Coradia iLint: Alstom's zero-emission train

Today, rail operators mostly use diesel multiple units with combustion engines to operate passenger service on non-electrified networks. The accompanying CO_2 emissions and noise levels from these trains are hampering the otherwise green nature of rail systems. That is why Alstom decided to design a new, quiet, emission-free regional train: the Coradia iLint. Powered by hydrogen fuel cells, its only emission is water, while it operates with low noise levels. Alstom is the first railway manufacturer in the world to develop a such a passenger train based on hydrogen fuel cell technology. Overall, the company has committed to reducing the energy consumption for its solutions by 20% by 2020.

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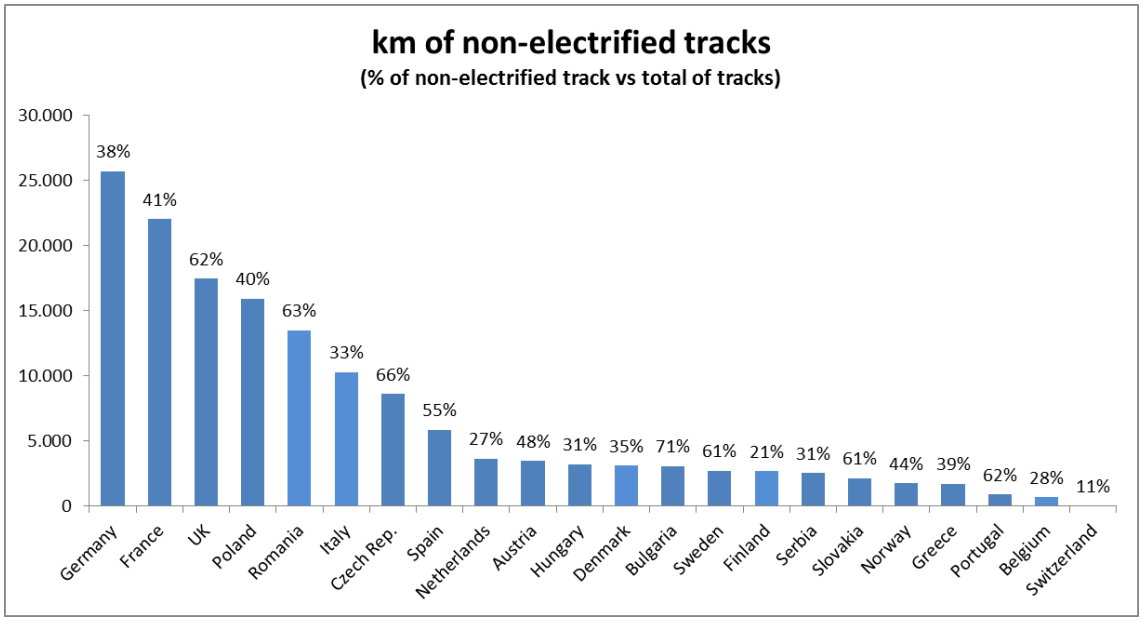
Urgent need for alternatives to diesel

Over the last century, railway energy sources have gradually changed, from coal to diesel to electricity. While coal provided an energy density of 34 MJ/kg, diesel provides 43 MJ/kg. Hydrogen, with an impressive 120 MJ/kg, is the ideal energy source for rail to meet the challenges of the future.

The rail sector is now facing some changes: the shift towards emission-free traffic, increasing prices for diesel and electrical traction energy in the medium and long term, stricter regulations on rail noise and accelerating urbanization.

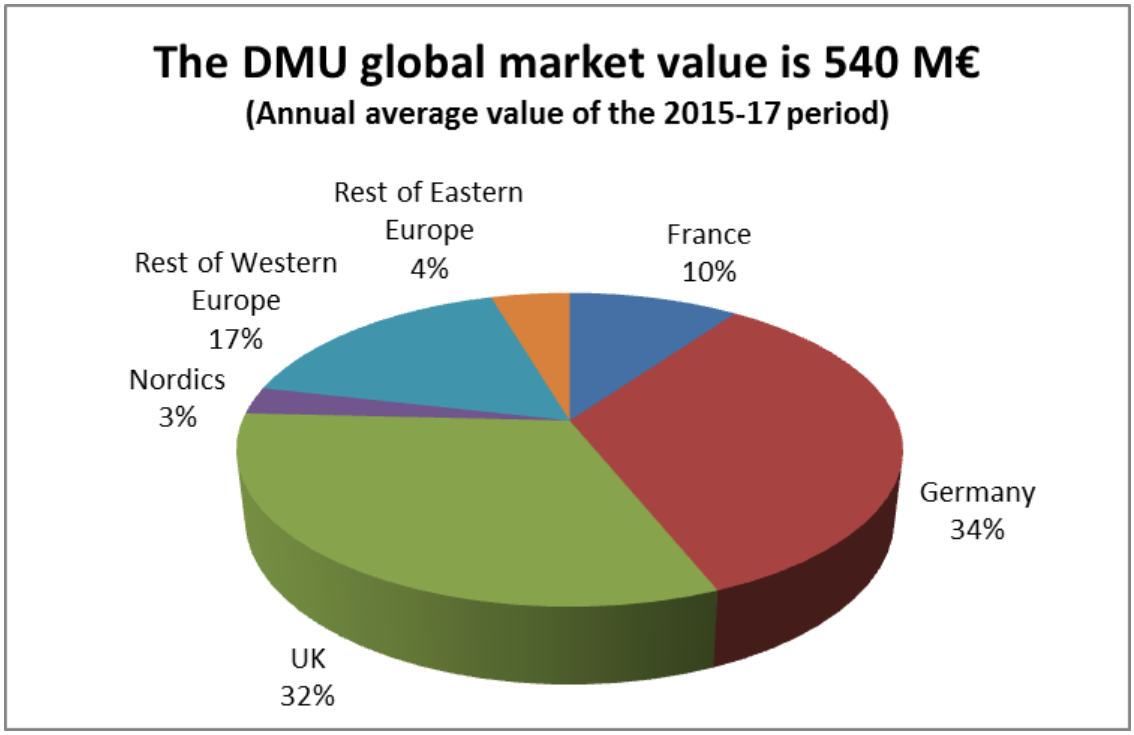
Despite many electrification projects in several European countries, a significant proportion of the continent's rail networks will remain non-electrified for the foreseeable future. Germany's extensive networks, for instance, are close to 40% non-electrified.



Source: UNIFE 2018

Electrification of rail lines remains expensive, estimated at approximately €1 million per kilometre. Batteries with adequate capacity - and therefore range - to replace diesel tanks face the issue of weight and limited lifetime due to repeated rapid charging.

In many countries, the number of DMUs in circulation is still high, with a need to renew them becoming more pressing in the next 5 to 20 years.



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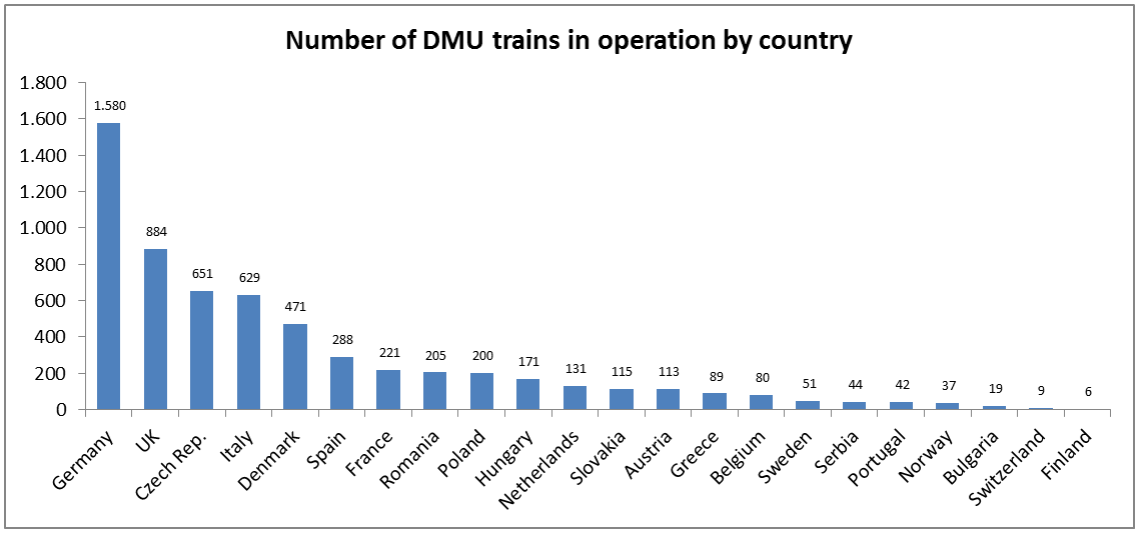


Source: UNIFE 2018

Germany, representing Europe's biggest diesel train market, has committed to reducing their CO_2 emissions by 40% by 2020 (compared to 1990) and to using 80% renewable energies in power supply by 2050. The need to reduce diesel operation is crucial.

Alstom first developed this new train for the German market, where customers increasingly demand innovative and environmentally friendly products and the transport authorities push for the implementation of regional emission-free transport technologies. As hydrogen

is an energy source that allows 100% CO_2-free traffic, Alstom signed in 2014 Letters-of-Intent with four German Landers (Lower Saxony, North Rhine-Westphalia, Hesse, Baden-Württemberg) and another LOI with one additional region (Calw) in 2015 for the development of a fuel cell train.

As an alternative to diesel, hydrogen fuel cells meet all the key requirements of a next-generation drive for rail. It is a sophisticated, mature technology and its price allows economical operation. Decades of research have already gone into the technology, and its safety has been established in numerous applications. According to the German Hydrogen and Fuel Cell Association (DWV), high-pressure reservoirs with hydrogen are in fact safer than petrol tanks in comparable hazard situations. Furthermore, homologation of rail vehicles is subject to extremely strict checks, which cover all safety-relevant aspects.

Alstom's ambition is to position hydrogen as a strategic partner in the broader energy transition. Alstom believes hydrogen is a game changer on the road to a cleaner, and ultimately zero-emission, energy system. Rail applications are the ideal fit for accelerating hydrogen deployment, as the quantities of hydrogen needed are high, predictable, localised and stable over time.

Alstom's ground-breaking innovation: Coradia iLint

The Coradia iLint, designed and built at Alstom's site in Salzgitter, Germany, is special for its combination of different innovative features: clean energy conversion, flexible energy storage, and smart management of the traction power and available energy.

The train is based on the service-proven diesel train Coradia Lint 54. Replacing the diesel traction by fuel cell technology allows completely clean train operation with a performance matching that of regular Coradia Lint diesel multiple units. This means the same maximum **speed of 140 km/h** and comparable acceleration and braking performance. Likewise, passenger **capacity is up to 300 passengers** and the train will have **range of 1,000 kilometres,** as already demonstrated during tests.

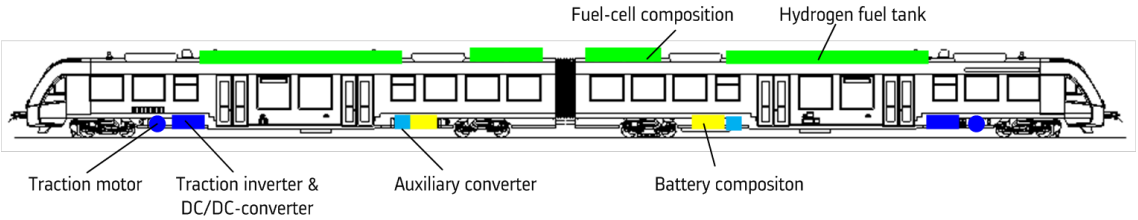
A first contract in Germany, passenger service

In November 2017, **Alstom signed its first contract for 14 Coradia iLint** trains with the local transport authority of Lower Saxony – LNVG. This followed the previously signed Letters-of-Intent for 50 trains with the four German Landers. **The first two pre-series trains will start passenger service between the cities of Cuxhaven, Bremerhaven, Bremervörde and Buxtehude on 17 September 2018**, homologation having been received in Germany. Fleet operations will begin in 2021-2022.

Several other countries, notably the UK, Netherlands, Denmark, Norway, Italy, Canada, have also expressed interest in the technology.

Fuel cell and energy storage

The fuel cell is the core of the system, the primary energy source to power the train. It is supplied with hydrogen on demand and the trains are powered by an electrical traction drive. The fuel cell provides electrical energy by combining the hydrogen stored in tanks on board with oxygen from the air. The only exhaust is water steam and condensed water. No greenhouse gases or particles are exhausted from the train and electricity is produced without any generator or turbine, which makes the process much quicker and more efficient.



The efficiency of the system also relies on the storage of energy in high performance **Lithium-ion batteries**. The battery stores energy from the fuel cell when not needed for traction or from the kinetic energy of the train during electrical braking and allows supporting energy delivery during acceleration phases. They accumulate the energy not immediately used, supplying it later as needed. This results in a better management of the fuel consumption.

During **acceleration phases,** power from the fuel cell is mainly used to supply traction power, as demanded by the traction inverter, and the onboard systems, as demanded via the auxiliary converter. Additionally, during these phases, power from the battery will be used to boost acceleration. The level of fuel cell power depends on amplitude and duration of high power demand: short acceleration phases with limited power demand will be mainly supplied by the battery. Only during longer phases of high power demand lead to a full power operation of the fuel cell.

During **phases of lower acceleration or coasting,** the fuel cell power will recharge the battery while supplying the onboard systems via the auxiliary converter. If the battery is charged enough, the fuel cell is powered down to only supply the onboard systems/auxiliary converter. This reduces hydrogen consumption.

During **braking,** the fuel cells are powered down nearly completely. The traction inverter supplies the DC-link with electricity generated from the kinetic energy of the vehicle. This power is used to supply the onboard systems via the auxiliary converter. Surplus power is used to recharge the battery. It is the secondary energy production. This system has an additional consumption advantage, as it saves hydrogen.

Since the energy produced, or recovered from braking, is intelligently managed, Coradia iLint matches the reach and performance of similar regional trains, but with nearly no impact on the environment.

A system approach

To make the deployment of the Coradia iLint as easy as possible for operators, Alstom offers the complete package consisting of the train itself, its maintenance, as well as the hydrogen infrastructure. This way, the operator can focus on its core competencies while Alstom and its partners take care of all rolling stock and hydrogen-related matters. Alstom's selection of partners depends on local constraints and infrastructure. For the project in Lower Saxony, Linde Group, a world-leading gases and engineering company, will is the supplier of hydrogen. Linde will erect and operate the world's first hydrogen filling station for trains in Bremervörde.

The Coradia range: proven regional trains

Coradia iLint belongs to Alstom's Coradia range of modular trains, which has a proven service track record of more than 16 years and can boast a consistently high rate of availability. Over 2,900 Coradia trains have been sold around the world.

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