Cost Efficient Electrification: The railway industry continues to meet the cost challenge of electrification through research

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Research by the University of Sheffield, Furrer+Frey and Network Rail is helping to embed cost-efficient electrification in the UK's rail network. After four years, two PhDs have been completed both focusing on different areas of cost-efficient electrification and improved reliability.

New electrification is seen as an essential step to decarbonise rail as part of the UK government's Net Zero 2050 decarbonisation targets. Engineers from Sheffield University, supported by Furrer+Frey and Network Rail, have conducted extensive research with an aim to improve the reliability of both current and future electrification schemes.

The University of Sheffield, Furrer+Frey and Network Rail are all members of the UK Rail Research and Innovation Network (UKRRIN). Their research shows how collaboration between universities and industry can play a vital role in bringing innovation to Britain's railways. The work shows how engineering research can help underpin electrification of the UK's rail network, alongside improving reliability for passengers and driving innovation in the industry.

The PhDs, undertaken by Sam Hayes and Özgün Sunar from Sheffield University's Department of Mechanical Engineering, were both supported by Furrer+Frey and Network Rail and had a special focus on the cost-efficient electrification of the UK's rail network. The PhDs were jointly funded by the University of Sheffield, Furrer+Frey and European Union funding under a programme to improve research with industry to improve the railway sector.

Professor David Fletcher, head of the research group at Sheffield, said: "The engagement with Furrer+Frey has been really great in funding and steering these research projects. Their expertise has ensured the research stayed focused on industry needs, ensuring that the academic input of our PhD students will have a real impact on the industry".

The first PhD undertaken by Sam Hayes, supported by Prof. David Fletcher and Katherine Chan of Furrer+Frey, examined the effects of wind, the train speed and the gradient, with the aim to avoid the need for extensive bridge reconstructions in future new electrification projects.

The performance of the wires was recorded using both large-scale wind tunnels and computational fluid dynamics to create a digital twin of the wiring geometry. The digital twin was then validated with real-world testing at Network Rail's test track at the Melton Rail Innovation & Development Centre. The PhD study looked at the maintenance impact of steeper gradients, ultimately with the aim to determine if fewer bridge reconstructions would be required. The work is part of a package of works the industry is undertaking to reduce the need for bridge reconstruction in future electrification schemes. Bridge reconstruction has been a key driver behind the increasing electrification costs, and hence reducing the need for these reconstructions is key to reducing the costs, as highlighted in the Rail Industry Association's Electrification Cost Challenge. These are among a number of industry projects designed to reduce the need for reconstructions, and it is hoped the results of this PhD will further reduce the need for these reconstructions.

Engineering Director at Furrer+Frey, Rob Daffern said: "I studied at The University of Sheffield, so to be working with cutting edge research back at Sheffield has been tremendous. The whole industry is focused on reducing costs and research is key".

The second PhD was undertaken by Özgün Sunar, supported by Prof. David Fletcher and under the industrial supervision of Chris Bryan of HS2. The focus of this PhD was to improve the reliability of overhead line electrification equipment, particularly when short-circuits and arching occurs. The research used both modelling and mechanical/electrical testing to establish intervention points and to better understand when maintenance is needed prior to service-interrupting failures occurring. The research also trialled innovative new conductor materials. The ultimate aim of the project was to improve the electrification performance and to enhance passenger journeys and the travel experience by preventing failures.

Director of Furrer+Frey, Noel Dolphin said: "We're proud to be supporting decarbonisation through

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electrification. Research and study are among the keys to making electrification cost efficient. However, as the Railway Industry Association’s Electrification Cost Challenge Report has shown, we need to remember that implementing a rolling programme of electrification would have the biggest impact on costs. By reducing costs and improving reliability, we can make the business case for this much stronger”.

Dr Patric Mak, Senior Engineer for Network Rail's Technical Authority, said: "It's really important for Network Rail and the wider rail industry to continue to look for ways to bring innovation to Britain's railways and at how we can address new challenges, such as the likelihood of experiencing more extreme weather in the future”.

"On behalf of Network Rail, I've been delighted to support both of these PhD students with their research, which will help us to create a more modern and resilient railway, meaning fewer delays for both passengers and freight services."

Demonstrating cost-efficient electrification has been a key component of moving away from the more traditional pattern of boom-and-bust infrastructure building. The railway industry has called for a rolling programme of electrification.

- Electrification is the most efficient method of traction power for railways, and specifically electrified railways:

- Are better for the environment, with carbon emissions 60% lower than diesel trains today and will be around 80% lower with the estimated 2040 grid mix, and these represent the only practical option for decarbonising intensively used lines;
- Produce no air pollutants at the point of use;
- Are quieter, reducing noise pollution for those living and working near the tracks and with reduced noise and vibration for passengers;
- Have a strong economic and business case, i.e. compared with diesels, electric trains cost less in the long term when compared to the whole-life costs of diesel services, are cheaper to build, more reliable requiring less maintenance, and are cheaper to operate and are longer-lasting;
- Are lighter weight, meaning less wear of the track and therefore less maintenance is needed, and carry more passengers; also, acceleration is better and journey times shorter, even with relatively frequent stops;
- Reduce passenger delays, as electric trains are more reliable than diesel trains;
- Will be vital in decarbonising rail freight, which is already a low carbon mode of haulage and delivers benefits in excess of £1.7bn each year to the economy.

Joint academic research in collaboration with industry could be key to delivering future cost-efficient electrification and a reliable railway.

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