Decarbonising TTBP: The Role of Hydrogen Trains

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Decarbonisation & the rail industry

- “I would like to see us take all diesel-only trains off the track by 2040.”
- “Alternative-fuel trains powered entirely by hydrogen are a prize on the horizon and I’d like to see hydrogen train trials on the UK railway as soon as possible because hydrogen offers an affordable and potentially much cleaner alternative to diesel.”
- **Jo Johnson, (then) UK Minister of State for the DfT, 12 February 2018**

Decarbonisation & the rail industry

- “Amongst other elements this embryonic Scottish Green Deal includes commitments to reduce emissions from Scotland’s railways to zero by 2035 through the continued electrification of the network, the procurement of battery-powered trains and exploration of the potential of hydrogen-powered trains in Scotland.” **The Government’s Programme for Scotland 2019-20, September 2019**
- Labour party members back Green New Deal motion calling for a 2030 net zero target. The shadow business secretary, Rebecca Long-Bailey is one of the most senior party figures backing the 2030 target which, even if not in the manifesto, gives a sense of direction.

So why not just use “clean diesel”..?

- There are the two key snags:
  - Carbon – which we are told will kill us tomorrow
  - Particulates – which we know are killing us today
- Even the best emissions control isn’t “zero emission”
- But we must also consider the product life of a train of 35 years – will even a “clean” 2020 diesel still be acceptable in 2055 and beyond?

#Dieselgate

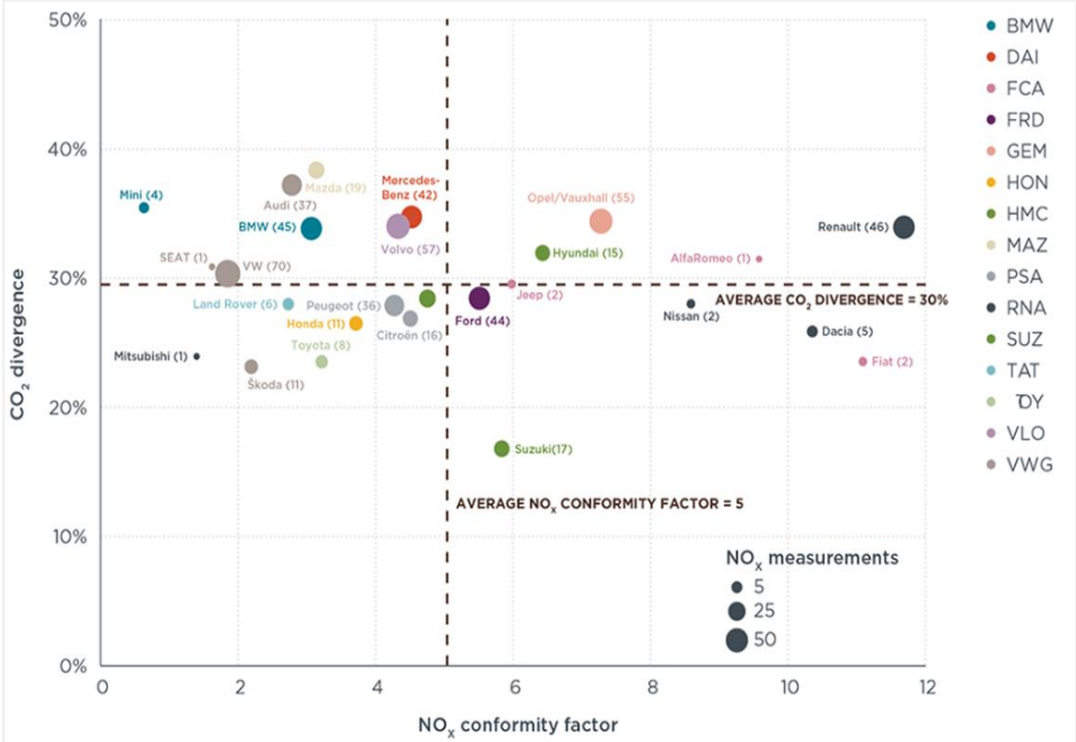


Figure ES-3: Euro 6 diesel passenger car gap between real-world and type-approval CO_2 emission values vs. on-road NO_x emissions conformity factors by manufacturer.[4]

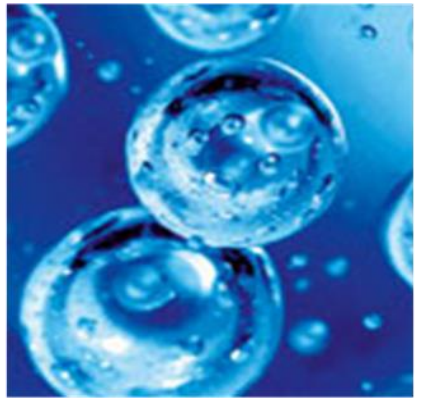
Rail is environmentally friendly, isn't it..?

- Electrification offers one route to lower emissions on certain routes but we still need trains where the wires won't go – **self powered trains**
- Our diesel fleet is second only in size in Europe to Germany – including ~2,400 diesel vehicles forming regional trains
- Despite this, rail contributes only 0.6% of the UK's total CO2 emissions
- Rail is by far the most environmentally-friendly form of surface transport
- This position will not last forever as other modes clean-up, and let's not mention clean air issues…
- So what are our self powered options?

Overall UK rail industry emissions

	CO_2e (000 tonnes)	% of total
Total	**5,700**	
Traction energy	**3,600**	**63%**
Diesel (gasoil)	2,100	37%
Electricity	1,500	26%
Staffing and services	**175**	**3%**
Staff and offices	81	1%
Services	93	2%
Subsystems	**1,920**	**34%**
Track	490	9%
Rolling stock	165	3%
Stations	223	4%
Depots	539	9%
Structures	229	4%
Electrification	44	1%
Train control systems	233	4%

How to power trains without electrification – there's no clean "silver bullet"

Coal	Diesel	Li-Ion	Hydrogen
			
■ 34 MJ/kg	■ 43 MJ/kg ■ 35.8MJ/l	■ 0.6 MJ/kg ■ 0.9-2.3 MJ/l	■ 120 MJ/kg ■ 4.6MJ/l @35MPa
			

- Hydrogen traction requires **3kW of electricity to deliver 1kW** of power to the wheel.
- A hydrogen train requires fuel storage **eight times the volume of a diesel** train's fuel tank.
- A battery train trialled in 2015 showed that a 7.2 tonne battery pack could deliver **electrified-comparable performance for 77km.**
- A battery to give Coradia iLint performance would weigh **33 tonnes**

Hydrogen is a solution for non-electrified, regional railways

High speed ?

- Very high energy and power demand and;
- Electrified (typically)

Trams ?

- Electrified difficult in urban setting
- H2-Trams ideal alternative?

Regional Traffic?

- Majority never intended to be electrified – need longer range
- Fits available energy/power range

Freight

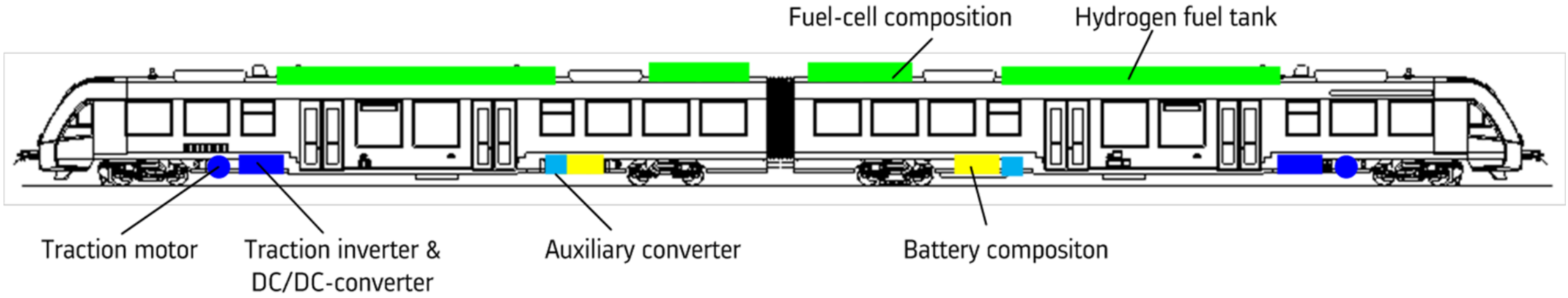
- Like HS, very high energy demands
- Key factor in route strategy for electrification

So we developed the world’s first hydrogen hybrid train: Coradia iLint

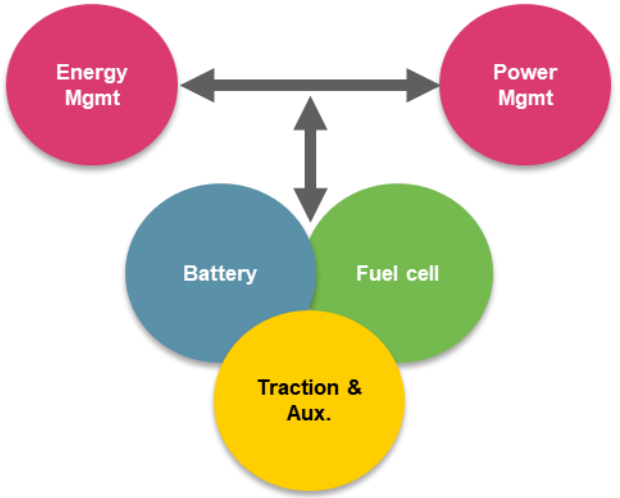
From an idea in 2012, unveiled in 2016, in service in 2018, now 41 trains ordered…

Alstom Coradia iLint

The Coradia iLint – how it works



- Diesel traction replaced with electric traction system
- Primary energy supply from hydrogen fuel cells
- Intermediate energy storage from Li-Ion batteries
  - to boost during acceleration
  - to recover kinetic energy during braking
- All electric auxiliary supply



What we are doing in the UK

- For the UK, we are working with Eversholt to convert Class 321 electric trains to create the first UK gauge, UK built, zero emission trains and to deploy them across Britain.
- We are exploiting the proven know-how from Coradia iLint, repackaging it for the UK and pioneering the homologation process to establish the basis for product and system approval.

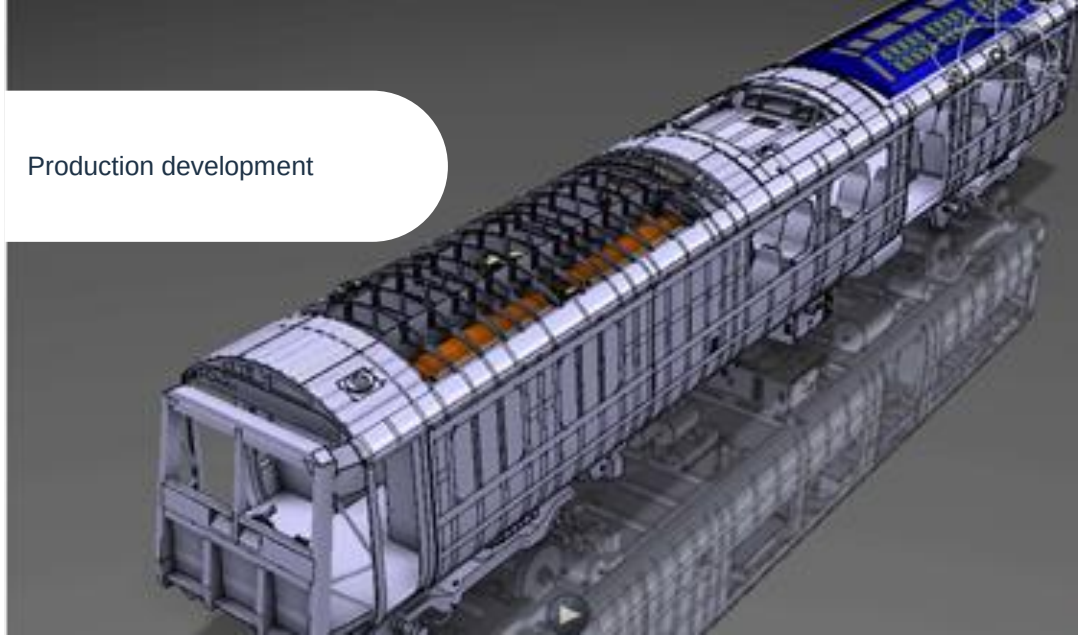
Class 321 EMU

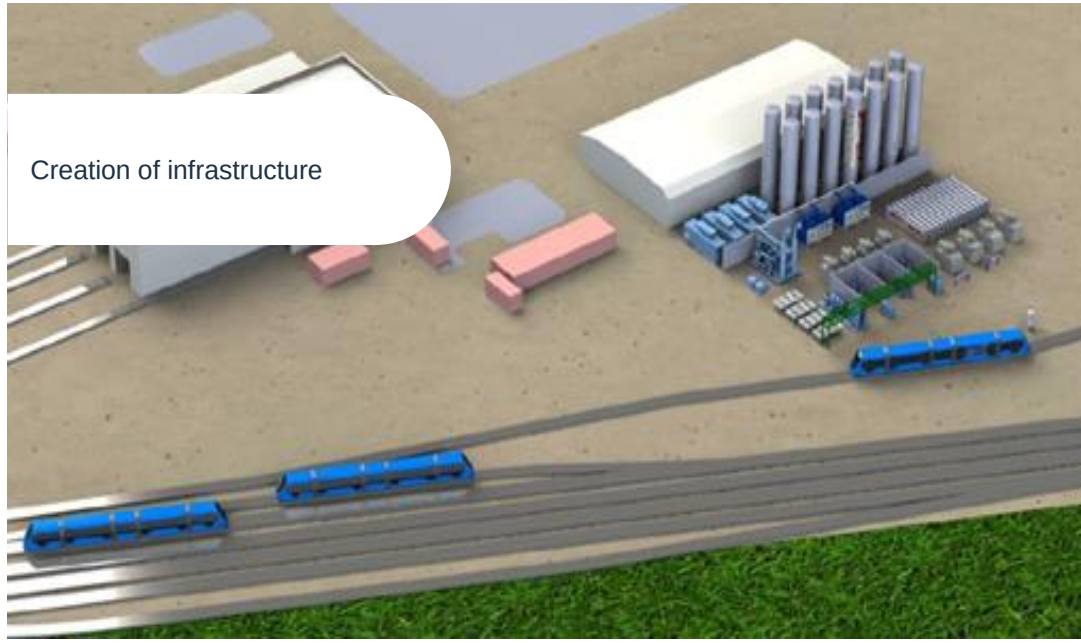
A system approach

Alstom/Eversholt Breeze – the UK’s hydrogen train

Next steps – the route to decarbonisation

- Completion of business cases with operators to include full system provision – trains, fuelling, operation and technical support
- Approval to proceed, including appointment of hydrogen supplier
- Launch system safety case approval process with operator
- Detailed design of the train conversion including the hydrogen propulsion system integration
- Parallel design of the hydrogen refuelling facility(ies)
- First unit build with train level testing commencing 2022
- Fleet build late 2022
- Fleet in passenger service in 2023
- Roll-out additional fleets and expand fuel network nationwide





The potential impact this could all have

Potential for 1200 hydrogen powered rail vehicles

Consuming 150+ tonnes of H2 per day

Saving 533,000 tonnes of equivalent CO2 per year

Equivalent to taking 383,000 cars off the road*

Saving £100m per year in health costs & 110 premature deaths

* To do this with electric cars would cost the government £1.35bn in subsidy on the cars alone, excl, charging, etc.

Any questions?

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