Are hydrogen-powered trains the future of rail?

A hydrogen-powered train that uses off-gas from industrial processes – and with a raft of environmentally friendly features to help reduce its impact on the environment – could hold the key for sustainable transport of the future: writes Robin Whitlock for World Steel.

The Coradia iLint, first presented to the world at the Innotrans rail industry trade fair in 2016, is the world's first, and to date, the only hydrogen fuel cell passenger train. Photo: Alstom

The Coradia iLint hydrogen-powered train generates electricity only when the train accelerates, powering down while it brakes, and stores unused electricity inside its lithium ion batteries. Meanwhile, high-strength steel means thinner gauges can be used, which reduces the weight of the train, thus lowering carbon emissions and improving fuel efficiency.

Alstom call their new Coradia iLint the 'train of the future'. It certainly could be, given that it's the world's first passenger train powered by a hydrogen fuel cell, capable of almost noiseless traction with no emissions apart from water in the form of steam.

The Coradia iLint was first presented to the world at the Innotrans rail industry trade fair in 2016. It is the world's first, and to date, the only hydrogen fuel cell passenger train and Alstom believes it could initiate a new movement in the industry towards hydrogen power.

The overall design is based on Alstom's successful Coradia Lint diesel train, available in single car or articulated two or three car units. High-strength stainless steel is used in the car shells, as it is corrosion-resistant and longer lasting than other materials. High-strength steel's ability to deliver the required toughness at a lower weight means lower carbon emissions and improved fuel efficiency.

The train's fuel cell sits on top of the roof of the vehicle, utilising gaseous hydrogen supplied from a mobile hydrogen filling station. This is pumped into a pressure tank, also situated on the roof, which feeds the fuel cell. The hydrogen is currently sourced from industry as a by-product, but Alstom hopes to soon be able to produce hydrogen, via electrolysis, from wind power.

The electricity generated by the fuel cell provides the power for traction with only water emitted as steam. Excess electricity is stored in lithium ion batteries located beneath the vehicle. Next to the battery set is an auxiliary converter that supplies electricity to various on-board systems.

The iLint's fuel cell only works when the vehicle is accelerating, powering down when it brakes, thereby saving hydrogen, and the cell is managed by the train's smart energy management system and its flexible energy storage capacity.

The train has a low-floor so it is easy to access, and it generates little sound, thereby reducing noise nuisance for local communities. Given that the iLint can travel for up to 1 609 km on a single tank of hydrogen, travelling at speeds of up to 140 kph, Alstom believes it is ideal for non-electrified routes.

The iLint was designed by Alstom at the company's Salzgitter site in Lower Saxony, Germany, with the traction system and brakes designed separately at two sites in France, at Tarbes and Ornans. The vehicle's first successful test took place in March 2017 at Salzgitter, followed by further tests at Velim in the Czech Republic. It is now fully commissioned, with electrical and pneumatic systems tested, while TÜV Süd has certified the vehicle's battery, hydrogen pressure tank and fuel cell.

The aim is for Coradia iLint to replace existing diesel multiple units, such as those currently operating between Bremervörde, Bremerhaven and Cuxhaven where 14 units will take over from December 2021, operated by Elbe-Weser-Verkehrsbetriebe (evb).

A trial run on the evb network commenced in spring of 2018. Safe, silent, and sustainably powered: the future of rail travel has arrived. ❑

Energy-efficient SOFC fuel cell applications emerge in Europe

VTT Technical Research Centre of Finland is coordinating a five-year European consortium worth more than €10-million, which is developing commercial applications from solid oxide fuel cell technology (SOFC). The aim is to implement the reliable production of low-emission electricity and heat, which will lead to significant efficiency gains and carbon emissions savings compared to traditional energy production methods.

VTT's SOFC fuel cell system in Espoo, Finland: Photo VTT.

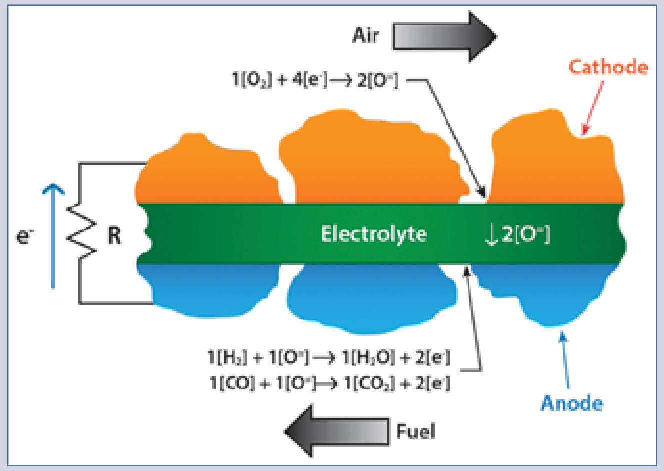
New commercial and energy-efficient fuel cell applications are emerging from the ComSos (commercial-scale SOFC systems) EU project, which is being coordinated by VTT. The project involves the demonstration of fuel cell-based energy solutions in authentic client environments, in cooperation with leading European system experts. Convion of Finland is participating in the project, alongside Sunfire from Germany and SOLIDpower from Italy. The ComSos project will involve the implementation of a total of 25 SOFC technology-based power generation solutions around the world.

"Through the project, we will develop world-class commercial products based on European fuel cell expertise. VTT has been developing fuel cell technology for over a decade and we have strong system expertise. We are now bringing this expertise into a project to ensure that the equipment is efficient, environmentally friendly and provides added value to end-users," says project coordinator, Jari Kiviaho of VTT.

Inside an SOFC, oxygen in the air is reduced (gains electrons) into oxygen ions at the cathode. These oxygen ions can then diffuse through the solid oxide electrolyte to the anode. At the anode, H_2 and CO molecules – derived by reforming a hydrocarbon fuel – react with the negative oxygen ions that have passed through. The hydrogen reacts with one oxygen ion to form steam (H_2O) from, while the CO reacts with another to form CO_2.

In the process, two electrons are released from each reaction, generating an electric current in the external circuit. The most notable advantage of using solid oxide technology instead of conventional hydrogen fuel cells is that natural gas/biogas or diesel fuel and can be used instead of hydrogen gas.

SOFC technology has major potential in the bio and circular economy, as it enables the scalable, highly efficient utilisation of biogas. The technology is also suitable for small-scale, decentralised local production. When combined with solar and wind power, SOFC evens out daily fluctuations in the power grid. The technology can be utilised wherever electricity and heat are needed,



Inside an SOFC: Oxygen from the air gains electrons. Oxygen ions pass though the solid oxide electrolyte. H_2 and CO from reformed fuel react with the oxygen ions. Electrons are released, generating an electric current in the external circuit.

for example in industry, data centres, hospitals, hotels, households and agriculture.

The advantages of fuel cell technology over competing technologies are best realised in small plants of under 1.0 MW. For example, Convion, Sunfire, and SOLIDpower's fuel cell power plants operate with an efficiency of well above 50%, thereby producing much more electrical energy than conventional power plants using the same amount of fuel. ❑