FCH2RAIL

Fuel Cell Hybrid PowerPack for Rail Applications

Half of the railway lines in the European Union are electrified and already enable locally emission-free rail transport. On the remaining lines diesel-powered trains are used. Over the last few years, many public and private transport authorities, both in the EU and in other countries around the world, have shown a growing interest in replacing these units with emission-free altenatives and provide a major contribution for the decarbonization of railway transport. The main challenge is to achieve a competitive alternative to diesel trains: hydrogen fuel cell based technology is a promising candidate for the railway sector.

In the EU project FCH2RAIL (Fuel Cell Hybrid PowerPack for Rail Applications), the consortium is developing and testing a new kind of train prototype with partners from Belgium, Germany, Spain and Portugal:

At the heart of the project, there is a bi-mode hybrid powertrain system that combines the electrical power supply from the overhead line with an emission-free hybrid power pack. This power pack consists of fuel cells and batteries and operates independent of the overhead line.

DLR CAF TOYOTA renfe adif Centro Nacional de Hidrógeno Infraestruturas de Portugal Stemmann-Technik A Wabtec Company

Overhead line and hybrid system for emission-free travelling

The basic idea: Where energy is available from overhead lines, the train runs on it. Where there are no overhead lines, the energy comes from the fuel cells and battery system, the "Fuel Cell Hybrid PowerPack".

"We want to show that this type of bi-mode powertrain is a competitive and environmentally friendly alternative to diesel power", states project coordinator and researcher Holger Dittus from the Institute of Vehicle Concepts in German Aerospace Center (DLR).

Across Europe, more and more railway lines are being electrified, i.e. equipped with overhead lines. A very expensive and long-term project that always depends on the local geographical conditions.

Purely battery-powered trains have a limited range of 30 to 100 kilometres, depending on the route profile and outside temperatures. Today's diesel trains have restrictions in speed and acceleration compared to vehicles powered from overhead lines.

"Our bi-mode powertrain combines the advantages of both technologies. This lets us make rail transport even more sustainable and energy-efficient", says Eva Terron, technical project coordinator from Construcciones y Auxiliar de Ferrocarriles (CAF), summarising the main goal of the project.

With a budget of 14 million euros, the project aims to develop, demonstrate and approve such a system until end of 2024. The project is funded with 10 million euros by the European Clean Hydrogen Partnership.

Clean Hydrogen Partnership

Co-funded by the European Union

Project objectives

The project begins with the analysis of different use cases and railway applications for hydrogen power packs. It focuses on use cases in Spain, Portugal and Germany and covers applications in passenger and freight transport.

The project pursues ambitious goals:

- Develop, build, test and homologate a Fuel Cell Hybrid PowerPack. This scalable, modular and multi-purpose energy source shall be applicable for new vehicles as well as for retrofitting existing multiple units, mainline and shunting locomotives.
- Demonstrate the innovative power pack in a Civia electric multiple unit. This Civia is converted into a bi-mode fuel cell hybrid train demonstrator. It will use external energy supply in catenary operation and the hybrid power pack on non-electrified sections.
- Identify and benchmark energy saving potentials of innovative solutions for heating, ventilation and air conditioning in fuel cell trains.
- Evaluate the refuelling and autonomy competitiveness of bi-mode fuel cell traction against existing diesel solutions.
- Propose a normative framework for hydrogen in railway vehicles, identify gaps in existing hydrogen and railway standards and contribute to standardisation activities.

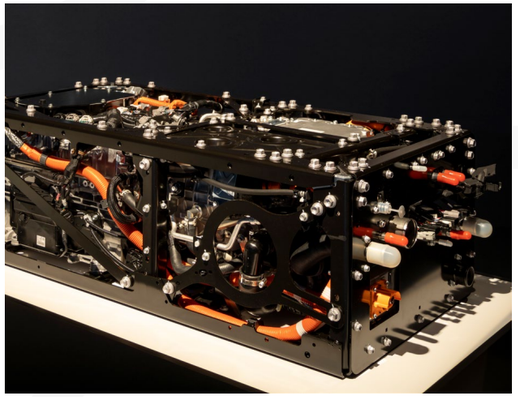
Fuel Cell Hybrid PowerPack

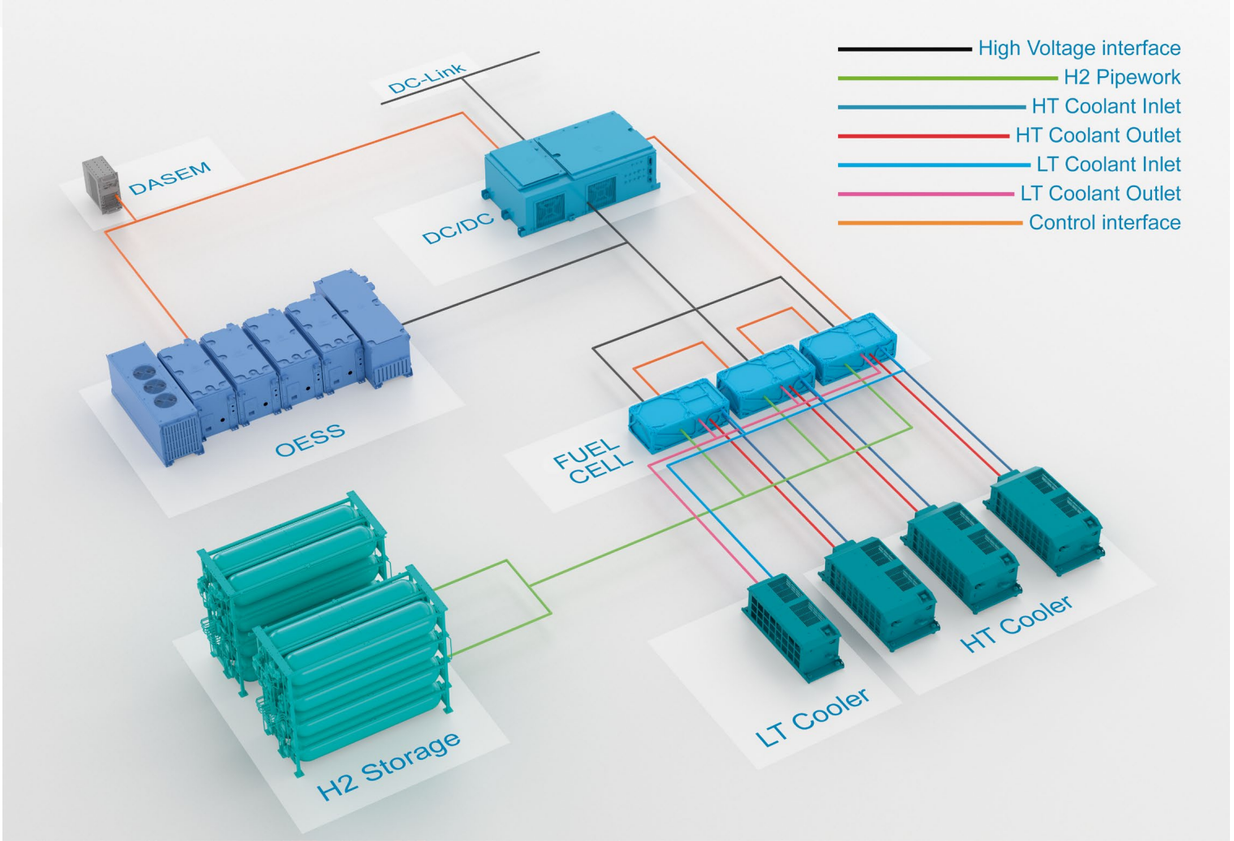
The innovative Fuel Cell Hybrid PowerPack is intended to be suitable for newly developed rolling stock as well as for retrofitting existing electric and diesel powertrains in multiple units, mainline and shunting locomotives. It can also be used in bi-mode traction systems together with overhead catenary.

The Fuel Cell Hybrid PowerPack (FCHPP) includes the fuel cell modules from Toyota Motor Europe and the modular onboard energy storage system (OESS) from CAF. CAF also provides the power electronics (DC/DC), which allow to adapt to different voltage levels, and the driver assistance system and energy management (DASEM), which controls all devices in a smart and energy efficient way. The cooling system of the fuel cell modules and the hydrogen storages are also integrated in the power pack and provided by third parties.

The scalability of the power pack is achieved by variation of the number of modules and other characteristics of the subsystems. The use case specific design depends on the requirements in terms of power and energy demand: the average energy demand conditions the number of fuel cell modules, while the peak power determines the balance between batteries and fuel cells. Finally, the required range or autonomy between refuellings defines the capacity of the H_2 storage system.

The holistic energy management enables using the power pack in different applications providing an energy efficient operation, thus reducing hydrogen consumption and operating costs for trains with this kind of power pack.





Put on track: Demonstration with converted commuter train

Which railway lines are suitable for trial runs in Spain and Portugal? And what are the environmental impacts of such a system, from its production, to its use, up to its disposal? To answer these question in a test under real conditions, it is planned to integrate and demonstrate the Fuel Cell Hybrid PowerPack in a Civia electric commuter train.

The FCH2RAIL demonstrator train is based on one of Renfe's Civia commuter trains, which was manufactured by CAF. The new FCHPP is combined with the vehicle's existing traction system. As a result, this train becomes one of the first bi-mode demonstrator trains with hydrogen fuel cells. In other words, a zero-emissions vehicle concept which is able to replace diesel traction while it is also paving the way to more polivalent services currently not provided by single mode trains, either diesel, electric or even pure fuel cell hybrid trains.

Initial functional tests and trial runs for approval take place on Spanish and Portuguese tracks with the support of the infrastructure managers Administrador de Infrastructuras Ferroviarias (ADIF) and Infraestruturas de Portugal (IP). The Spanish hydrogen research centre Centro Nacional de Hidrogeno (CNH2) has been entrusted with the construction of a portable hydrogen refuelling station. This HRS will be used during the demonstration phase of the bi-mode Civia hydrogen train.

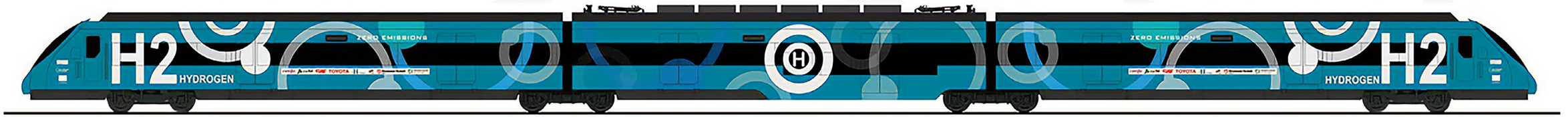
Benchmarking the Fuel Cell Hybrid PowerPack

For novel propulsion systems such as the Fuel Cell Hybrid PowerPack, it is essential to compare them with the state of the art. The bi-mode approach of FCH2RAIL enables emission-free operation on non-electrified line sections while using the efficient overhead line, if available.

One of the objectives of the project is to assess the competitiveness of FCHPP against existing diesel solutions currently used on these lines and against KPIs of Clean Hydrogen Partnership. In this activity, which is lead by DLR, well-established key performance indicators are complemented by further project-specific KPIs and evaluation methods.

The project KPIs include operational, economic and environmental indicators:

- Refuelling downtime
- Train autonomy or range on non-electrified sections
- Lifetime of the fuel cell system
- Power pack availability
- Hydrogen consumption at train level
- Life cycle cost (LCC) aspects



Railmap of major results

Stay up to date and check all project results.
www.fch2rail.eu

2021

- Analysis of different use cases for bi-mode Fuel Cell Hybrid PowerPack
- Performance requirements and architecture of the FCHPP
- Digital twin for the FCHPP developed
- Fuel cells and batteries for the demonstrator selected and available

2022

- Hardware-in-the-loop tests of FCHPP subsystems
- Test of FCHPP on stationary test bench
- FCHPP integration in the demonstrator train and start of track testing
- Portable H_2 refuelling station ready for the first refueling
- First analysis of gaps in the normative framework of H_2 in railways

2023

- Track testing of demonstrator train in Spanish commercial lines
- Portable H_2 refuelling station used in different locations in Spain
- TRL7 train homologation achieved in Spain
- Modifications of normative framework proposed

2024

- Track testing of demonstrator train in Portugal
- Train authorization study for Germany
- Competitiveness against diesel service assessed
- Energy saving potentials of novel HVAC systems evaluated
- Final analysis of gaps in the normative framework of H_2 in railways

Consortium

German Aerospace Center

With its Transport Program, DLR is the second largest institutionally funded transport research body in Europe. 26 DLR institutes develop innovative solutions for a sustainable transport system. The Institute of Vehicle Concepts and the Institute of Transportation Systems research, develop and evaluate new vehicle concepts and advanced railway technologies in light of future demands on the transportation system.

As FCH2RAIL Project Coordinator, DLR leads project management, dissemination and communication activities. From the technical perspective, DLR performs use case analyses and supports the development of efficient energy management strategies for the hybridized powertrain system. It also leads the KPI evaluation and the LCC analysis of the Fuel Cell Hybrid PowerPack versus Diesel traction. Furthermore, DLR supports the identification of gaps in normative framework with regard to hydrogen trains.

Construcciones y Auxiliar de Ferrocarriles

The CAF Group, with more than 100 years of experience, is one of the leaders in the international market as a provider of comprehensive transport systems at the forefront of technology and high added value in sustainable mobility. CAF's range of vehicles stands out for its zero-emission solutions.

As Technical Leader of the FCH2RAIL project, CAF's major contributions are related to the design, manufacture and testing activities of the new Fuel Cell Hybrid PowerPack, first separately and next after its integration in an existing Civia Electric Multiple Unit to convert it into a bi-mode Fuel Cell Hybrid Train demonstrator. CAF leads the design, performs the integration of all these components in the train, tests the demonstrator train, and manages the authorization of the train in 3 european countries. CAF leads the safety management of the project. CAF also participates in the preparation of the regulatory framework for this type of vehicles at European level.

Toyota Motor Europe

Toyota Motor Europe NV/SA (TME) oversees the wholesale sales and marketing of Toyota, GR (Gazoo Racing) and Lexus vehicles, parts and accessories, and Toyota's manufacturing and engineering operations in Europe. Toyota views hydrogen as one of the key building blocks towards carbon neutrality, using fuel cell technology for mobility and in the wider economy beyond transport. As a hydrogen frontrunner, Toyota's advanced fuel cell technology is already integrated into passenger cars, buses, trucks, marine and stationary applications for a range of business customers and other OEMs. To meet growing demand in the region, TME started producing its 2nd generation compact fuel cell modules in Europe in January 2022.

For the FCH2Rail consortium, TME's main contribution as a fuel cell manufacturer, is to supply its fuel cell technology to the project. Together with the supply of its 2nd generation fuel cell modules, the Fuel Cell Business Group at TME will provide technical support and expertise to guarantee the optimal use of the module and successful integration in the project.

Renfe Operadora

In its search for cutting-edge technologies, Renfe has in its crosshairs achieving a significant reduction or even elimination of the remaining 20% of non-renewable energy sources from which diesel-powered trains are fed. Progressively, Renfe will rely on entirely pollution and greenhouse effect free energy sources as Hydrogen. Related to this, the Spanish Government has developed 2020 the Roadmap of Hydrogen from the Ministry of Ecologic Transition and Demographic Challenge. This roadmap is a materialization of the compromise with the development and understanding of these technologies, and it includes a target of having two hydrogen-fuelled lines by 2030.

Renfe, as a partner in the FCH2Rail project, leads the analysis of potential use cases and the development of the requirements specifications. They provide an important support in all the activities related to the demonstration of the new bi-mode train concept with the Fuel Cell Hybrid PowerPack.

Administrador de Infraestructuras Ferroviarias

ADIF is the Administrator of Railway Infrastructures of Spain. It is a public business entity dependent on the Ministry of Transport, Mobility and Urban Agenda. One of the ADIF´s objectives is to promote rail transport through the development of a safe, efficient, sustainable infrastructure system from an environmental point of view, with high quality standards and facilitating access to infrastructure under equal conditions.

As railway infrastructure manager, they will play a key role for the authorization of the train demonstrator to run in the Spanish lines. They will provide an important support in all the analysis related to the interfaces between the new train concept and the infrastructure, as for example the location of refuelling stations.

Centro Nacional de Hidrogeno

Spanish Nacional Hydrogen Centre (CNH2) is a Research and Development and Innovation Centre, devoted to scientific and technology research in all fields related to hydrogen and fuel cells technologies. The Centre has been created as a Consortium between Spanish Ministry of Science and Innovation and Castilla La Mancha Government.

CNH2 is responsible for testing the Fuel Cell Hybrid PowerPack in an stationary test bench in their facilities, before the integration of the FCHPP in the train. CNH2 will be leading also the activities, related to the normative framework. They will be also be responsible of providing the Hydrogen Refuelling System.

Infraestruturas de Portugal

Infraestruturas de Portugal (IP) is the manager of the rail and road network of Portugal, whose sole shareholder is the Portuguese State. IP's object is the conception, design, construction, financing, maintenance, operation, requalification, enlargement and modernisation of the national road and rail networks, including the command and control of rail traffic.

As railway infrastructure manager, IP will play a key role for the authorization of the train demonstrator to run on Portuguese lines. IP will provide an important support in all the analysis related to the interaction and operational conditions of the train in the infrastructure, as per example the refuelling system.

Stemmann-Technik

As part of the Wabtec cooperation Stemmann-Technik is a certified partner of various market leaders in industrial engineering (Conductor Lines, Slip Ring Assembly Systems as well as Cable Reels and Cable Festooned Systems or Charging Systems for e-busses or e-ferries) and railway technology (Roof-Mounted Pantographs and 3rd Rail Current Collector as well as Ground Contacts and Stinger Systems).

With 100 years of expertise Stemmann-Technik contributes the know-how of Pantographs, overhead lines and normative framework. In cooperation with Faiveley Transport Leipzig as centre of competence for HVAC solutions in the Wabtec group, we are also developing a solution to ensure that the exhausted heat from the fuel cell modules can be used efficiently for the train's heating and air conditioning systems.

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Clean Hydrogen Partnership

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