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Road/Railways - Environmental friendly railway: New study underlines potential for hydrogen-powered trains in Europe

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【概要：Summary】

In general, railway is considered being an environmentally friendly means of transport. The utilisation of electric trains offers the advantage of zero emissions, as electric trains do not emit local emissions compared to diesel locomotives. However, in Europe, there still exists a significant non-electrified part of the railway network. In these areas, trains with diesel locomotives are used and these trains emit a significant amount of CO2, particulate matter and NOx, as well as noise. Since these emissions of diesel-powered trains are negatively affecting the otherwise environmentally friendly performance of railway systems, the rail operators will have to shift from diesel-powered trains to other low emission solutions.

According to the European Commission, hydrogen based fuel cells (FCH) technology is a promising option to replace diesel combustion engines in rail transport. The FCH technology has a "great potential for clean, efficient power in stationary, portable and transport applications." FCH powered trains are equipped with fuel cells that produce electricity through a combination of hydrogen and oxygen, which leaves water as the main emission. Fuel cell trains do not produce any NOx gases or particulate matter in operation and they can also reduce CO2 emissions by around 50%, compared to equivalent diesel engine-powered trains. In the mid and long term, the utilisation of fuel cell trains could lead to a more sustainable train operation as the diesel-powered trains with high levels of particulate matter and NOx emissions can be replaced with environmental friendlier fuel cell powered trains. Also in the production of hydrogen, the CO2 emissions could be reduced by using wind energy or other renewables as energy sources. Ultimately, fuel cell powered trains could help to decrease the emissions levels for the railway sector, including also CO2 emissions.

The most recent study on FCH train technology, commissioned by the Shift2Rail and Fuel Cells and Hydrogen Joint Undertakings and conducted by the consultancy Roland Berger, underlines the advantages of the utilisation of fuel cells and hydrogen in the railway environment. This new study on the use of FCH train technology assesses the state of the art, business case, market potential and technical and non-technical barriers, among others, for the introduction of FCH technology in the railway sector.

The main conclusion of the study points towards a positive potential for hydrogen based fuel cell trains as replacement of diesel rolling stock in the European railway sector and the potential for the FCH technology to reducing GHG emissions and other pollutions. Some recent examples in Germany show that the market introduction of FCH based trains in passenger transport is picking up pace.

【記事：Article】

1. The FCH technology in railway transport

While 80% of railway traffic runs on electrified lines, representing 60% of the mainline network, it needs an environmentally friendlier solution for the still remaining non-electrified part of the European railway system that relies on diesel-powered trains. Currently, there are already FCH buses and cars in operation in Europe, and the hydrogen refuelling infrastructure network is growing steadily. Also for the railway sector, and in particular when considering the necessary improvements in reducing emissions from transport, hydrogen powered trains are considered being a suitable replacement for diesel-powered trains. The FCH based trains as replacement for diesel trains could also help to enable the decarbonisation of the railway sector. According to the Roland Berger study, entitled "Study on the use of fuel cells and hydrogen in the railway environment" by 2030, one in five newly purchased train vehicles in Europe could be powered by hydrogen. However, in order to apply the hydrogen based fuel cell technology successfully in the railway sector, several technological and non-technological barriers will still have to be overcome. Furthermore, targeted research and innovation (R&I) investments from the railway companies and rail supplier industry will be required. Moreover, while several stakeholders have shown interest in the potential of fuel cell and hydrogen technologies for trains, additional support, including state subsidies, could potentially be crucial for the further development of this technology since the development of train prototypes and new infrastructure as well as the market introduction are associated with high costs.

2. The analysis of the utilisation of the hydrogen based fuel cell trains

The Shift2Rail Joint Undertaking and the Fuel Cells and Hydrogen Joint Undertaking commissioned the study entitled "Study on the use of fuel cells and hydrogen in the railway environment" by Roland Berger. The aim is to assess the potential of the FCH technology for railways. The study's main aspects include the state of the art, the business case, the market potential, specific case studies and technical and non-technical barriers to the use of FCH technology in different railway applications.

The entire study comprises of three reports and one final report with the main conclusions and outcomes of the accompanied three reports. Report 1 focuses on the state of the art, the business case and market potential of FCH technology in the railway sector. Report 2 includes the analysis of boundary conditions for potential hydrogen rail applications of selected case studies in Europe. Report 3 focuses on the question of how to overcoming technological and non-technological barriers in order to allow for a widespread use of FCH in the railway sector. It also includes recommendations on future research and innovation (R & I) and the analyses of the opportunities to enable a larger introduction of hydrogen based fuel cells (FCH) within the European railway market.

Regarding the Report 1 on the "State of the art and business case and market potential", it provides an overview of past studies or technological trials on the implementation of fuel cell and hydrogen technologies in the railway sector. 22 trials and demonstrations in 14 countries across Europe, Asia, North America, the Middle East, Africa and the Caribbean since 2005 are identified and analysed. Furthermore, the report considers the business cases for FCH railway applications and assesses the market potential to replace diesel-powered trains in Europe by 2030. The analysis focuses on the FCH technology applications regarding Multiple Units, Shunters and Mainline Locomotives and concludes that there is significant potential to decarbonise the railway sector.

Report 2 on the "Analysis of boundary conditions for potential hydrogen rail applications of selected case studies in Europe" evaluates the economic potential of fuel cell and hydrogen technologies in the European railway sector, based on 10 case studies, covering the application in Multiple Units, Shunters and Mainline

Locomotives, in nine European countries. The analysis demonstrates that the FCH technology can be economically and environmentally competitive with other powertrain technologies.

Report 3 on "Overcoming technological and non-technological barriers to widespread use of FCH in rail applications – recommendations on future R & I", analyses 21 technological and 10 non-technological barriers that hinder the mass-market introduction of the FCH technology in the railway sector. They are described in detail and prioritised according to their impact on the FCH technology application and on reaching the technology's full potential. Regarding the R&I needs, recommendations on future projects are provided. This includes one demonstration project and two technology development projects in the short term. The three targeted research and innovation topics (R & I), with an estimated total budget of EUR 113 million, have been proposed as the means to tackle the most important barriers. These three evaluated applications show already some positive Total Cost of Ownership (TCO) development for fuel cell trains.

Freight locomotives have a more difficult economic justification although if electrification of the tracks was not an option, fuel cells would be the only zero-emission option, according to the report.

3. The Final Study's main results

The Final Study summarises the results of analysis regarding the potential of the utilisation of FCH trains in Europe. The study concludes that FCH trains are economically viable in particular when they are used on longer non-electrified routes of over 100 km. FCH trains can also be used for last mile delivery routes, but also for main routes that have very low utilisation with up to 10 trains per day. FCH trains enable a continuation of operation with very short brakes of less than 20 minutes for fast refuelling and they also withstand long operating hours of more than 18 hours without refuelling. Therefore, FCH trains overcome the technical constraints of battery-powered trains on non-electrified railways. In some other cases, battery-powered trains may appear as a more cost-effective option. However, the battery-powered trains have the operational constraints resulting from their highly route-specific tailored battery configurations. As a result, there is significant market potential for FCH technology, as it provides a flexible, zero-emission and potentially cost-competitive solution. Therefore, the study comes to the conclusion that FCH trains are an economically feasible clean alternative to current diesel-powered trains in many cases. The most mature FCH application, i.e. Multiple Units, has the potential to become cost competitive with diesel-powered trains in the short term. With this competitiveness of FCH technology and the given framework conditions, FCH Multiple Units are expected to have the potential to replace 30% of diesel trains as the most market-ready application by 2030.

According to the Executive Director of FCH JU, Bart Biebuyck, hydrogen is one of the best technologies to decarbonise transportation. In particular where other electrification alternatives to reach the zero-emission objectives have proven unfeasible from a technical and also an economical point of view, FCH trains can be utilised. Regarding the analysis of applications on the FCH technology, the FCH-powered multiple units could also increase export opportunities to non-European countries, as the global FCH train market development activities are currently concentrated in Europe. According to the Executive Director of S2R JU, Carlo Borghini, Europe is at the forefront of FCH train technology, which also creates new opportunities for the global export.

In order to present the results of the study on the utilisation of fuel cells and hydrogen in the railway environment, S2R JU and FCH JU organised a workshop in Brussels on 17 May 2019, which gathered technology providers, representatives of the rail sector and policy makers for discussing the further use of FCH trains.

4. Recent FCH technology based train projects

Regarding the search for options to replace

diesel-powered train fleets in order to achieve a fast and consistent decarbonisation of the entire energy and transport system, various regions in Europe are considering the introduction of hydrogen-powered trains. Hydrogen based fuel cells are considered as one of the best technologies to achieve decarbonisation of railway transport, in particular where other electrification alternatives are technically or economically not feasible.

On 20 September 2016, Alstom presented the first Coradia iLint hydrogen based fuel cell regional passenger train. The Coradia iLint fuel cell trains have a maximum speed of 140 km/h and can cover a distance of about 800 km without refuelling. The low-noise zero-emissions trains are powered by hydrogen fuel cells, which can be used on non-electrified tracks as an alternative to diesel locomotives. Alstom sees opportunities for the Coradia iLint fuel cell train across Europe like in the UK, Denmark, the Netherlands and Norway, but especially in Germany, where thousands of diesel locomotives could be replaced by the fuel cell powered trains.

On 16 September 2018, the world's first hydrogen fuel cell Coradia iLint train was inaugurated in passenger service for public transportation, in Lower Saxony, Germany. Two fuel cell powered trains offer commercial service for public transport on the nearly 100km line running between Cuxhaven, Bremerhaven, Bremervörde and Buxtehude. The fuel cell trains replaced the existing diesel train fleet of the public transport provider Eisenbahnen und Verkehrsbetriebe Elbe-Weser (EVB). The on-site production of hydrogen by electrolysis and wind energy is planned for a later phase of the project.

Most recently, the Rhein-Main-Verkehrsverbund (RMV) public transport company in Hessen, Germany, announced that one of its subsidiaries, "fahma", has ordered 27 Alstom fuel cell trains, with a total order volume of around EUR 500 million. It is so far the world's largest fleet of fuel cell trains ordered from Alstom. The German federal government is said to cover 40% of the additional costs, which arise compared to diesel trains. The government also supports the expansion of the hydrogen filling station. The Alstom Coradia iLint fuel cell trains are set to be up and running by 2022 and will replace diesel train sets on four regional lines in the Taunus region. The new trains will replace the current diesel-powered trains on the lines RB11 (Frankfurt-Höchst – Bad Soden), RB12 (Frankfurt – Königstein), RB15 (Frankfurt – Bad Homburg – Brandoberndorf) and RB16 (Friedrichsdorf – Friedberg). Alstom will also supply the hydrogen, maintenance and the provision of reserve capacities for the trains over the next 25 years. Alstom is able to offer the supply of hydrogen based on a cooperation with Infraserve GmbH & Co. Höchst KG, Frankfurt am Main, Germany. The hydrogen used the operation of these trains is produced as a by-product of other chemical processes in Industriepark Höchst. Thereby, the trains will not use hydrogen produced by renewable sources, but no extra production of hydrogen will become necessary for the operation of these new hydrogen fuel cell powered trains.

5. Conclusion

Reducing GHG emissions is a main issue for all industry sectors and also the transport sector in order to avoid severe climate changes. Railways are considered being an environmentally friendly mode of transport as 80% of its traffic runs on electrified lines and also represents 60% of the mainline network. However in reverse conclusion, this also means that 20% of rail traffic and around 40% of the mainline network are still served by diesel-powered trains, which are known for their high emissions of particle matters, NOx and also CO2 emissions. Therefore, the European railway sector must take action and find solutions for further reducing the railways' emissions on the non-electrified tracks. The diesel-powered trains need to be replaced by low or zero emission alternatives. Hydrogen and fuel cell based trains are considered being an environmentally friendlier and quieter alternative to diesel trains on non-electrified railway lines.

The Shift2Rail Joint Undertaking and the Fuel Cells

and Hydrogen Joint Undertaking commissioned study on the use of fuel cells and hydrogen in the railway environment by Roland Berger assessed the potential of the FCH technology for railways. The study found that this new technology faces no different barriers to any other novel technology. Therefore, the study concludes that, while the FCH technology provides a flexible, zero-emission and potentially cost-competitive solution to replace diesel trains, within certain contexts, it still needs additional subsidies, including state subsidies. The study considers additional subsidies, including state subsidies, be necessary to cover the significantly higher costs to introduce FCH trains. This is confirmed by the latest FCH train project in Hessen, Germany, as the Federal government will support the introduction of FCH trains by covering 40% of the additional costs compared to diesel trains and by supporting the expansion of the hydrogen filling station. Nevertheless, the introduction of 27 Alstom Coradia iLint fuel cell regional passenger trains in Hessen, is the first of its kind in the railway sector to operate hydrogen trains at a significant scope.

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