HOW HYDROGEN TRAINS CAN HELP DECARBONISE THE TRANSPORT SYSTEM

UNIVERSITY OF BIRMINGHAM

EXECUTIVE SUMMARY

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- Electrification is the best way to decarbonise the rail network. However, system-wide electrification is unlikely to be completed in time to achieve the Government's decarbonisation targets.
- Hydrogen and battery technologies are the most viable alternatives to achieve decarbonisation of the rail network. Hydrogen trains are potentially carbon neutral in operation, while delivering similar performance to existing diesel trains.
- HydroFLEX is the UK's first hydrogen train, developed by Porterbrook in partnership with the Birmingham Centre for Railway Research and Education. HydroFLEX will commence mainline testing in March 2020.

Decarbonising the rail network

Electrification is the most effective means of decarbonising the rail network. Yet only around 40% of the network is currently electrified, which is much lower than comparable European countries, and recent electrification projects have incurred high costs. However, a recent report from the Railway Industry Association found that future schemes could be delivered at 33-50% lower cost.[1]

With network-wide electrification still some way off, the most viable alternatives are hydrogen and battery systems, a view supported by the Rail Safety and Standards Board.[2] Hydrogen fuel cell technology is an effective and environmentally-friendly alternative, which offers similar performance to diesel combustion. Depending on how the hydrogen was originally produced, they are potentially entirely carbon neutral in operation.

Rail decarbonisation would help to improve air quality. A University of Birmingham paper found that stationary diesel trains had a particularly harmful effect on air quality. Passengers and staff at relatively enclosed railway stations where there are a significant number of diesel trains, such as Birmingham New Street, Marylebone, and Waverley, are most at risk.[3]

About HydroFLEX

The UK's first hydrogen train, HydroFLEX, was developed by Porterbrook in partnership with the Birmingham Centre for Railway Research and Education (BCRRE) at the University of Birmingham.

The HydroFLEX system was created by retrofitting an existing Class 319 train with a hydrogen power pack and battery. This gives it the ability to operate along existing electrified routes (on either 750 DC third rail or 25kV overhead power) as well as being able to operate in self-powered mode without the need for diesel engines.

In the HydroFLEX train, up to 20kg of hydrogen is stored

in high pressure tanks. This is then passed through a pressure regular and combined with oxygen from the air in the fuel cell, which produces 100kW of electricity. Two Lithium ion battery packs then store the electrical energy, which is then used to power the train using the existing Class 319 traction equipment. There are no harmful emissions; the only by-product is water.

The performance of hydrogen-powered trains is similar to those powered by diesel combustion, but since they are powered through electric motors, they are quieter and benefit from a smoother, quicker ride with greater acceleration providing improved journey times. However, in the short term, hydrogen could not be adapted for high-speed trains, or very long-range trains due to the volume of hydrogen needed.

Generating hydrogen

Despite being the most abundant atom in the universe, hydrogen is mostly bound up in molecules. There is therefore an energy cost associated with its production and, depending on the process used, there can also be a CO_2 cost. In our work for the decarbonisation studies, we calculated the amount of CO_2 per output kWh for hydrogen fuels. This ranges from something comparable to the fuels we have now, to near zero for hydrogen produced through the use of renewable energy.

Power generated by the national grid off-peak could be used to produce hydrogen (or charge batteries) needed for fuel. Managing our national energy consumption in this way would mean we could use hydrogen generation as a means of energy storage. This would lower the operating costs of both railways and the grid.

About BCRRE

Based in the University of Birmingham, we are the largest specialist railway centre for research, education and innovation in Europe and the leading partner of the £92 million UK Railway Research and Innovation Network (UKRRIN), involving eight universities and 15 industry partners. Rail Alliance was integrated at the start of 2019, giving us a thriving community of more than 500 SMEs engaged in the rail supply industry with a specific focus on introducing innovation and enterprise into the sector.

Contact us

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Further reading:

- BBC News (20 June 2019), All aboard Britain's first hydrogen train, https://www.bbc.co.uk/news/business-48698532
- HydroFLEX demonstration video, https://youtu.be/3TmVKYDyYjs

1 RIA Electrification Cost Challenge (March 2019), https://www.riagb.org.uk/RIA/Newsroom/Stories/Electrification_Cost_Challenge_Report.aspx

2 RSSB Rail Industry Decarbonisation Taskforce - final report for the Minister for Rail (July 2019), https://www.rssb.co.uk/en/Research-and-Technology/Sustainability/Decarbonisation/Decarbonisation-our-final-report-to-the-Rail-Minister

3 Thornes et al, Air quality in enclosed railway stations (April 2017), https://www.icevirtuallibrary.com/doi/full/10.1680/jtran.15.00094