【欧州】【鉄道】

Road/Railway – Environmental friendly vehicle: Hydrogen fuel cell-powered train tests expand to the Netherlands

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【概要：Summary】

The European Commission identifies electricity, hydrogen, biofuels, natural gas, and liquefied petroleum gas (LPG) as alternative fuels. In particular, electricity and hydrogen are considered as alternative power sources for an environmental friendly transport. Several studies on fuel cells and hydrogen (FCH) train technology have underlined the advantages of the utilisation of fuel cells and hydrogen in the railway environment.

The FCH trains have a potential to replace diesel rolling stock in the European railway sector and thereby to reduce GHG emissions and other pollution. FCH trains are considered an economically feasible clean alternative to current diesel-powered trains. Some examples in Germany show that the market introduction of FCH based trains in passenger transport is picking up pace. 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 by 2030. In the mid and long term, the utilisation of fuel cell trains could lead to a more sustainable train operation than diesel powered trains with high levels of particulate matter and NOx emissions. After the start of operating FCH trains in Germany in 2018, the tests for the utilisation of FCH trains is expending into the Netherlands, which also has a larger non-electrified railway network. It is expected that ultimately, fuel cell powered trains could help to decrease the CO2 emission levels also in the railway sector.

【記事：Article】

1. Background

Railways are considered being an environmentally friendly mode of transport, as 80% of its traffic runs on electrified lines. However, 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. In the EU, there still exist a significant number of non-electrified railway tracks, and diesel trains and locomotives are used in those areas. However, diesel locomotives emit a significant amount of CO2, particulate matter and NOx, among others. In order to eliminate these emissions of diesel-powered trains, they need to be replaced by low or zero emission alternatives. Rail operators will have to consider a shift from diesel-powered trains to other low emission solutions like hydrogen-powered trains, which are considered being an environmentally friendlier alternative.

In the railway sector, hydrogen is described as an energy carrier with "great potential for clean, efficient power in stationary, portable and transport applications." In particular, in the vast areas with non-electrified railway networks, new low-emission FCH trains are considered being a suitable choice for replacement of the diesel locomotives. If then also the CO2 emissions in the production of hydrogen are considered, and the CO2 emissions are reduced by using wind energy or other renewables as energy sources, a decarbonisation of the railway sector could become reality.

2. Comparison of potential replacement options to diesel traction

According to the European Commission, fuel cells and hydrogen (FCH) technology is a promising option to replace diesel combustion engines also in rail transport. The FCH powered trains are equipped with fuel cells that produce no NOx or particulate matter emission while in operation and they can also reduce CO2 emissions, compared to equivalent diesel engine-powered trains. If the utilised hydrogen is produced from renewable energies, FC-powered engines have a great potential to reduce CO2 emissions.

The study entitled "Study on the use of fuel cells and hydrogen in the railway environment" by Roland Berger Consultancy, commissioned by Shift2Rail Joint Undertaking and the Fuel Cells and Hydrogen Joint Undertaking, assessed the potential of the FCH technology for railways.

The study provided, among others, an overview of past studies or technological trials on the implementation of fuel cell and hydrogen technologies in the railway sector. Furthermore, the market potential to replace diesel-powered trains in Europe by 2030 was assessed.

The study concluded that FCH trains are economically viable in particular when they are used on longer non-electrified routes of over 100 km. Since FCH trains can operate with very short brakes of less than 20 minutes for fast refuelling, FCH trains overcome the technical constraints of battery-powered trains on non-electrified railways.

In contrast to the battery-powered trains, which have the operational constraints resulting from their battery configurations, the FCH have a greater flexibility and have a significant market potential, as they provide a flexible, zero-emission and potentially cost-competitive solution. Therefore, the FCH trains are an economically feasible clean alternative to current diesel-powered trains. In particular where other electrification alternatives to reach the zero-emission objectives are not unfeasible, FCH trains can be utilised. However, in order to apply the FCH technology successfully in the railway sector, several technological and non-technological barriers will still have to be overcome.

Main benefits of alternatives to diesel traction

	General strengths	Key applications
Battery-powered traction	easy recharging little additional infrastructure required	Shunting in yards Multiple-units or locomotives on partly electrified lines
Hydrogen fuel cell	Operation over longer non-electrified routes than with battery traction Larger numbers of trains can be supplied by a central refuelling infrastructure Fast refuelling (compared to recharging batteries)	Shunting mixed with main line of up to 200 km distances Multiple-units/main line locomotives for routes with longer non-electrified sections Cross-border traffic with different power systems
Electrification with catenary	Unlimited access to electricity, high power range possible Energy recovery without the need for storage	High speed rail traffic Long / heavy freight trains Passenger trains with frequency of at least 2 trains/h

Source: Streichfuss, Martin/ Schwilling, Andreas: Accelerating the decarbonisation of rail. In: https://www.railwaygazette.com/in-depth/accelerating-the-decarbonisation-of-rail/55086.article, 11 November 2019, retrieved 19 November 2019

Comparing the environmental effects of the various traction options, according to Streichfuss, Martin/ Schwilling, Andreas, fuel cells have potential applications on routes where service frequencies are too low to justify fixed electrification and a longer range is required that would demand large and heavy batteries. However, fuel cells have the disadvantage of requiring two energy conversions with their efficiency losses compared to just one for batteries. Battery power has advantages over fuel cells in terms of CO2 emissions, even when the CO2 emissions from the production of the batteries is taken into consideration. However, the weight of the batteries will continue to limit the range of the vehicles. Battery power is suited to shunting locomotives, which usually have idle times during the day that allow for recharging, as well as hybrid multiple units or locomotives equipped with pantographs that can operate on electrified lines and recharge from catenary or fixed charging points on non-electrified lines.

Considering the main benefits and disadvantages of conventional electrification trains, fuel-cells trains and battery powered trains, there will be a role for all three options in the future. However, given the long lifespan of rolling stock, diesel vehicles will remain a significant factor in the railway transport for some years. However, regulations to incentivise the replacement of diesel vehicles before the end of their economically optimal service life could contribute to accelerating the decarbonisation of the railway transport sector.

3. Start of FCH train's public transport operation

Several railways in Japan and Europe have put battery-electric trains into service on regional lines, particularly where part of the route is already electrified. However, 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. A prototype fuel cell trainset is currently on test at Japan's Railway Technical Research Institute. JR East has started work on a new generation of vehicles with the intention of having the first train ready for commercial use in 2024. On the search of options to replace diesel-powered train fleets, in South Korea, Hyundai Rotem and Hyundai Motor's Mabuchi Research Institute have started developing a fuel cell tram, following several similar projects in China. The aim is to achieve a fast and consistent decarbonisation of the entire energy and transport system

Also in Europe, several regions and countries are considering the introduction of hydrogen-powered trains. In Germany, the Deutsche Bahn alone operates 2,343 diesel train sets for passenger transport, which have eventually to be replaced by more environmentally friendly alternatives. In 2014, the German federal states of Lower Saxony (Niedersachsen), North Rhine-Westphalia, Baden-Württemberg and the Public Transportation Authorities of Hesse signed a letter of intent with the train manufacturer Alstom for starting trials with 2 fuel cell Alstom Coradia iLint trains by 2018. On 20 September 2016, Alstom presented the first Coradia iLint hydrogen zero-emission train, with exhaust being only steam and condensed water. The Coradia iLint zero-emission FCH powered passenger train, which has a maximum speed of 140 km/h, can cover a distance of about 800 km without refuelling. The Coradia iLint was funded by the German government as part of the National Innovation Program for Hydrogen and Fuel Cell Technology (NIP). The Coradia iLint has been granted approval by the German Railway Office (EBA) for passenger service in Germany and 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 trains of the public transport provider Eisenbahnen und Verkehrsbetriebe Elbe-Weser (EVB).

The necessary hydrogen refuelling facility was funded through a EUR 8.4 million grant from the German federal government's National Innovation Programme for Hydrogen and Fuel Cell Technology. In the longer term, this will be replaced by an on-site hydrogen production.

Furthermore, 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, which are set to start operation by 2022. Alstom will also supply the hydrogen, maintenance and the provision of reserve capacities for the trains over the next 25 years. The FCH trains will replace diesel train sets on four regional lines in the Taunus region. It is so far the world's largest fleet of fuel cell trains ordered from Alstom. Alstom underlined that there are more opportunities for the utilisation of the Coradia iLint fuel cell train across Europe, and not only in Germany.

4. Coradia iLint Fuel cell train test in the Netherlands - the first pilot project outside Germany

After the Coradia iLint hydrogen trains have started their regular passenger service in Lower Saxony in Germany in September 2018, the Dutch province of Groningen has decided to start a test of the Coradia iLint fuel cell trains in 2020. The railway network in the Netherlands has about 1,000km of non-electrified lines and FCH trains could replace the diesel trains in this non-electrified part of the railway network, The planned test with a fuel cell train in a first pilot project in the Netherlands.

In 2017 the Dutch provinces of Groningen and Friesland awarded Arriva a 15-year contract to continue to operate their regional passenger services from December 2020 onwards. As part of this, the fleet of 51 Stadler GTW DMUs will be fitted with batteries to enable braking energy to be recovered for reuse, reducing emissions and cutting noise when accelerating. A further 18 new Stadler Wink trainsets have been ordered, which will be able use overhead electrification or hydrotreated vegetable oil fuel, also with batteries for regenerated braking energy. Furthermore, the Coradia iLint hydrogen fuel cell trains are tested to show that they represent a highly suitable environmentally friendlier solution, according to Managing Director of Alstom Benelux Bernard Belvaux. On 31 October 2019, Alstom and the Province of Groningen, local operator Arriva, the Dutch railway infrastructure manager ProRail and the energy company Engie have signed an agreement for the pilot project to test the Coradia iLint hydrogen fuel cell passenger train for the first time in the Netherlands. The Coradia iLint hydrogen fuel cell multiple-unit passenger train is to be tested on the Groningen – Leeuwarden line. Testing at up to 140 km/h is planned to take place over two weeks in the first quarter of 2020. The testing is aimed at demonstrating that hydrogen fuel cell technology is an appropriate way to achieve zero-emission railway operation on non-electrified lines in the Netherlands, which are currently operated using diesel-powered trains.

Since the Coradia iLint hydrogen fuel cell train is quiet and emission-free, emitting only water and steam during operation. It represents a clean alternative for railway operators and regional authorities wishing to replace diesel fleets on non-electrified lines with low or zero-emission, environmental friendlier trains.

5. Conclusion

The European railway sector must take action and find solutions in order to further reducing the railways' emissions on the non-electrified parts of the railway network. Due to the high levels of particulate matter and NOx emissions as well as CO2 emissions and the noise levels of the diesel-powered trains, which are used on the non-electrified parts of the railway network, the rail operators' continued focus on diesel has to shift to low emission solutions. Although hybrid electro-diesel and diesel-battery trains have been considered as solutions, obviously, only battery and hydrogen fuel cell based solutions have the potential to reach a zero emission transport operation. Although railways are considered being already an environmentally friendly means of transport, in order to further improve its carbon footprint and to achieve zero-emissions, the diesel traction needs to be eliminated on the non-electrified part of the railway network. In this respect, the FCH trains could be a more sustainable solution. The FCH trains are expected to offer some environmental advantages for the vast non-electrified parts of the railway networks. Hydrogen based fuel cells are considered being one of the best technologies to achieve decarbonisation of railway transport, in particular in regions, where other electrification alternatives are technically or economically not feasible.

Fuel cells and battery technology will find a growing role in the rail sector for replacing diesel traction, as the pressure to decarbonise rail transport increases. However, the wider factors of the power generation of hydrogen and the related emissions need to be considered, which will also influence deployment choices.

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