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How hydrogen could get UK rail’s decarbonisation efforts back on track

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Ben Foulser, Partner, Infrastructure Advisory Practice and Head of the Future Mobility Team, KPMG in the UK, discusses the role hydrogen could play in traction decarbonisation.

As the UK strives to meet its 2050 net zero target, rail has an opportunity to become what Andy Bagnall, chief executive at Rail Partners, termed "the sustainable travel mode of choice". But, if we're to prove that railways are a truly green alternative to roads, one thing remains clear: we must decarbonise the network.

And, while 2020's Traction Decarbonisation Network Strategy (TDNS, which looked, for the first time, at how this could be achieved) was a great start, its focus on electrification schemes has since been called into question – particularly given unresolved cost issues related to these schemes. Now, we need a revised plan, exploring the alternatives, including hydrogen. As the UK falls behind its European neighbours, it's time to kickstart investment in traction decarbonisation.

Below, I'll discuss the benefits of, and challenges associated with, hydrogen – exploring whether a case exists for this investment.

Traction decarbonisation: the journey so far

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While traction decarbonisation has been on the cards for a number of years, government's 2050 commitment served as a touch paper, igniting interest, and driving projects forward.

Over the last few years, traction decarbonisation has been a particularly thorny issue. Now, with Great British Railways poised to 'reset' the industry, we have a fantastic opportunity to make it more sustainable.

But what about the journey so far? Network Rail's TDNS was the first document to explore, in detail, how the UK rail network could move away from diesel passenger and freight services.

According to the latest figures from the Office of Rail and Road (April 2021 to March 2022), 38.1 per cent of the network is now electrified. The TDNS stated that 80 per cent of the remaining railway should also be electrified, citing this as the most sustainable route to decarbonisation. There would, it suggested, be use cases for hydrogen – but few and far between.

While both Overhead Line Electrification ('OLE') and third rail present a range of operational challenges, they offer fairly good 'well to wheel' sustainability – providing that the energy's original source is decarbonised. Third rail also presents limitations on both power provision (due to its use of low voltage, high amperage Direct Current, necessitating multiple sub-stations) and speed (due to the mechanical action of the shoe used by rolling stock to draw power).

The problem is the significant costs associated with electrification – which, in the TDNS, were estimated to be between £1m and £2.5m per Standard Track Kilometre ('STK'). Three years since its publication, and concerns have been raised about the affordability of this strategy. Industry figures are asking whether electrification is the best route forward, and urging government to explore the alternatives – from synthetic fuels to hydrogen.

Hydrogen: the challenges ahead

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One solution is partial electrification – bimodal trains, which rely on a combination of electricity and diesel, or electric and battery power. Unlike other transport modes, rail has largely overlooked synthetic fuels (although a case could be made for their use on diesel trains, as a stopgap measure.)

Which brings us to hydrogen – is it a viable option for rail? Potentially – but the operational and commercial challenges associated with this green fuel are significant.

While we have been exploring its use since the 1940s, work to harness hydrogen's potential is around five years behind electrification in most transport fields. This gap is wider still in the rail industry.

Sourcing is one issue. Of the four types of hydrogen available, 'green' (made by splitting water through electrolysis) is the cleanest and most stable. 'Blue' is made from natural gas, with any resultant carbon waste captured and stored. Take, for example, Liverpool's flagship fleet of hydrogen-powered buses which have had to be taken off the road this month due to inability to source fuel (be this grey or green hydrogen).

It's clear that, if we want to use hydrogen as a clean fuel for rail, it must be green or blue. Unfortunately, green hydrogen is expensive, and few facilities are equipped to produce it. Neither does the UK have a hydrogen distribution network; corrosive to pipes, it must be transported via tanker, as a compressed gas or liquid. Pilots are underway to establish whether such a distribution network could be created without

replacing the existing gas network.

Storing hydrogen also presents a challenge; at present, few bunkering facilities exist in the UK. And, as a flammable fuel, the safety protocols around its use are strict and costly. As an example, storage and fuelling facilities for a new hydrogen bus fleet in Crawley are still pending safety certification for use having been installed some six months ago.

Gearing up for a new generation of hydrogen-powered trains

The rail industry is working hard to address these challenges, with two hydrogen train projects currently underway in the UK: HydroFLEX (a collaboration between Porterbook and the University of Birmingham) and Breeze (led by Eversholt, with support from Alstom).

Their trial vehicles are equipped with large hydrogen tanks and fuel cells, which convert the hydrogen into electricity, producing waste water. Electricity is stored in onboard battery stacks, which are drained to power the train.

Trials are underway – and, while we're still in the 'proof of concept' phase, the initial findings are promising, with successful testing having taken place in the UK, Netherlands and Germany.

A route to decarbonisation: the benefits of hydrogen

The push to explore hydrogen use is supportable. It's one of several potential solutions to rail's decarbonisation problem, and may ultimately prove cheaper and quicker than electrification programmes. It may also be more suitable for routes in challenging terrains where installation of OLE is technically and / or commercially unviable, and / or bi-modal trains could not operate.

Use of hydrogen economy could protect jobs, creating opportunities for skilled oil and gas workers should the country decarbonise completely. It would also ensure that we weren't relying solely on the grid to power our rail network (a national security risk in itself.)

We believe that, in future, we'll see hydrogen rolling stock operating on our network with a focus on freight, further supporting the argument for modal shift for the logistics sector.

A net zero network: the route forward

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With updated evidence from trials and a renewed sense of urgency to deliver on net zero commitments, now is the time for government to review, update and recommit to the TDNS.

Attracting private investment will also be key. As long-term, 'can't-fail' assets, electrification assets and hydrogen trains have the potential to be attractive opportunities for private finance; they'll be critical to national infrastructure, and should have a steady, predictable demand profile. They'd also be a great asset class for institutional investment.

Electrification is highly unlikely to be the sole solution for rail decarbonisation; if the sector is serious about achieving net zero, it must explore alternative routes – including hydrogen. KPMG's infrastructure advisory service will be with it every step of the way, supporting companies, asset owners and government as they develop their own decarbonisation road maps, business cases, and funding models.

To learn more about KPMG's Infrastructure Advisory Group, visit https://kpmg.com/uk/en/home/services/deal-advisory/infrastructure-advisory.html.