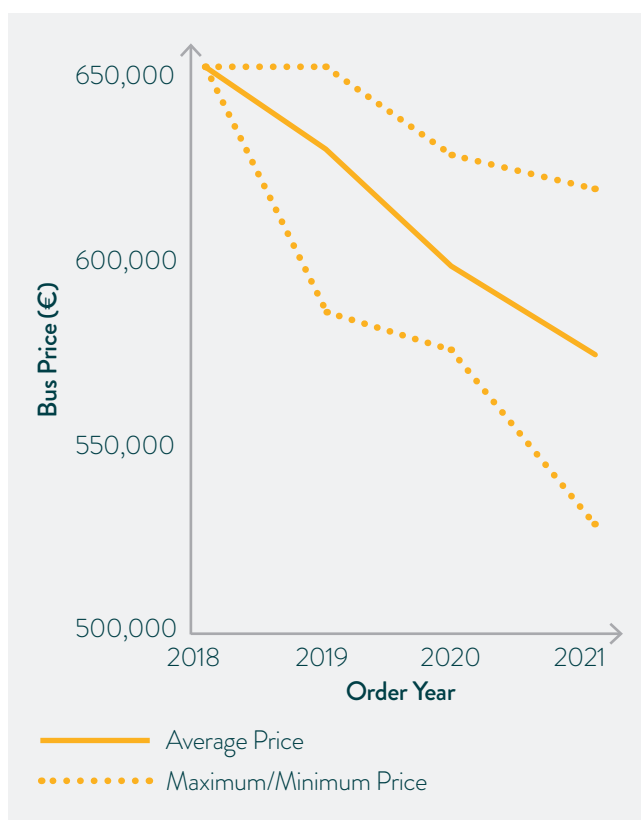
Using reliable bus operations data, the deployment site operators were able to analyse the impact of fuel cell technology on urban bus service operations. The FCBs were tested across a wide range of climates and topographies in Europe, enabling an in-depth analysis of operational experience. In terms of learnings, the JIVE projects were pivotal for the advancement of the technology due to the variety of fleet and bus types deployed (five different European original equipment manufacturers (OEMs) had buses deployed in the projects), leading to a wide range of operational insights. The extensive operational data analysis confirmed the high overall bus performance, particularly in relation to fuel efficiency across a broad set of different conditions. **Hydrogen consumption was in the range of 5.5-9.1 kilogrammes (kg)/100km for 12m and double-decker buses and around 9kg/100km for 18m articulated buses.** The buses showed good fuel efficiency, with performance exceeding the project targets. Furthermore, the data analysis revealed a significant reduction in fuel consumption over the course of the project and compared to previous projects, reflecting progress in technology and operations. This is crucial, as high performance decreases both the operating expenditure (OPEX) of the buses (cost advantage) and the buses' environmental impact (less hydrogen (H₂) needs to be produced). In terms of operational range, across the different sites, **the buses demonstrated a consistent range of up to 500km** in diverse climate conditions, proving their reliability and flexibility. Naturally, external factors must be considered — **e.g. ambient temperature can affect hydrogen consumption** — but in most cases, the buses met the range expectations of operators and sites.

Table 1: JIVE and JIVE 2 Project Partners

PARTNER	COUNTRY
Environmental Resources Management	UK/France (FR)
Brighton & Hove Buses	UK
CA de L'Auxerrois	FR
Engie Energy Services	FR
Ov-Bureau Groningen Drenthe	Netherlands (NL)
Province of South Holland	NL
Regionalverkehr Köln GMBH	Germany (DE)
Pau Béarn Pyrénées Mobilités	FR
Hydrogen Europe	Belgium (BE)
Rebelgroup Advisory	NL
Sphera Solutions GmbH	DE
Union Internationale des Transport Publics	BE
WSW Mobil GmbH	DE
Vätgas Sverige Ideell Förening	Sweden (SE)
Transports de Barcelona SA	Spain (ES)
HyPort	FR
Transdev Occitanie Ouest	FR
Connexion Vloot BV	NL
Connexion Openbaar Vervoer NV	NL
TwynstraGudde Mobiliteit & Infrastructure BV	NL
Messer SE & Co. KGAA	DE
EE Energy Engineers GmbH	DE
ZeroBus OÜ	Estonia (EE)

As with any innovative technology, the deployment sites encountered certain challenges. However, the detailed analysis of vehicle performance data, along with the lessons learned from operational experience, constitutes a valuable body of knowledge generated by the projects. In this respect, the projects acted as a catalyst to stimulate discussions and develop solutions for the challenges encountered, as well as encourage future FCB uptake. JIVE and JIVE 2 produced numerous reports and guidelines on various aspects of FCB deployment, covering all deployment stages, from project conceptualisation, financing, and planning to operations and maintenance. The full list of reports and documentation is available via the project's [website](#), including the [Final Best Practice and Commercialisation Report](#). The report provides a case study of what ideal FCB implementation might look like, to underline the most important best practices derived from the projects, and constitutes a valuable source of information for operators and authorities interested in deploying FCBs.

DECREASE IN BUS PRICE



► Figure 2: Average JIVE and JIVE 2 Standard Bus Price

*The assessment is based on 19 orders (259 buses) out of the 21 orders made within the JIVE projects. Prices shown are the base bus prices, which exclude add-ons such as USB ports, Wi-Fi, lighting, etc.

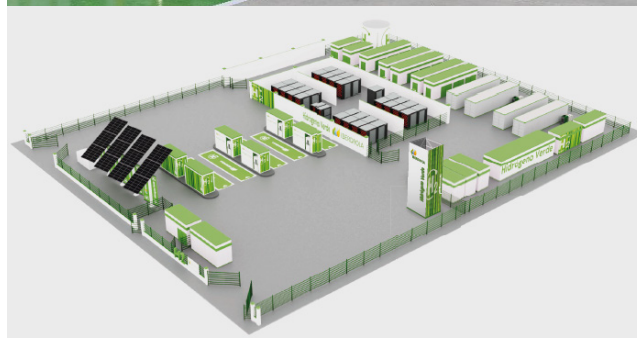
One of the most **significant achievements of the JIVE projects was their contribution to decreasing the FCB purchase price**. The projects have helped reduce the price difference between FCBs and diesel buses compared to previous funded FCB projects by increasing the deployment scale under JIVE and JIVE 2. During the JIVE projects, a downward trend in FCB prices was observed, with both projects meeting their price targets (below €650,000/€625,000 per standard bus and under €1m per articulated bus), which were aligned with the Clean Hydrogen Partnership's Multi-Annual Work Plan (MAWP) targets for 2020. In general, the lowest prices were typically achieved for orders of more than 10 buses, although final costs varied based on vehicle specifications, warranty extensions, and other factors. Despite these achievements, further cost reductions are needed to achieve commercially viable, subsidy-free offers.

Taking a deep dive into the economics of FCB deployment, a total cost of ownership (TCO) and lifecycle analysis (LCA) [study](#) was carried out by Sphera, one of the data partners, to evaluate the environmental, operational, and economic performance of FCBs against alternative solutions, such as battery electric and diesel bus systems.

TMB CASE STUDY

TMB'S INTEREST IN HYDROGEN AND JIVE INVOLVEMENT

- TMB was part of the JIVE User Group.
- In 2020, TMB joined the JIVE 2 project.
- TMB demonstrated 18-hour operational target is achievable with hydrogen.
- TMB's 2025 Strategic Plan calls for 65% of displacements made by low-/zero-emission public transport.
- By 2026, over 60 FCBs are planned for deployment.



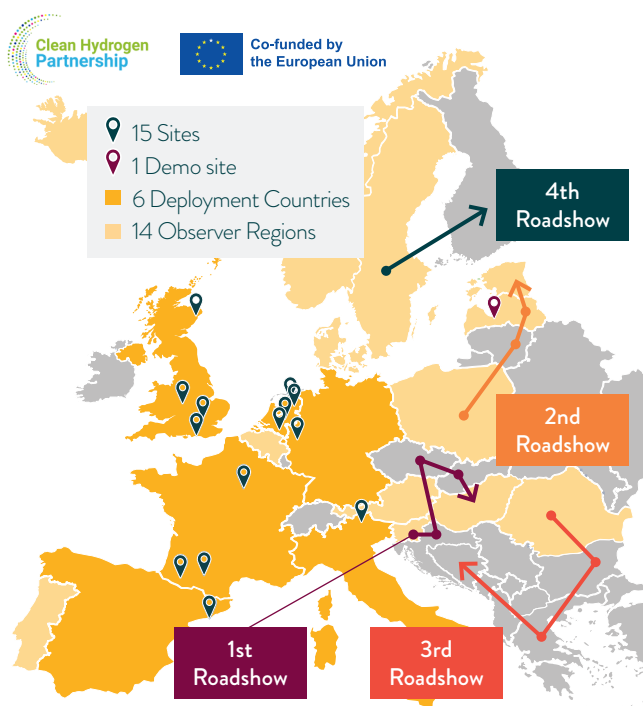
TMB'S HYDROGEN ACHIEVEMENTS

- First Spanish city to deploy fuel cell buses.
- Deployment of 10 FCBs in the JIVE 2 project, including 2 articulated 18m buses.
- February 2021: A 10-year partnership was formed with Iberdrola on public HRSs in Zona Franca, a first in Spain.
- September 2023: TMB awarded Solaris a tender for 36 additional FCBs.
- June 2024: The first of the new buses entered operation.



JIVE ROADSHOWS

As FCB rollout has strongly focused on Western Europe, JIVE 2 proposed a side activity in the form of a bus roadshow across selected cities in 15 different countries in Central, Eastern, Southern, and Northern Europe. The aim of these roadshows was to showcase the technology and allow new cities to experience and test it, with the ultimate goal of encouraging FCB orders after the tour. Furthermore, the roadshows enabled the collection of new data, contributing to the operational assessment and analysis of bus performance under new and different conditions. Four roadshows covering 35 cities in 15 countries were organised, including workshops, multi-day test trials, and collaborating with local events in each country. **Drivers, operators, and passengers were all satisfied with the vehicle performance, and the roadshows' major impact was that over 79% of all targeted cities expressed a formal interest in deploying FCBs afterwards.** The roadshow also served as an additional source of key learnings for FCB operations under new and different conditions.



► Figure 3: Map of 4 JIVE and JIVE 2 Roadshows

The first JIVE 2 roadshow, in Central and Eastern Europe (CEE), took place from mid-November 2022 to the end of January 2023, across Slovenia, Croatia, the Czech Republic, and Hungary. It attracted over 900 participants, who attended national workshops, student events, professional events, and media events (13 events were organised in total). The different events reached out to a wide range of stakeholders, including government representatives, operators, local authorities, students, professors, and researchers, ensuring that the roadshow had the greatest possible impact. Each city stop lasted approximately one week, including transport and installation/deinstallation of the mobile station. A national workshop was held in each country during the roadshow. The national workshops always included discussions on available European funding mechanisms for FCBs and associated infrastructure and presentation of the JIVE and JIVE 2 project results, along with the results of the technology trials.

Following the success of the first roadshow, the JIVE 2 project **organised a second roadshow that took place across selected cities in Poland, Latvia, Lithuania, and Estonia.** The roadshow started in Poland in mid-September 2023, before proceeding to Lithuania and Latvia and concluding in Estonia at the beginning of October 2023. The roadshow consisted of 19 events with over 970 participants, including national workshops and events with students, sector professionals, and the media. Extensive media coverage, in the form of physical and digital newspapers, TV, radio, and social media, allowed the activities to be disseminated to over 2.7 million people. The roadshow was a success, with all the cities that tested the technology announcing a formal interest in deploying FCBs after the roadshow (an expected 159 buses will be deployed across the region).

The third JIVE 2 roadshow covered four countries in the summer of 2024: Romania, Bosnia-Herzegovina, Bulgaria, and Greece. The roadshow included a total of 15 events, such as national workshops, student events, professional events, and media events, that were attended by over 2,000 participants. The extensive media coverage also allowed it to be disseminated to a wider audience, highlighting the positive results of the roadshow. During the roadshow, the bus was tested for at least 100km in all nine cities covered. Certain trials were conducted in typical spring temperatures or without any passengers, two factors linked to lower fuel consumption rates. Some tests recorded significant mileage (>200km), contributing to a more balanced understanding of fuel consumption. In all urban contexts, the bus performed extremely well, with reliable operation on existing routes and, in Romania and Bulgaria, with passengers on the bus. Overall,

most bus operators indicated that hydrogen buses were viewed as a viable alternative for their bus fleets and that they were eager to include FCBs in their fleets in the near future.

The fourth and final roadshow took place over the spring and summer of 2025, covering eight cities across Finland and Sweden. There were 15 events in total with 960 participants, including national workshops, student events, professional workshops, and media events. The test drives involved a variety of driving conditions, including urban routes with frequent stops and regional stretches with longer distances. A primary focus of this roadshow was identifying opportunities for the application of FCBs in airport settings. The roadshow was the first time an FCB was operated on the runway apron in the Nordic region. In all cities where the bus was tested, key stakeholders were interested in exploring the possibility of deploying hydrogen buses in their city, along with other applications for fuel cell technology, such as heavy-duty and specialised utility vehicles – e.g. runway snow clearers. In cities that were already engaged in hydrogen technology deployment, the roadshow and bus testing was an opportunity for relevant authorities to confirm that the advantages of hydrogen infrastructure and vehicle deployment.



KEY TAKEAWAYS FROM THE ROADSHOWS

The roadshows successfully expanded the operational analysis of FCBs in different conditions and fulfilled its objective of enabling more countries in Europe to test the technology. They went beyond bus performance, enabling data collection on drivers' and passengers' experiences with FCBs. All four roadshows helped identify key learnings and barriers to FCB deployment in areas where uptake had been limited thus far. Some of the identified challenges included:

- The high cost of hydrogen and FCBs.
- The need for funding to cover the high costs associated with the technology and infrastructure.
- Legislative barriers to FCB testing and deployment.
- Limited hydrogen availability and lack of necessary infrastructure.

The roadshows were an important forum for clarifying and discussing the potential barriers to FCB deployment. The roadshows generated a lot of interest amongst the cities involved, as well as across the wider regions, through the dissemination of the JIVE projects' results. Latvia and Hungary are two success stories resulting from the first and second CEE roadshows. After the first roadshow, in 2024, Hungary launched a national pilot to test FCBs as part of its hydrogen strategy. During the second roadshow, the city of Jelgava, Latvia expressed a keen interest in hydrogen technology. Following a request, Jelgava joined the JIVE 2 consortium and is now deploying FCBs on local routes, as well as playing a key role in the organisation of regional dissemination activities inspired by the JIVE roadshows.

“Through four roadshows across different strategic regions, the JIVE project brought a hydrogen bus and associated infrastructure to 35 cities. These demonstrations allowed local stakeholders to experience the buses firsthand, sparking awareness, interest, and momentum in cities with strong potential for future deployment. At ERM, we are proud to have coordinated these initiatives together with key partners who made them possible.”

*Eva Baker, Managing Consultant,
Low Carbon Solutions, ERM*

Table 2: Main Results of JIVE and JIVE 2 Roadshows

	1ST ROADSHOW	2ND ROADSHOW	3RD ROADSHOW	4TH ROADSHOW	TOTAL
Number of countries	5	4	4	2	15
Number of cities	8	9	10	8	35
Total distance travelled (km)	1,641	1,450	2,814	660	6,592
Hydrogen used (kg)	227.7	71.5	166.4	42.53	508.13
Average hydrogen consumption (kg/100km)	7.6	5.04	5.92	5.65	6.05
Average speed (km/h)	NA	27.9	27.4	36.49	
Average outside temperature (°C)	NA	19.7	19–31	13	
Number of events	13	19	15	15	62
Number of attendees	~900	~970	~2,000	~960	~4,830

JIVE PROJECTS: CHALLENGES AND LESSONS LEARNED

The JIVE projects (together with MEHRLIN) represent the first large-scale FCB and HRS deployment projects to date, and they inevitably faced challenges at different stages across the deployment sites. The lessons learned are very valuable for operators and authorities that intend to utilise FCBs to decarbonise their transport networks, and it is important to consider them carefully, in order to adopt the best possible remedies to limit their impacts.

FUEL CELL DEGRADATION

Some sites experienced performance losses over time due to fuel cell degradation, highlighting the need for continuous monitoring, robust maintenance strategies, and ongoing collaboration with OEMs to improve long-term durability.

HYDROGEN PRICES

Elevated hydrogen prices, partly driven by the electricity price crisis in 2022 and 2023, had a significant impact on operations at several sites. The high price of hydrogen remains a challenge, and there was a significant increase during the project, with the current price sitting above the target of €9/kg. High energy prices continue to impact hydrogen production, resulting in unaffordable green hydrogen prices without government support. There was a relatively wide range of prices across the sites and regions involved in the project, providing some useful context for the factors that contribute to high

prices. Partners that negotiated fixed long-term contracts at the start of the project, for either the price of electricity or hydrogen, were less affected. High hydrogen prices have been flagged as a key obstacle to further deployment for many project partners and interested stakeholders.

HRS AND FCB AVAILABILITY

A lack of redundancy in HRS design led to technical vulnerability and, in turn, more downtime. HRS reliability emerged as a critical issue in the projects.

In terms of the buses, long waiting times for spare parts and maintenance services decreased FCB availability. Transport operators' willingness to adopt and invest in FCB fleets is crucial for demonstrating viability and accelerating the shift to cleaner public transport. To support this, reliable maintenance for stations and buses, as well as secure spare part supply chains, must be ensured. Moreover, buses and especially HRSs must reach higher levels of reliability.



KEY BEST PRACTICES FROM OPERATORS' JIVE EXPERIENCES

DEVELOPMENT, FINANCING, AND PERMITTING

Rigorous planning can help project managers avoid or mitigate most of the typical challenges experienced in the deployment and operations phase. Connecting all the involved stakeholders — drivers, operators, local groups, and local governments — can help ensure broad commitment to successful FCB and HRS deployment, while the impact of political changes can also be mitigated.

PROCUREMENT

The HRSs, hydrogen, and buses should be procured in parallel. If not, there is a risk that the buses will stay idle, with a risk of component damage, while the supply side is still being deployed. Having a diverse and secure backup hydrogen supply is key. It is also important to ensure the proposed solutions can incorporate future scale-up and easily address potential reliability issues. Finally, HRS planning and permitting should be carefully assessed — how this process is managed, who is responsible for delivery, and how this is contractually structured.

DEPLOYMENT AND OPERATION

The operation of hydrogen infrastructure requires specific expertise and adds a layer of complexity compared to a conventionally fuelled vehicle. Ensuring backup refuelling — which can be in the form of trailers, redundancies in the HRS, multiple stations, or hydrogen being trucked in when necessary — is essential to maintain steady operations. There should be onsite technical support from OEMs in the early stages and critical spare parts kept in stock.

THE ROAD AHEAD

The JIVE projects, through the deployment of almost 300 buses and four roadshows, have achieved important learnings and significant steps forward for the sector. A set of challenges still persists, including station reliability and hydrogen supply, hydrogen prices, and spare part availability. However, the key projects' takeaways and achievements can help operators and authorities successfully deploy FCBs. In this context, it is important to identify use cases where FCBs can add value in bus fleet decarbonisation strategies and are the right choice for transport operators and authorities. Operational performance is of high relevance for decision making; depending on operators' requirements, FCBs can have advantages regarding range and flexibility on certain bus routes. With the majority of operators expected to phase out diesel buses in the coming years, FCBs now represent an attractive option when and where the right conditions are in place. It is clear that the economics remain crucial, and in this sense, the JIVE projects were extremely effective in decreasing the capital expenditure (CAPEX) through economies of scale. Going forward, the wider hydrogen sector needs to bring together stakeholders from the entire supply chain to develop solutions to the remaining challenges that are as innovative and promising as fuel cell technology itself.



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