D5.1.- FCHPP Implementation and Integration in Demonstrator Train

WP5 – Demonstrator Integration, Testing and Homologation

Task 5.1 – FCH PowerPack Implementation and Integration in Demonstrator Train

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Contributions Table

Partner	Contribution
CAF	Installation of the FCHPP in the demonstrator train applying all the necessary electrical, mechanical, and pneumatic modifications to the train to allow a safe integration of all new equipment.
TME	Support for preparation and integration of FC modules assembly to the train
RENFE	Train delivered to CAF. Quality Check performed to support the handover of the train. Revision of the train works and progress, at demand.
CNH2	Follow-up of train progress. Consultancy related to hydrogen interfaces.

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Executive Summary

The project 'Fuel Cell Hybrid Power Pack for Rail Applications' was an innovation action in Horizon 2020, the most significant research program in the European Union. Aimed at reducing the production costs of fuel cell systems in transport applications while increasing their lifetime to levels that can compete with conventional technologies, the program developed the project entitled FCH2RAIL, under Grant Agreement No. 101006633 [1].

The main objective of the FCH2RAIL project is to develop, build, test, demonstrate and homologate a scalable, modular, and multi-purpose Fuel Cell Hybrid PowerPack (FCHPP) applicable for different rail applications, and suitable for retrofitting existing electric and diesel trains, to reach TRL7.

The implementation and integration of two Fuel Cell Hybrid PowerPacks into a demonstrator train was the first task to be completed. Following this the CIVIA train provided by RENFE was converted into a Bi-mode Fuel Cell Hybrid demonstrator train for the purposes of testing.

The integration of the two Fuel Cell Hybrid PowerPacks was undertaken as part of WP2 in parallel with the design of the Fuel Cell Hybrid PowerPack, developed in WP3. The new equipment is integrated into both the existing traction architecture and the existing train control architecture. The design of the demonstrator train includes a transformation of part of the passenger area into a technical area, where the new equipment is installed both inside the car and on the roof.

As it is a public deliverable the transformation of the train is captured in a video: https://youtu.be/bFBR6nhyEVI

Whilst the video provides the main evidence of fulfilment of the task, at the time it was recorded only one of the two powerpacks was actually installed in the train. As a result, this document contains a photographic report showing integration of the second powerpack into the train, using the same process as the first powerpack.

Figure 1 Train transformation video on YouTube

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Glossary of Terms

Abbreviations	Description
FCHPP	Fuel Cell Hybrid Powerpack

Acronyms	Description
CAF	Construcciones y Auxiliares de Ferrocarriles
CNH2	Centro Nacional del Hidrogeno
GA	Grant Agreement
FCH2RAIL	Fuel Cell Hybrid PowerPack for Rail Applications
TME	Toyota Motor Europe

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Contents

1. Civia Train Arrival at CAF Zaragoza

The Civia Train arrived at CAF's Zaragoza facility on the 23rd of September 2021. Figure 2 and Figure 3 are documenting this milestone.

Figure 2 CIVIA train arriving in CAF facilities (1/2)

Figure 3 CIVIA train arriving in CAF facilities (2/2)

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2. Civia Train Transformation

2.1 Components of the Fuel Cell Hybrid PowerPack

The FCHPP main subsystems are:
- Fuel Cells
- Fuel Cell cooling system
- Hydrogen storage system
- Onboard Energy Storage system
- HV DC/DC converter
- Driver Advisory System and Energy Management (DASEM)

Figure 4 is showing the architecture of one Fuel Cell Hybrid PowerPack. Two Fuel Cell Hybrid PowerPacks are installed in the demonstrator train.

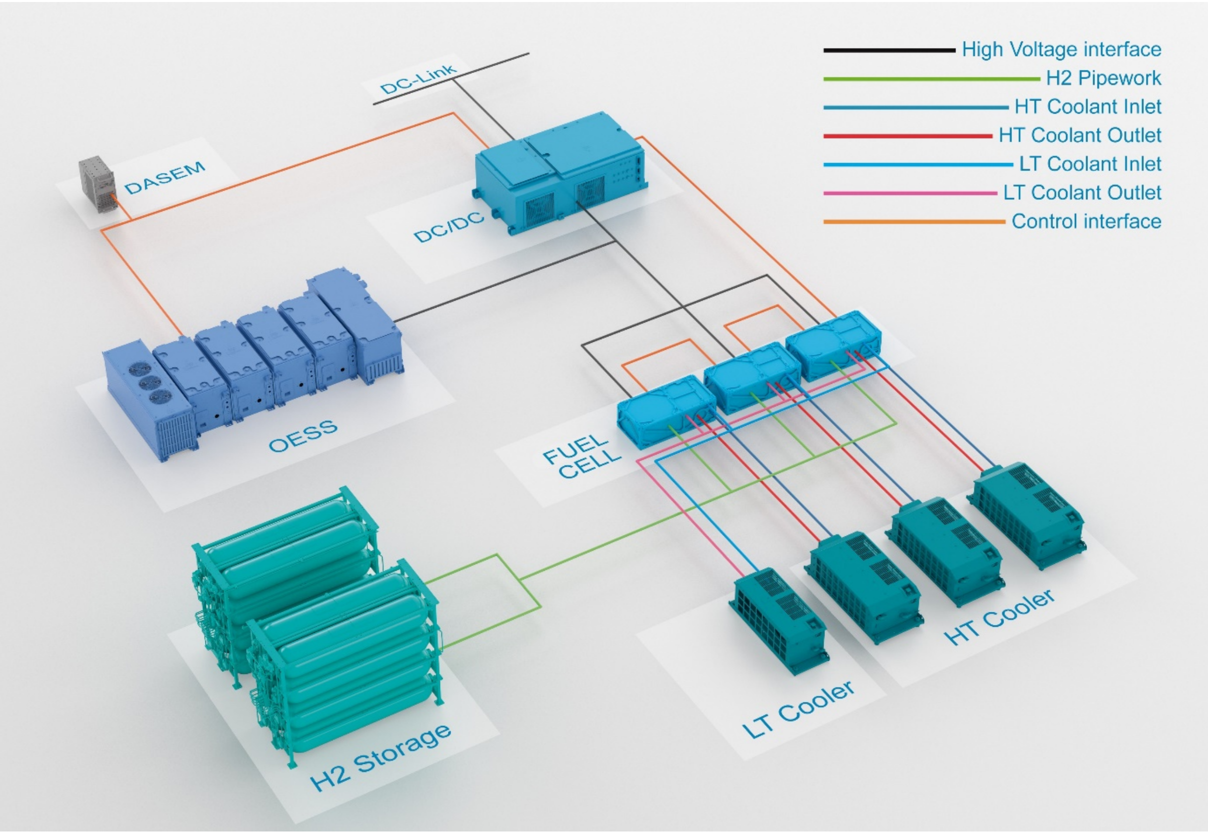

Figure 4 Architecture of the complete Fuel Cell Hybrid Powerpack

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2.2 Distribution of Components in the demonstrator train

The components of both powerpacks are arranged in the following way in the demonstrator train:

Car A1/A2: Driving Car

- Inside the passenger saloon area: Battery System (OESS (x2)), one per Car

Car A3: Intermediate Car

- Outside on top of the roof: Fuel Cells (x6) + Fuel Cells cooling system (x6 + x2)
- Inside the passenger saloon area: H2 Storage System (x4) + HV DC/DC Converter (3000/750Vdc) (x2)

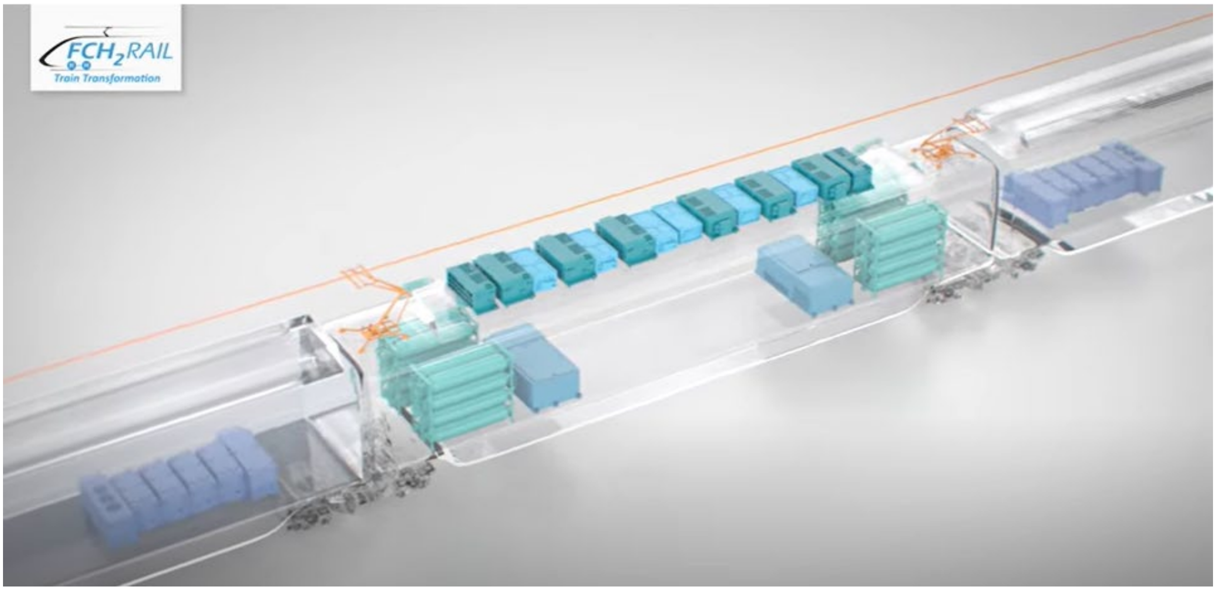

Figure 5 Arrangement of Components in the demonstrator train

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2.3 Installation of components on the roof of the intermediate car

The fuel cells and the cooling system were fitted on the roof of the intermediate car. After removing the air conditioning system of the former RENFE Civia unit, it was necessary to fix some new brackets onto the roof to be able to mechanically support the new equipment. Then, all necessary electrical and hydraulic tubing connections were fitted. Finally, the coolant tubing was connected between the fuel cells and the cooling system.

Figure 6 One HT Cooling System inside its transportation box

Figure 7 One Fuel Cell about to be installed

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Figure 8 Fuel Cell modules being lifted onto the roof

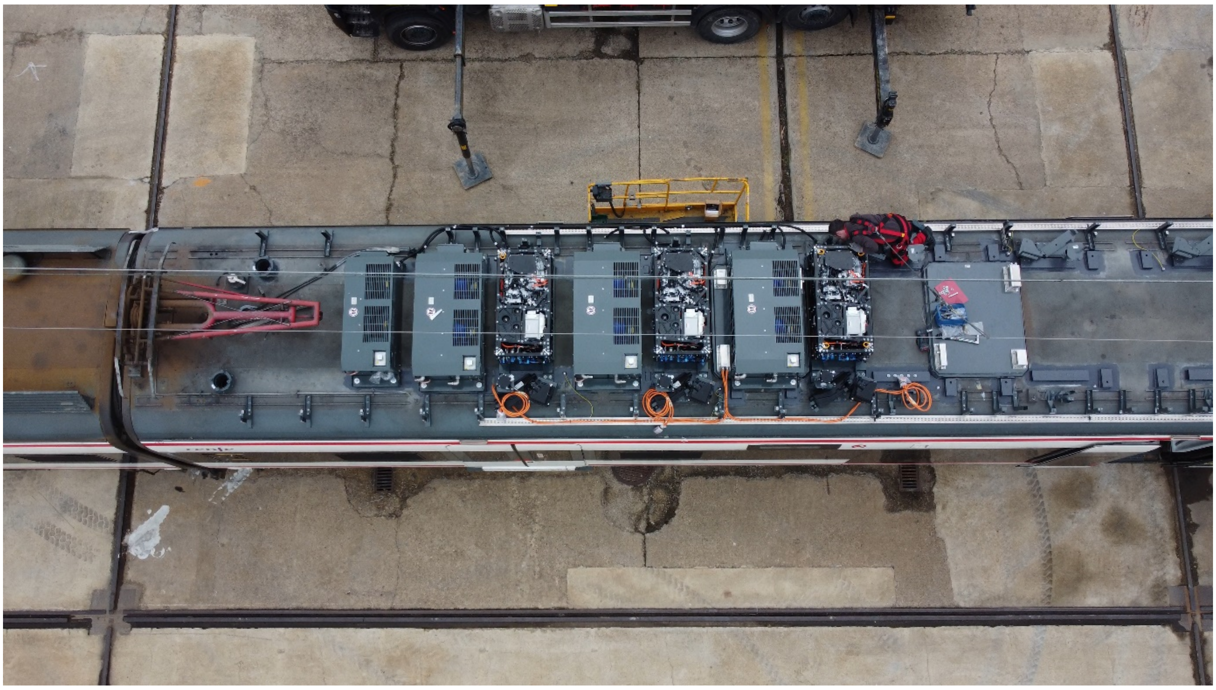

Figure 9 One PowerPack Fuel Cell modules and Cooling System installed on the roof

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Figure 10 Both PowerPack Fuel Cell modules and Cooling System installed on the roof

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2.4 Installation of components inside the intermediate car

The first stage of the train remodeling phase was dedicated to removing some high volume or unnecessary elements inside the unit: seats, handrails, luggage storage devices, internal linings.

Then, due to the weight of the equipment, it was necessary to reinforce the lower part of the flooring to avoid any permanent deformation or damage to the train structure:

Figure 11 Lower frame reinforcement due to weight of new elements

The hydrogen storage systems and the two DCDC 3000V converters were fitted inside the intermediate car. Due to volume constraints, a specific industrial company was hired to be able to insert the modules through the intermediate car access doors. The DCDC 3000V converters were installed in front of the same access doors. Once both parts were inside the train, all electrical and pneumatic connections were made. In the intermediate car, a part of the external windows was substituted by ventilation grills.

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Figure 12 Hydrogen Storage System in its transport box

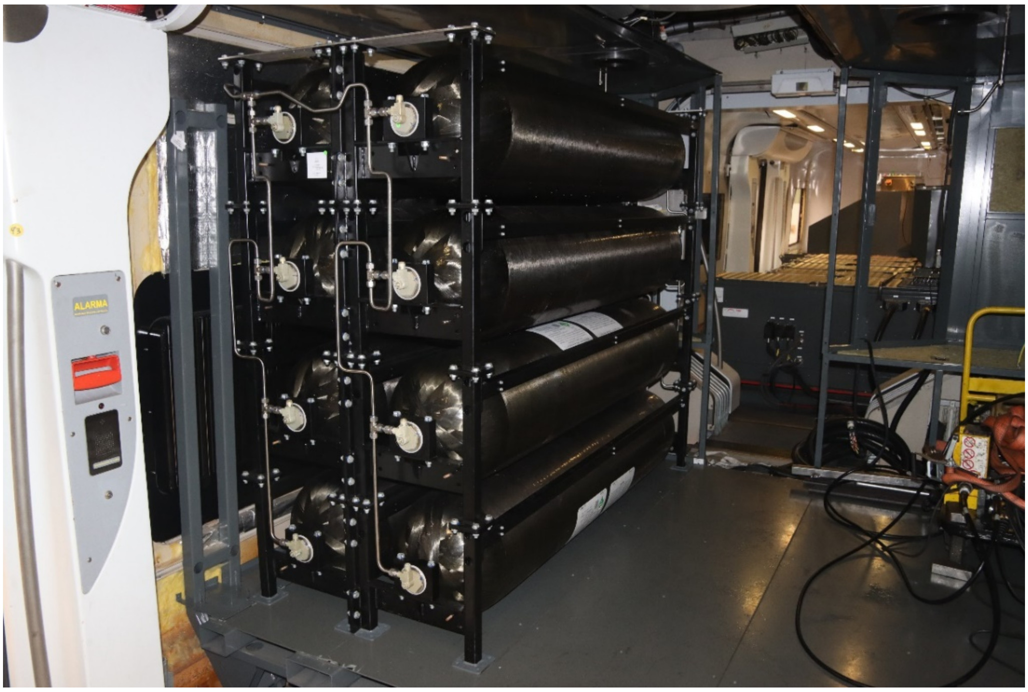

Figure 13 One Hydrogen Storage Module moved into the train

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Figure 14 Hydrogen Storage System installation inside the intermediate car

Figure 15 Hydrogen System being installed, connected, and wired in its enclosure

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Figure 16 Hydrogen Storage System extractor fan

Figure 17 Hydrogen Storage module in its closed enclosure

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Figure 18 Installation of the DC/DC converter

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2.5 Installation of components inside the driving car

As with the intermediate car, it was necessary to remove some high volume or unnecessary elements inside the unit: seats, handrails, luggage storage devices, internal linings. All windows, located within the fire barrier area, were substituted with grills, to be able to cool the OESS, which is prone to heating due to cycling (charge and discharge cycles). A specific air duct was designed to be able to cool down the OESS through forced convection.

The complete OESS was then installed using a specifically designed crane, to be able to move those heavy elements inside the unit. Finally, electrical connections were made, and the thermal hydraulic system commissioned.

Figure 19 ESU modules of the OESS in its transportation boxes

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Figure 20 One ESU module being lifted

Figure 21 All modules of the OESS fitted into the train

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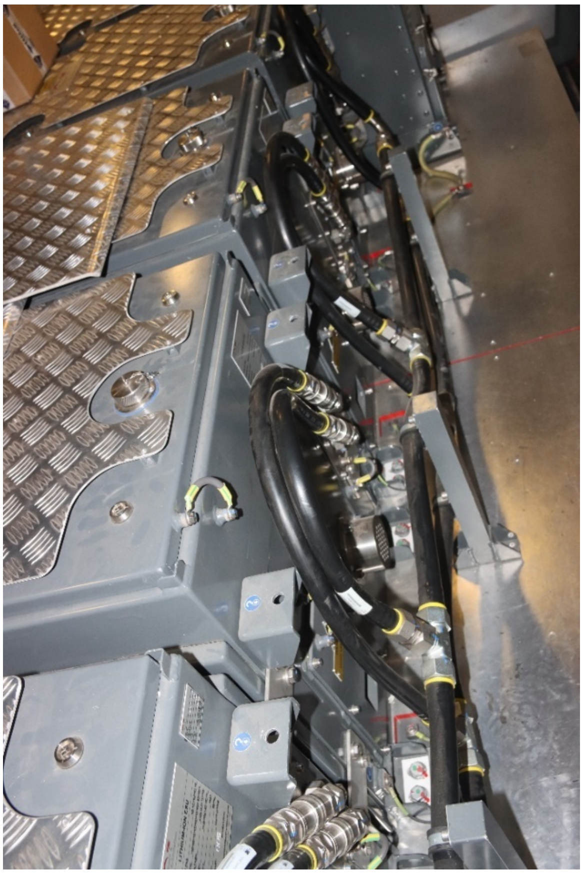

Figure 22 OESS hydraulic system being connected

Figure 23 OESS electrically connected

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Figure 24 Ventilation grills fitted

Figure 25 Installation of the Partition Wall (fire barrier)

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2.6 Installation of control components

A new electrical cabinet was designed and installed to house the new electrical protection equipment (Magnetic Circuit Breakers). Additionally, a specific Input Output Module (IOM) was installed to collect and communicate all of the new information being generated by the storage system.

The new electrical cabinet was fitted in the intermediate car and the new TCMS / DASEM module in the driving cars (on both sides).

Figure 26 Wiring of the new Input Output Module (IOM) and Magnetic Circuit Breaker panel

Figure 27 Installation of the new TCMS / DASEM (RH side) and Communication Router (LH side)

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2.7 Installation of components in the driver desk

A new HMI screen was installed in both of the vehicle cabs to display information related to the new hydrogen system and OESS to the driver and testing staff.

Figure 28 New HMI installed on the driver's desk (1/2)

Figure 29 New HMI installed on the driver's desk (2/2)

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3. Conclusions

Significant space was needed to install the two Fuel Cell Hybrid PowerPacks into the vehicle, requiring the removal of several elements of the former commercial train, mainly seats and air conditioning equipment.

The equipment for both PowerPacks is now correctly fitted and connected. All necessary modifications (mechanical interfaces, piping, electrical interfaces, cooling) were made to the prototype train enabling successful integration of all the required components.

The prototype train can be now declared as ready to start its Testing and Commissioning phase as described in Task T5.2.

Figure 30 Train Prototype with external vinyl applied

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4. References

[1] European Comission, “Grant Agreement Number- 101006633 - FCH2Rail,” 2020.

[2] Consortium FCH2Rail Project, “Consortium Agreement FCH2Rail,” 2020.

A.1 List of Figures