JIVE 2 Deliverable 5.7

Training /Specialist subject workshop material collated and distributed

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ZERO EMISSION

JIVEs / MEHRLIN projects

@fuelcellbus www.fuelcellbuses.eu

Clean Hydrogen Partnership

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Main author(s): Flavio Grazian
Contributor (s):

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List of Abbreviations/Nomenclature

Abbreviation	Definition
BEB	Battery Electric Bus
CBEP	Clean Bus Europe Platform
EU	European Union
FCB	Fuel Cell Bus
FCH JU	Fuel Cells and Hydrogen Joint Undertaking, first phase of the FCH JU under the EU 7th Framework Programme
H2	Hydrogen
HRS	Hydrogen Refuelling Station
JIVE	Joint Initiative for Hydrogen Vehicles across Europe, project co-funded by the FCH 2 JU under the European Union's Horizon 2020 Framework Programme (2017 – 2022)
JIVE 2	Second Joint Initiative for Hydrogen Vehicles across Europe, project co-funded by the FCH 2 JU under the European Union's Horizon 2020 Framework Programme (2018 – 2023)
KPI	Key Performance Indicator
OEM	Original Equipment Manufacturer
PT	Public Transport
PTO	Public Transport Operator
PTA	Public Transport Authority
UG	User Group
UITP	Union Internationale Des Transports Publics
WP	Working Package
ZE	Zero Emissions
ZEB	Zero Emission Bus

1. Introduction

This document is a deliverable of the JIVE 2 project, whose full name is Joint Initiative for hydrogen Vehicles across Europe 2. The present report constitutes the deliverable 5.7: Training /Specialist subject workshop material collated and distributed. The following activities refer to WP5 of the JIVE 2 project and specifically to the Task 5.5: Training and specialist subject workshops implemented by UITP in the framework of WP5 (Dissemination).

Introducing new technology implies acquiring new skills at all levels of operation and planning. Lessons learnt in the JIVE and JIVE 2 projects were used to develop a specialised fuel cell training programme to guide stakeholders through planning, procurement, operation, and maintenance of hydrogen buses. The training programme have been developed in collaboration with UITP Training department (UITP Academy) targeting decision makers, public transport authorities (PTAs), and public transport operators (PTOs) planning to introduce FCBs into their fleets. Furthermore, some specialised workshops have also been carried out in cooperation with other EU-funded initiatives, such as the Clean Bus Europe Platform and the EU-funded project ASSURED. Finally, the main concepts and lessons learned coming from the JIVE projects have been distributed in the form of a e-learning with a free access hosted on UITP learning management system (LMS).

This report presents a summary of the activities and results related the training workshops and the e-learning developed and implemented.

2. Trainings and Workshops

Introducing new technology implies acquiring new skills at all levels of operation and planning and this is particularly important in relation to Fuel Cell Buses (FCBs). The JIVE projects were pivotal in gathering extensive knowledge on the different elements that lead to the deployment of FCBs. Throughout the projects UITP engaged with its membership all around the world due to the growing interest around the technology. PTOs and PTAs showed an increased interest around FCBs, and the JIVE projects represented a cornerstone of the knowledge provided due to the operational data and the lessons learned under the different operational and planning aspects (maintenance, operations, depot adaptations etc.).

Within this task, UITP sought to educate and train representatives from a wide range of cities and PTOs/PTAs to the main concepts of the deployment and operation of FCBs. The trainings were designed by the UITP Bus Unit, Knowledge and Innovation Department with close cooperation with UITP Academy, thanks to the JIVE learnings and sites, shared insights on different aspects of fuel cell electric bus (FCEB) deployment. The different trainings and workshops organised included a comprehensive overview of this new solution, including use cases from the JIVE and JIVE 2 projects and a practical set of guidelines for every step of introduction of the fuel cell technology. The workshops followed the main lessons learned and best practices acquired throughout the duration of the JIVE projects and touched upon subjects such as depots and maintenance, operation, and technical basics. During the workshops and trainings, UITP involved experts from the across the sector as well as from the JIVE/2 deployment sites. Due to the increased amount of consolidated data coming from the projects, the related learnings always consistently featured in the UITP trainings on the subject. It is now widely accepted by the sector that FCBs represent a valuable option with relative advantages in certain operational conditions and when infrastructure is in place. Additionally, these trainings and events were useful to collect further feedback from PTO/PTAs and enlarge the assessment of the technology. Finally, UITP international membership ensured a wide outreach and the involvement of different stakeholders.

2.1 JIVE User Group

FCBs represent a zero-emission solution alternative to traditional diesel buses used in public transport, but large-scale deployment requires the acceptance and commitment of PTAs and PTOs. At the same time, local and national authorities' support is a necessary precondition to assisting PTOs and PTAs' efforts to achieve large-scale deployment of FCBs. Recognising the need to understand all possible factors that lead to the acceptance of FCBs, particularly from PTOs and PTAs external to the project, UITP set up a User Group as part of JIVE task 3.2. This group drew inputs from cities that have not yet included FCBs in their strategy, but are interested in the technology and in following its developments, allowing the JIVE Consortium to better understand the various factors that lead to the acceptance of FCBs. The User Group was created with the following objectives:

- Enlarge the operational assessment and validation of the JIVE concepts and results through external and independent expertise.
- Contribute to the understanding of user acceptance of FCBs.
- Follow the progress and assess the results of the project in a constructive manner.
- Contribute to the dissemination of JIVE outcomes and results through the different communication channels of the members (events, website, newsletters, etc.).

The JIVE User Group Members also received dedicated trainings around the main concepts of FCBs through active participation in specific workshops.

Throughout the project, the JIVE User Group became one of the most important platforms for engaging with PTOs and PTAs external to the JIVE project, and it consists of 25 PTOs/PTAs across Europe and beyond.

The User Group followed the results of the JIVE projects' bus performance, service quality, operations, maintenance, and other relevant aspects related to FCB technology. The group especially focused on best practice exchanges from the JIVE projects' learnings and feedback on FCB technology from point of view of PTOs/PTAs, and members of the User Group participated in the training sessions that were organised.

Through the years, the User Group meetings provided an important platform for PTOs and PTAs to discuss how to overcome technical, operational, and economic challenges related to bus acquisition, construction of hydrogen production infrastructure, storage and refuelling, operation and maintenance. Additionally, the User Group meetings discussed common challenges in the broader discussion on zero emission technologies applied to buses.

Where possible, UITP aligned the JIVE user group meetings to other key events in the bus sector to maximise the knowledge and views exchange. UITP tried also to build synergies with other relevant projects or initiatives on zero emission technologies thus to allow a more comprehensive overview in the sessions and more in-depth discussion in relation to the topic.

2.2 Synergies with other European initiatives, projects and UITP working bodies

In relation to trainings, it was of particular importance that cooperation and synergies be established with other EU-Funded initiatives. These synergies allowed for the further enlargement of the outreach and participation of PTOs and PTAs interested in acquiring more knowledge about the operation of FCBs. This also allowed for dedicated training efforts to be synchronised between the JIVE User Group and other EU-funded initiatives and projects covering different aspects of clean and Zero Emission Buses (ZEBs).

UITP organised several meetings jointly with ASSURED project's partners. Both projects' User Groups shared the same format and strategic objectives, and during the meeting, common discussions touched upon refuelling and charging infrastructure challenges

needed for the transition to zero emission fleets. Another example of such partnerships was the collaboration with the Clean Bus Europe Platform, an initiative under the European Commission's Clean Bus Deployment Initiative that aims to support the deployment of clean bus technologies across Europe. The Platform brings together European cities and PTOs/PTAs with relevant stakeholders like social dialogue partners, industry, financing and funding institutions, and associations to boost and support the exchange of knowledge and expertise on clean bus deployment, including fuel cell technology. Another important EU-funded project, 3Emotion, contributed to the sixth JIVE User Group meeting that took place in Madrid, Spain on 26th October 2022. The project, which was approaching its conclusion at the time, shared valuable lessons learned from the deployment of FCBs across five different sites in Europe.

Over the years, due to the growing interest on the topic of FCBs, UITP built synergies with its working bodies such as the Bus Committee. This allowed an important exchange of knowledge and returns on operational experience, culminating in a training session organised in conjunction with the Clean Bus Europe platform during the 7th JIVE User Group Meeting that took place in Birmingham and Coventry, United Kingdom on 26th April 2023.

2.3 Workshops and Trainings

The chapter presents the details of workshops and trainings sessions organised throughout the project. In total, UITP organised four in-depth workshops, but JIVE learnings were also included in other sessions. The trainings were organised either in the framework of the JIVE User Group meetings or in cooperation with other relevant EU-funded initiatives. One of the trainings was organised directly by UITP training department, UITP Academy. Finally, UITP Academy also integrated the knowledge and best practices from the JIVE projects in other training sessions or occasions and distributed the training materials.

Where possible, UITP organised these training within larger public transport events or aligned them in with other European projects related to the sector to maximise the knowledge and views exchange.

The meetings usually focused on a specific topic, such as FCBs, HRSs, funding, maintenance, operations, etc and included regular agenda points such as an overview of JIVE projects' progress, the available collected data, and relevant news from the fuel cell sector. Furthermore, the meetings were aimed at also receiving experiences from external PTOs and PTAs and providing knowledge on technical challenges related to bus deployments, such as setting up HRS/FCB projects (technical, communication, etc.). When possible, UITP organised a technical visit to HRSs and/or depots at relevant sites to complement the meetings. All presentations and training materials were collated and distributed at the end of the trainings.

2.3.1 JIVE USER GROUP #4 with Specialised JIVE 2 fuel cell bus Training – Cancelled due to the COVID 19 Pandemic

Building on the discussions of the 3rd JIVE User Group meeting in which OV-Bureau Groningen Drenthe, a JIVE 2 partner, presented about its FCB deployment, the 4th JIVE User Group meeting was planned to take place in Groningen for 18th March 2020 in conjunction with the JIVE General Assembly and UITP JIVE 2 specialised FCB training, including site visits to the Groningen bus depot, HRS, and buses.

The purpose of the 4th JIVE User Group meeting was to provide an update on the FCB deployment projects and activities that are ongoing in the JIVE User Group member cities. The meetings also aimed to share latest JIVE projects' results and learnings, as well as to present the second JIVE Best Practice and Commercialisation Report with a guided discussion in a workshop setting. However, due to the COVID-19 outbreak, UITP cancelled the meeting at the last minute along with the JIVE General Assembly and JIVE 2 UITP training, postponing it to a later date.

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JIVE User Group Update Meeting

Groningen, Netherlands

18th March 2020

Day 1 **Venue: Van Der Valk Hotel Groningen - Hoogkerk**

Time:	Duration:	Session:	Presenter:	Who:
13:00	60	***Arrival & Networking Lunch***		JIVE User Group and Project Partners Only
14:00	10	Welcome & Introduction	UITP - Efe Usanmaz	
14:10	80	Tour de Table - Updates from the JIVE User Group members about the plans on FCEBs in their cities/regions - Q&A	ALL	
15:30	30	Update on project progress (JIVE, JIVE 2 & MEHRLIN)	Element Energy - Sophie Eynon	
16:00	15	***Coffee***		
16:15	75	JIVE Best Practice and Commercialisation Report 2 & Guided Discussion	PLANET - Klaus Stolzenburg	
17:30		***Wrap up & Insights into 2nd Day***	UITP - Efe Usanmaz	

Figure 1: 4th JIVE User Group Meeting in Groningen with JIVE 2 Training (cancelled due to COVID-19 outbreak) Agenda

2.3.2 Specialised JIVE 2 Fuel Cell Bus Training – Online

UITP and the project partners closely monitored the evolution of the COVID-19 pandemic, however once it became clear that the crisis was prolonged, UITP and partners decided to lose the momentum achieved towards fuel cell buses, so it was therefore decided to hold the replacement of the Groningen training as an online event on 3rd November 2020.

A dedicated booklet was prepared by UITP which set out the objectives, agenda, and speakers of this first UITP JIVE 2 specialised training session. An overview the key content included can be found below:

Training Goal: The goal of this dedicated training was to equip bus PTOs and PTAs with up-to-date and necessary information about the planning, procurement, operations, and maintenance of FCBs derived from both the JIVE projects and FC bus sector itself. This was the first in a series of workshops that UITP organised to transfer JIVE lessons learned on FCEBs to other sector stakeholders.

Content: The training included sessions on:

- An overview of the policy context and regulatory landscape of ZEBs at the European level (e.g. Clean Vehicles Directive, Alternative Fuels Infrastructure Directive),
- An overview of FCEB and HRS infrastructure, with a focus on what is available on the European market for both bus and infrastructure,
- An overview of the planning and procurement strategies for FCEBs and HRSs. JIVE lessons learned were drawn upon, particularly from the project set-up, infrastructure preparation, and planning for deployment and operations (e.g. route, bus depot design),
- The implementation and operational considerations of buses, including the initial lessons learned from a JIVE operator.

The training's structure was a panel format, with three panel sessions that included Q&A with participants under the guidance of moderators. It was determined that selecting fewer speakers/cases allowed the discussions to go deeper into specific issues & challenges of interest.

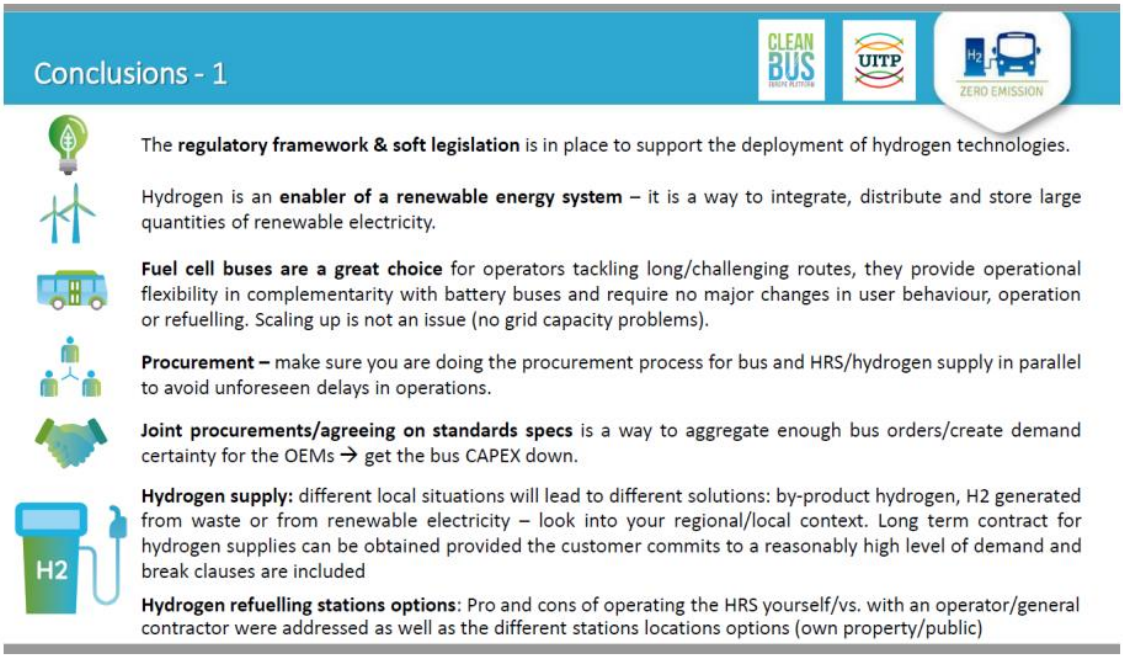

Figure 2. Conclusions by JIVE 2 UITP specialised Training held on 3rd November online format

Due to the partnership with the **Clean Bus Europe Platform**, 106 participants in total attended the training, mainly from European PTOs and PTAs from countries such as Spain, Poland, Hungary, France, Italy, Germany, Austria, United Kingdom, Denmark and Belgium. The training was held online with GotoWebinar platform, which gave the opportunity to launch some polls to better understand the composition of the participants and the main challenges from their point of view in deploying FCEBs.

All presentations and training materials were collated and distributed to the participants, while also being made available on the project repository and the UITP Clean Bus Europe Platform and fuelcellbuses.eu websites. An article summarising the main points of this first JIVE 2 UITP training programme was published on fuelcellbuses.eu. Following the training session, UITP launched a survey to the training's participants to measure the satisfaction and identify some future topics of interest for future trainings organised by UITP within the JIVE 2 project. According to the survey results, all survey participants were extremely grateful for the session and the knowledge content generated and presented from the JIVE projects. All participants commented that the experience was positive, and they are looking forward to next trainings. More trainings with physical site visits to bus depots, HRSs, as well as bus operations, were high priorities for the training's participants. Some of the key topics of interest identified for future specialised trainings are listed below:

- Key aspects of maintenance and design of bus depots/workshops,
- Implementation and operational considerations regarding mobility, as well as sharing challenges and opportunities based on latest performance of hydrogen bus deployments around the region,
- Planning and procurement, operational performance, economic feasibility,
- Operational performance and evaluation,
- Planning & procurement,
- Pricing, production, and availability of hydrogen at depots,
- Financing and business model,
- Data collection and performance analysis,
- Safety and security while operating and repairing FCEBs,
- Emerging legislation regarding hydrogen mobility,
- Pollution resulting from different technologies.

2.3.3 JIVE 2 Training #2 with User Group #5

UITP organised the fifth JIVE User Group meeting in collaboration with the Clean Bus Europe Platform and the JIVE 2 fuel cell FCB training on 18th November 2021 in Paris, France. The meeting was organised in a hybrid format with around twenty attendees participating on site and forty attending online. The meeting took place in the framework of the Zero Emission Bus Conference, one of the main events of the bus sector in Europe.

The training workshop updated participants on the state of FCB deployment in JIVE/JIVE 2, and presented initial lessons learned from the first months of FCB operations in those projects. At this stage, the JIVE deployment sites had a substantial number of buses and

some HRSs in operation and the data from the first months of operation had started to be analysed. The thematic focus of the meeting was to further discuss this operational data and the returns on operational experience learned by Wuppertaler Stadtwerke (Wuppertal, Germany) and Ov-Bureau Groningen-Drenthe (OBGD). From these sites' experience, participants were exposed to the main learnings of the interplay of FCB fleets and the HRS infrastructure, its main barriers, and the solutions to address them. The User Group meeting ended with a Caetano hydrogen bus demonstration tour in Paris facilitated by the Parisian Autonomous Transport Administration (RATP).

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FCB Training in Conjunction with JIVE User Group Meeting at ZEB Conference

Hybrid Meeting: Maison de la Chimie and Remote Connection
Salon 69 at Maison de la Chimie & Teams Meeting
18th November 2021
14:00 - 18:00 CET

Moderator: Arno Kerkhof, UITP Head of Bus Transport

Time:	Duration:	Session:	Presenter:	Participants:
14:00	15	**Welcome & Introduction**	UITP - Aida Abdulah & Efe Usanmaz	JIVE User Group Members & CBEP Cities & JIVE Project Partners
14:15	15	**JIVE/JIVE 2 Projects Updates** - Q&A	Element Energy - Madeline Ojakovoh	
14:30	20	**JIVE/JIVE 2 Fuel Cell Bus and Hydrogen Refuelling Structure Performance Evaluations** - Main performance findings from the first months of operations - Q&A	Sphera - Vanessa Roderer & PLANET - Katharina Buss	
14:50	60	**Operating Fuel Cell Buses: Return of Experience by Groningen and Wuppertal** - Putting buses into operations; interplay of buses and refuelling infrastructure; obstacles & solutions - Presentations & Discussion	OV Bureau Groningen Drenthe - Peter Mul & WSW Mobil - Andreas Meyer	
15:50	10	**Key Takeaways & Closure**	UITP - Arno Kerkhof	
16:30	90	**Fuel Cell Bus Demo Tour** - Caetano Fuel Cell Bus ride around Maison de la Chimie FCB ride and visit to Hydrogen Refuelling Station in Paris (Applicable only for in-person attendants) & return to Maison de la Chimie	Caetano Bus	

Figure 3. JIVE User Group #5 and JIVE 2 Hydrogen Bus Training Programme

Figure 4. Photo from the JIVE User Group Meeting #5 and JIVE 2 Fuel Cell Electric Bus Training Session #2

In the first session, Element Energy, the JIVE projects' coordinator, provided participants with the latest updates and results from the JIVE projects. Element Energy underlined the reduction of capital costs for FCBs below the FCH JU targets as a key achievement of the JIVE projects. In the following session, Sphera and PLANET presented the main data and performance findings from the first months of FCB and HRS operations. Their presentation underlined how more sites became operational and highlighted that even if some KPIs in the initiation phase often are not reached, after the teething phase, the bus operation becomes more stable. Additionally, the demand for FCBs has been steadily growing in Europe alongside the related wider knowledge of the technology across Europe.

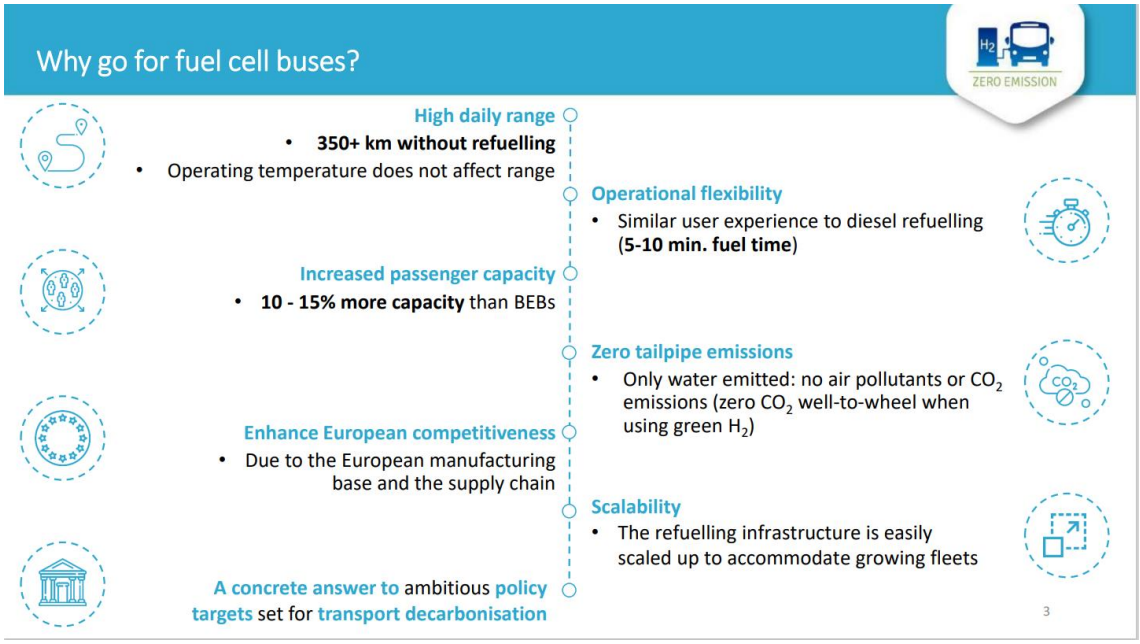


Figure 5. JIVE 2 Fuel Cell Bus Training #2 - Presentation of EE (now ERM)

In the last session, the JIVE partners OBGD and WSW presented the main learnings from their experience operating FCBs. The main highlights are outlined below:

- Hydrogen's storage capability enables the decoupling of refuelling from energy use,
- "Green" hydrogen can be produced using many approaches and is thus the ideal contribution of the mobility sector to CO2 neutrality,
- The comparison of mobility costs between diesel and self-produced H2 depends strongly on the underlying infrastructure support and the state subsidies in the electricity price,
- In terms of purely variable costs, the production of hydrogen mobility has significant cost advantages compared to diesel, but only without state electricity price components,
- In order to establish the technology, a significant cost reduction of buses is necessary in the next few years, as the cost of FCBs is still higher compared to diesel,
- When tendering, it is necessary to allocate risks where they best can be managed,
- In addition to the economies of scale required for OEMs, the establishment of a competitive environment is crucial to managing costs,

- A key factor is the adequate training and expertise of the staff in all components (drivers, logistics, project management).

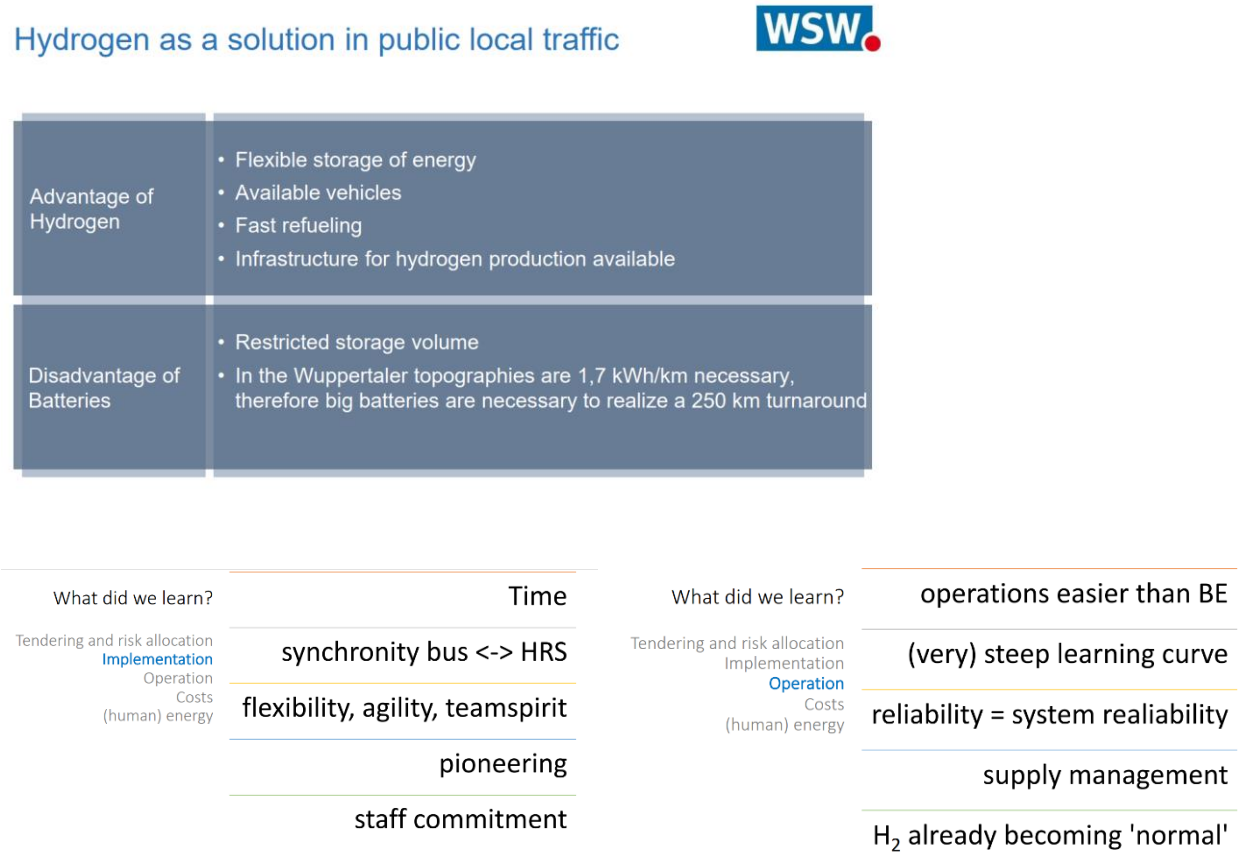


Figure 6. JIVE User Group Meeting #5 – Slides from the Presentation of WSW

Some of the main learnings from the training/user group meeting included:

- The technology is mature, but still presents teething issues for proper monitoring:
  - It is necessary to be ready for a steep learning curve.
- Mobility's high energy needs call for using hydrogen:
  - 1.7 kWh/km.
  - Careful monitoring of the energy needed for hydrogen production.
- Green hydrogen production plan based on different/case-based operational parameters (estimation 9kg/100km).
- Careful planning is required:
  - Good tendering and fair risk allocation for stakeholders involved.
  - To address financial risks and counter the uncertainty for the price of H2, a fixed price for a minimum amount per year should be set, and possible use subsidies could be introduced.
  - PTAs could also be the owner of depots currently owned or rented by PTOs with ZE Technologies.
  - It is important to create stimulus for operators to deploy ZEBs.
  - It is important to make TCO (CAPEX, OPEX) attractive for PTOs to run FCBs.

- An appropriate funding and legal framework is necessary for making hydrogen competitive.

- Data is key for operational purposes, yet it is still an issue and hard to handle:
  - Streaming data from the Controller Area Network (CAN) on this bus in real time.
- Implementation:
  - Timeline: deploy vehicles in parallel with the HRS.
  - Create right atmosphere for staff: issues and challenges need a cooperative, coordinated approach.
- Operation:
  - Operation is less complex than BEB: 10 years could be a realistic timeframe for FCBs to reach the same level of diesel.
  - HRS reliability / FCB reliability needs to be fully explored.
  - Refuelling times <15 min (cooling needs).
  - Maintenance costs might be similar to diesel buses, but more data and information is needed.
  - FCB operation is becoming increasingly normal.

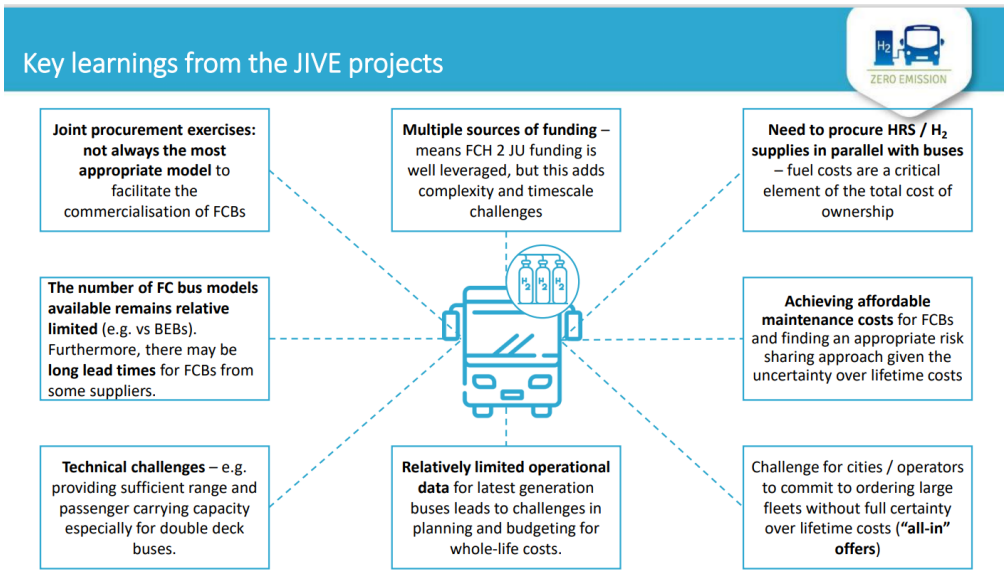


Figure 7. JIVE User Group Meeting #5 and JIVE 2 Fuel Cell Bus Training - Presentation of Key learnings

The meeting provided an increasing number of learnings, solutions and insights about fuel cell technology to the participants. Furthermore, the increasing number of buses in operation, together with the first set of reliable data on their performances, was of great value for the acceptance of the technology by operators external to the JIVE projects.

2.3.4 Fuel Cell Bus JIVE 2 Training #3 & JIVE User Group #7

Figure 8. FCB JIVE 2 Training #3 - Programme

A JIVE 2 Fuel Cell Bus Training took place in Birmingham and Coventry, United Kingdom, on 26th April 2023 in conjunction with the Clean Bus Europe Platform Study Tour and the UITP Bus Committee. UITP organised the meeting with a mix of technical visits and classroom sessions. There were two technical visits, one to the Tyseley Energy Park Hydrogen Facility in Birmingham, and another to the Coventry Electric Bus Depot. The classroom session took place in the Coventry Transport Museum as a training session touching upon Transport for West Midlands's (TfWM) strategy for clean bus deployment and the experience of FCB operations from South Holland in the JIVE 2 project. The meeting was organised as the 3rd JIVE 2 Fuel Cell Hydrogen Bus Training.

The joint training session, CBEP, JIVE User Group took and UITP Bus Committee, took place in a hybrid format and featured a presentation from TfWM on its strategy for and experience of clean bus transition and deployment. Furthermore, the session included a presentation from South Holland on its experience operating FCBs. This was followed by a joint discussion on challenges for ZEB deployment.

The programme included two technical visits to bus depots and energy facilities in the West Midlands region, providing the opportunity for participants to dive deeper into charging and fuelling infrastructure. The detailed agenda can be seen below.

Day 1. Wed, 26th April	**Technical visits Birmingham and Coventry with TfWM**	
8.15 Shuttle bus to Perry Bar for CWG route through Birmingham City Centre to Tyseley *Meeting point: hotel lobby Crowne Plaza City Centre Birmingham*		
9.45 – 11.30	Shuttle to technical visit #1 Tyseley Energy Park Hydrogen Facility	
11.30	*Shuttle to Coventry*	
12.15 – 13.15	Technical visit #2 Coventry Electric Bus Depot	
13.15 -14.30	Lunch break at Coventry Transport Museum with possibility to visit the museum	
Part 2. Classroom session and joint seminar CBEP + JIVE/JIVE2 **14.30 – 17.00** Venue: Coventry Transport Museum		
14.30 – 14.40	Welcome & introduction to the joint session of CBEP Study Tour and JIVE UG meeting	Aida Abdulah & Flavio Grazian, UITP
14.40 – 15.40	TfWM strategy for clean bus deployment (60') • Strategy & technological challenges • Tendering & system deployment • Description systems battery electric, fuel cell hydrogen • Future plans Q&A	Steve Hayes, Head of Network Transformation, TfWM
15.40 – 16.00	JIVE/JIVE 2 Projects Updates	Magali Senaux and Eva Baker, Element Energy
16.00 – 16.20	Return of Experience of FCBs Operation from South Holland	Wouter Tettero, Rebel Group
16.20 – 17.00	Panel discussion CBEP + JIVE (20') Joint discussion on challenges at their sites for ZEB deployment	All
17.00	Shuttle to Coventry train station and travel to London *Travel time approx. 1h 30'*	

Figure 9. JIVE 2 Training # 3 - Agenda

The morning started with a technical visit to the Tyseley Energy Park Hydrogen Facility, where attendees visited the HRS serving the area's FCB fleet. The attendees participated in a classroom session and study visit of the Birmingham Energy Innovation Centre where the institution provided participants with a session on the use of hydrogen in public transport. The Centre presented its work on the use of new technologies to promote innovation in waste, energy, and low carbon vehicle systems. As a recognised centre of excellence in hydrogen and fuel cells, energy storage, magnet and battery recycling, its work aims to create fully commercially viable energy systems that will contribute to fulfil Birmingham's commitments to reduce CO2 emissions by 2030 and to support the delivery of a greener and cleaner ecosystem for Birmingham and the West Midlands. The main goal is to create an exemplary sustainable working and living ecosystem which is recognised for its approach to net zero and sustainability. Participants then visited the local HRS.

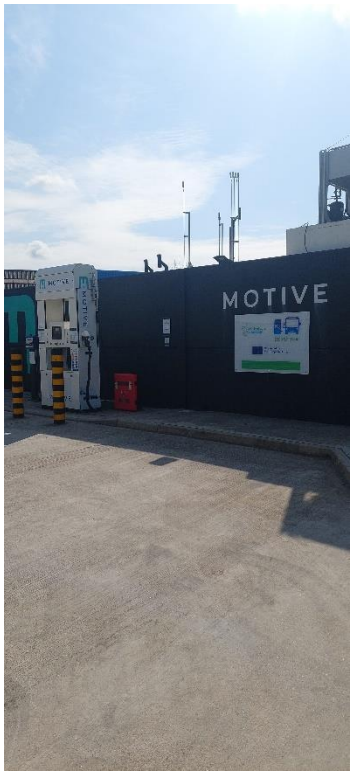


Figure 10. Birmingham energy innovation centre and HRS

The Motive Hydrogen Refuelling Station was commissioned in 2021 with the help of the JIVE project, and it is the largest green hydrogen refuelling station in the United Kingdom. It takes power from a dedicated offshore wind turbine and generates zero carbon, fuel cell grade hydrogen. The site comprises a car refueller operating at both 700 bar and 350 bar, as well as two bus refuellers operating at 350 bars, and a tube trailer operating at up to 450 bars. The site can generate over a tonne of hydrogen per day, enough to fuel up to 40 buses a day. Hydrogen is produced on site using a 3MW Motive Power Proton Exchange Membrane (PEM) electrolyser, which splits water into hydrogen and oxygen. The hydrogen generated is very high purity, meeting all requirements for FCEVs. The hydrogen is dispensed at 700 bar and 350 bar, ensuring a very quick and efficient refuel process that can provide for a 300–350-mile range. When hydrogen is used in a fuel cell, it returns to water vapour, meaning hydrogen as a fuel is a very clean fuel option.

In the afternoon, the programme provided the attendees, primarily external PTOs/PTAs, with a technical visit to the Coventry Electric Bus Depot, followed by a classroom session at the Coventry Transport Museum. The training workshop provided participants with a case study on Developing a Zero Emission Bus Delivery Plan for the West Midlands, delivered by TfWM. The presentation highlighted the methodology for developing a zero-emission bus delivery plan, the main challenges of the transition, and the emerging themes. The main objective is the introduction of 124 FCBs with a target of a 100% ZEB fleet in the region by 2030. For this purpose, the PTA developed a holistic, long-term bus decarbonisation strategy to 2030, prioritising depots and routes based on the evidenced

need and technical viability. To this end, TfWM remarked on the importance of the following elements for the delivery plan:

- Policy and strategy review,
- Baselining of current bus fleet and depot estate,
- ZEB technology and trends,
- Stakeholder engagement,
- Delivery Plan: Programme identified with timescales for implementation & guiding principles and policies adopted.

The presenters remarked on the importance of collaboration amongst all the stakeholders involved since no such delivery plan can exist in isolation. The engagement with bus operators and local stakeholders is crucial to shaping any ZEB delivery plan, as well as expanding the understanding of new options around technology, funding, and financing. In their policy and strategy review they presented their key findings:

- **The need to consider all technologies fairly:** new battery electric, new hydrogen and repowers all have a place.
- **The need for place-based solutions** with ZEB deployment targeted to particular areas and generators of transport emissions, linked to provision of required charging/fuelling infrastructure which need to be in the right places for the right users.
- **Alternative approaches to financing and ownership** of operational assets will increasingly be required, including vehicles and potentially depots.
- **Link infrastructure plans to other parts of the transport sector** such as heavy goods vehicles (HGVs), municipal fleets and rail – especially for hydrogen.

Finally, TfWM remarked on the importance of correctly assessing power supply capacity at the regional level, as well as the power needs by depot and operator.

The training workshop on FCBs also updated participants on the state of fuel cells buses deployment in JIVE/JIVE 2 and presented some of the lessons learned from FCB operation. At this stage, the JIVE deployment sites were operating a substantial number of buses and the data from the first years of operations started to be analysed. ERM (formerly Element Energy) delivered a presentation on the main updates from the JIVE projects. The last presentation of the day focused on the operational experience in South Holland, from which participants learned more about the interplay between fuel cell fleets and the refuelling infrastructure, including its main barriers, and the solutions to address them. Additionally, participants learned the tips and suggestions to set up an FCB deployment project. The presentation highlighted the importance of adapting a FCB deployment project to the features of the local context. The JIVE deployment site in South Holland presented the main lessons learned and the related challenges from the first pilot project and the following scale-up project regarding both operation of FCBs and HRSs. Some of the main elements mentioned included:

- Permitting,
- Securing hydrogen supply, for which long term contracts can enable lower prices,
- Hydrogen prices remain high,
- Expect a 6-month teething period,

- For larger fleets, multiple HRSs are recommended,
- co-develop the HRS and the bus and take the right time to analyse the conditions,
- Refuelling speed is important to consider in planning. Involving all stakeholders (OEMs, operators) from the start.

Overall, he noted that passengers and drivers have good experience with the buses. Finally, for intensive routes, such as on highways, good alignment with the OEM to secure the necessary vehicle design requirements was advised.

The last part of the session featured a discussion on the different challenges for the deployment of ZEBs. Participants highlighted many important aspects inducing increasing energy costs, the need for a stable hydrogen supply chain, and the adequate training of the workforce.

Figure 11. JIVE 2 Fuel Cell Bus Training #3. Classroom session in Coventry

2.3.5 UITP Training Hydrogen Buses for Urban Mobility, Vienna, Austria, 5-7 March 2024

The UITP Training Hydrogen Buses for Urban Mobility that took place in Vienna, Austria from 5th to 7th March 2024, and incorporated the main lessons learned from the JIVE projects into the programme, with a specific focus on deployment and operations. The objective of the training program was to discuss how to introduce clean energy vehicles, including both battery electric and hydrogen buses. The primary topics discussed in relation to this are outlined below:

- A comprehensive overview of these new technologies,
- Setting a long-term city strategy for energy transition,
- Defining a charging strategy and technology preference,
- The procurement, implementation, and operation of the entire system.

The training included an introduction to the JIVE and JIVE2 projects focusing on FCB operations, hydrogen supply, and storage. The training sessions also touched upon the

challenges and solutions for FCB implementation as well the key policy drivers for hydrogen. Finally, two sessions focused on joint procurement and on strategies to decarbonise a modern bus fleet. The speakers of the training session featured Hydrogen Europe, Sphera, Planet, and OBGD, JIVE 2 deployment site in Groningen, Netherlands. More than 20 participants attended the different sessions, and two PTOs joined the JIVE 2 User Group due to their interest in the technology. The training was organised in collaboration with Wiener Lienen, member of the JIVE User Group, and PTO in Vienna, Austria.

Figure 12. Fuel Cell Bus Training in Vienna - Classroom section

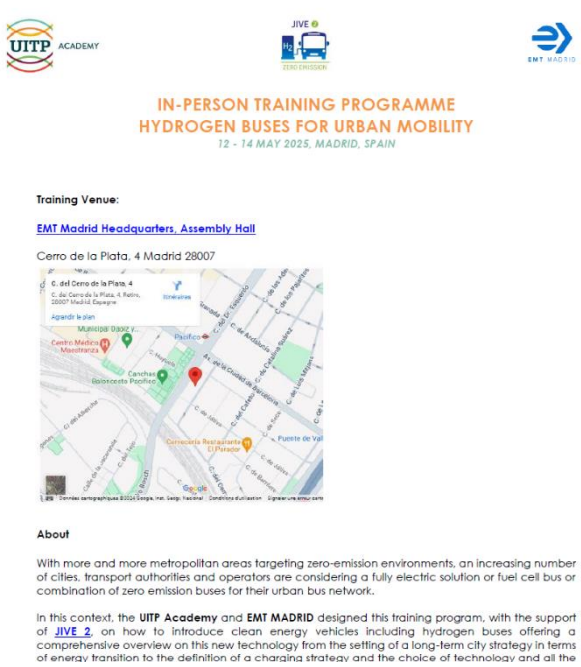
Figure 13. Fuel Cell Bus training in Vienna - group Picture

2.3.6 UITP & JIVE 2 Training Hydrogen Buses for Urban Mobility #4, Madrid, Spain, 12–14 May 2025

The UITP Training Hydrogen Buses for Urban Mobility that took place in Madrid from 12th to 14th May 2025 was organised with the support of JIVE 2 project by the UITP

Academy and EMT MADRID, a member of the JIVE User Group. The aim of this training was to give a clear idea about the policy considerations of implementing hydrogen vehicles into cities. The target audience of this training was decision makers, the upper management from PTAs and PTOs, local and national governments, and Municipalities who want to understand the policy drivers of how to implement hydrogen bus solutions. In total, 12 people attended the training that included the lessons learned coming from the JIVE 2 projects on operations, economics, hydrogen supply and storage. EMT widened the topic by providing insights on their strategic approach towards green hydrogen, including technical aspects such as design and engineering. Additionally, EMT explained the service aspects of FCBs, alongside rolling stock, procurement, and operational considerations. The session was complemented by discussions on operational best practice, safety, maintenance, and choices of procurement. This training session also explored business cases and the economics of hydrogen buses with relevant examples of how project conceptualisation, financing, planning, benchmarking, and other considerations could affect the business case. Other relevant sessions covered bus operations, hydrogen supply and storage, as well as hydrogen as a state-of-the-art alternative energy source. The lecture sessions were mixed with interactive exchanges between the participants and attendees. The speakers of the training session featured Sphera and OBGD, a JIVE 2 deployment site.

Figure 14. JIVE 2 #4 Fuel Cell Bus training in Madrid - Group Picture



IN-PERSON TRAINING PROGRAMME
HYDROGEN BUSES FOR URBAN MOBILITY
12 - 14 MAY 2025, MADRID, SPAIN

Training Venue:

EMT Madrid Headquarters, Assembly Hall

Cerro de la Plata, 4 Madrid 28007

About

With more and more metropolitan areas targeting zero-emission environments, an increasing number of cities, transport authorities and operators are considering a fully electric solution or fuel cell bus or combination of zero emission buses for their urban bus network.

In this context, the **UITP Academy** and **EMT MADRID** designed this training program, with the support of JIVE 2, on how to introduce clean energy vehicles including hydrogen buses offering a comprehensive overview on this new technology from the setting of a long-term city strategy in terms of energy transition to the definition of a charging strategy and the choice of technology and all the

Figure 15. JIVE 2 #4 Fuel Cell Bus training in Madrid - Programme

Figure 16. JIVE 2 #4 Fuel Cell Bus training in Madrid - Technical Visit at EMT Depot

3. Hydrogen Buses eLearning

Within the JIVE 2 project, UITP decided to digitalize existing training content to be hosted on its learning management system (LMS). The purpose is to freely offer digital training content to UITP learners and other public transport stakeholders to build on the best practises for the application of hydrogen for urban mobility from the JIVE projects. UITP considered the creation of an eLearning module on FCBs as the best way possible to collect and distribute the knowledge and materials that have come from the trainings and specialist subject workshops carried out during the project. The eLearning has been created in cooperation with the UITP Training Department, UITP Academy.

UITP created a unique learning experience in a centralized digital learning platform that offers both digital self-paced and blended learning solutions. While the e-learning was not originally foreseen in the Grant Agreement, UITP decided to utilise some of the budget available to produce an additional element which ensured the project learnings and outcomes were available to the wider public transport stakeholders' community. The e-learning module will be publicly available and accessible via the UITP website and will be an important element for interested stakeholders to get involved and obtain useful knowledge on the integration of FCBs in a zero-emission strategy for decarbonising public transport.

This e-learning program is made of five eLearning modules covering five macro-areas around the topic of FCBs, the estimated duration of each being approximately 10-12 minutes, with the total duration being no more than 60 minutes. The different modules

allow participants and learners to build a solid foundation and understanding of FCBs. The modules cover these five different topics:

- Introduction to hydrogen buses including their architecture and the key policies drivers for implementation.
- Business case of Fuel Cell Buses, covering the project conceptualisation, zoning and permitting as well as financial and planning.'
- Planning for FCBs roll-out and operations, covering hydrogen production, supply and storage and depot adaptation for fuel cell buses.
- Best practices on operations, safety and maintenance.
- Bus procurement, exploring the different available options, hydrogen supply, permitting and warranties.

The objective of the eLearning is also to analyse the possible scenarios and best-case studies of introducing FCBs in the most sustainable and efficient way for our cities. Learners can also get inspired by current operational practice, technology and policy orientations

A recognised certification will be awarded to those who successfully complete all modules.

The detailed structure of the content is available in the figure below.

Module title	Duration
1. Introduction to Hydrogen Buses • General Architecture of fuel cell bus • Basic hydrogen characteristics • Market overview and trends • Comparison of energy densities • Global key policies drivers in Hydrogen Bus implementation	10 min
2. Business case H2 Buses • General motivation for the choice • H2 powertrain technology choice advantage • Project Conceptualisation • Zoning & Permitting • Financing and Planning • Benchmarking • Other considerations that could affect the business cases • Additional Costs	10 min
3. Planning for H2 Bus roll-out and operations • Key stakeholders – where to start? • Hydrogen production, supply and storage • Backup of supply • Hydrogen refuelling stations • Depot Adaptation for H2 buses • Commissioning ant testing • Integrating hydrogen buses into your current fleet: challenges and best practices	10 min
4. Best practice on operations, safety and maintenance • Daily operations • Workshop safety considerations • Preventative and corrective maintenance • Training • Use cases	10 min
5. Bus Procurement focusing on H2 • Different options for procuring and operating refuelling station (in the depot, through partnership...) • Hydrogen Supply, permitting and HRS warranties • Tender test • Industry overview	10 min

Figure 17. Structure of the five modules of the eLearning on Fuel Cell Buses

All modules are linked to external references if the audience wish to have more information, e.g. the JIVE 2 deliverables or papers. The e-learning platform's main purpose is to connect the specialised fuel cell training programme with an efficient tool for distributing and disseminating the knowledge acquired during the projects. This can be used as a guide through the planning, procurement, operation, and maintenance of hydrogen buses for relevant stakeholders. The course provides interested PTOs/PTAs with a set of guidelines for every step of the process to introduce fuel cell technology. The course is also implemented with interactive elements, such as videos, quizzes, etc. The eLearning module includes a highly visual design for all topics and case studies that uses illustrated characters and scenes alongside complimenting English language audio.

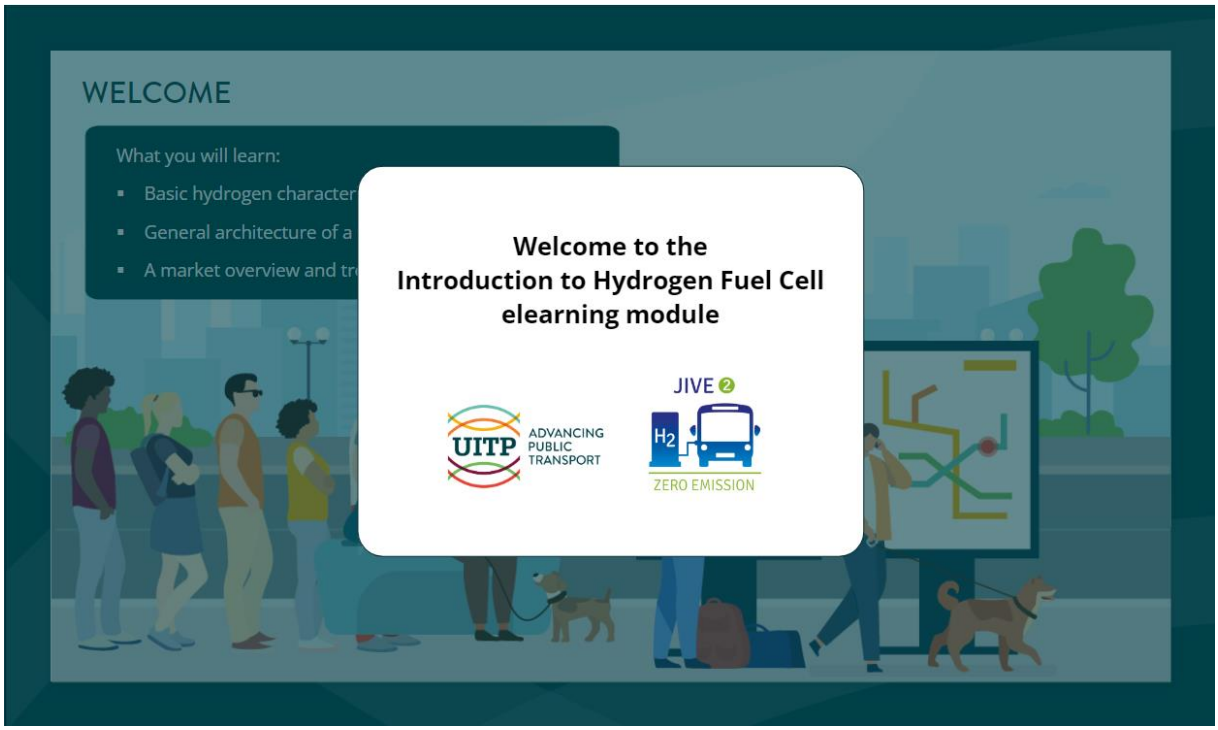


Figure 18. E-learning Introductory page

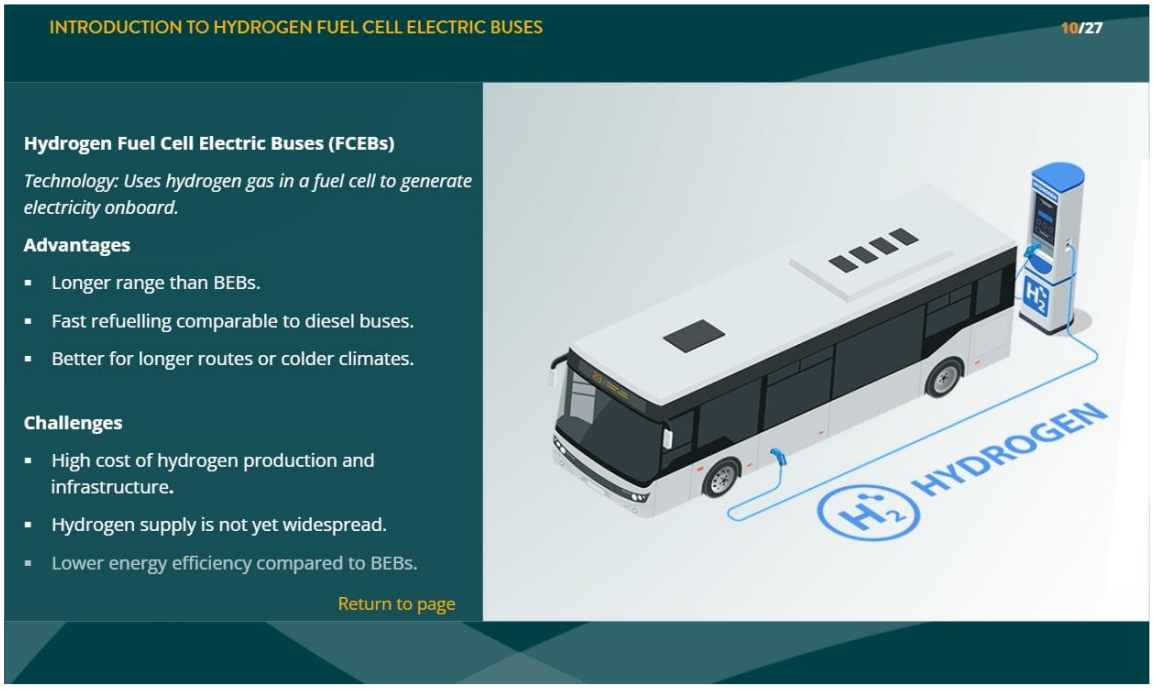


Figure 19. E-learning Introduction to Hydrogen Fuell Cell Electric buses

4. Future work

UITP, as the international association of public transport, will keep its membership engaged on the topic by continuing to disseminate the knowledge acquired through JIVE

and JIVE 2, as well as monitor the evolution and rollout of FCBs keeping. Future work could leverage potential future project forums, the Zero Emission Bus Conference, as well as the Zero Emission Observatory of the UITP Bus Committee. The UITP Bus Unit in the Knowledge and Innovation department together with the UITP Academy will continue to both provide training sessions to interested PTOs and PTAs and will foster exchange of best practices and lessons learned from the JIVE projects in the wider public transport sector. Finally, the eLearning on Hydrogen Buses will ensure that interested stakeholders have the opportunity to access a free and comprehensive source of knowledge, which will support capacity building and informed decision-making related to the deployment and operation of hydrogen bus technologies with an overview of the best practices and lessons learnt from the JIVE and JIVE 2 projects.

Project coordination:

ERM

Project dissemination:

Hydrogen Europe

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@fuelcellbus
www.fuelcellbuses.eu

Clean Hydrogen Partnership

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