

Rail Cymru – Can Hydrogen help Decarbonise Rail?

Arcadis Energy Transition solutions

April 2024

Paul Aspinall

© Arcadis 2022



Arcadis Global Hydrogen Community:



Hendrik-Jan Bakhuizen
Global Cabinet Leader
– Power and Hydrogen



Paul Aspinall
Global Hydrogen
CoP Lead



Carolien Gehrels
Global Energy
Transition Lead



Matt Yonkin
USA



Doug Chambers
Canada



Kristine Chapidze
Hydrogen Sales
Partner



Ian Dixon
Hydrogen Sales
Partner



Luis Soruco
Chile



Felipe Martinelli
Brazil



Marc Humm
Australia



Dominik Dabrowski
Poland



Moreno De Respinis
Netherlands



Stephan Gerschütz
Germany



Koen Huylebroek
Belgium



Lorenzo Bertole
Italy



Paul Aspinall
United Kingdom
and Ireland



Mariette Voillard
France



Steven van den Heuvel
Spain & Portugal



Gabriela Requiz
Panama

Supported by our Hydrogen Champions and sector experts

About Arcadis

45,000

Employees worldwide

40+

Countries with offices

35,000+

Number of projects

70+

Countries of Projects

Our Values



People first



Sustainability



Collaboration



Client Success



Integrity

Over 100 people within our business have dedicated hydrogen or Alternative Fuels experience working on decarbonisation projects

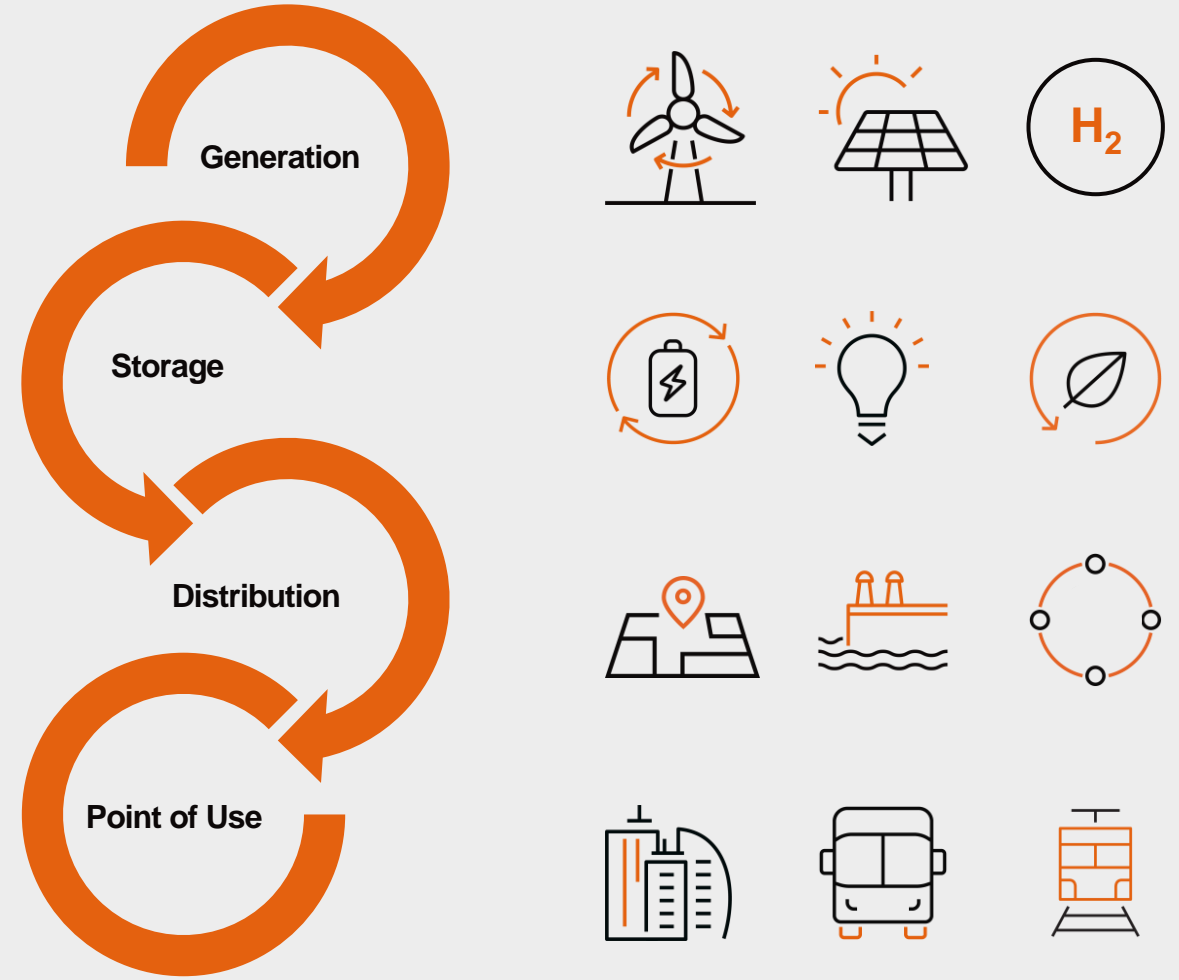
Vision Statement

“Our vision is to support the simultaneous growth of supply and demand of the hydrogen industry, deploying hydrogen with the lowest possible carbon intensity to decarbonize all sectors. We will help our clients implement carbon reduction solutions through renewable energy and zero carbon technologies, driving them towards a sustainable net zero future”

Arcadis Energy Transition Strategy

Supporting the Hydrogen Value Chain

Across all sectors:



- Advisory Services
 - Design & Engineering
 - Environmental Planning + permits
 - D&E of renewable energy
- assets
- Generation, distribution, storage, grid design
 - EV charging, smart grids
 - Project management and -
- controls
- Program management
 - Asset management support
 - Cost & Commercial management

Decarbonising Rail – The Challenges

- The UK rail network is currently only 38% electrified, meaning the majority of routes are reliant upon diesel trains.
- Network Rail's Decarbonisation Strategy - aspiration to remove diesel trains from the network by 2040.
- The Strategy advocates for new electrification of 13,000 single track kilometres (STKs) – what about the balance?
- Between 2013 and 2019, 747km of electrification works were completed, and only 2.2km in the year from April 2021 to March 2022.

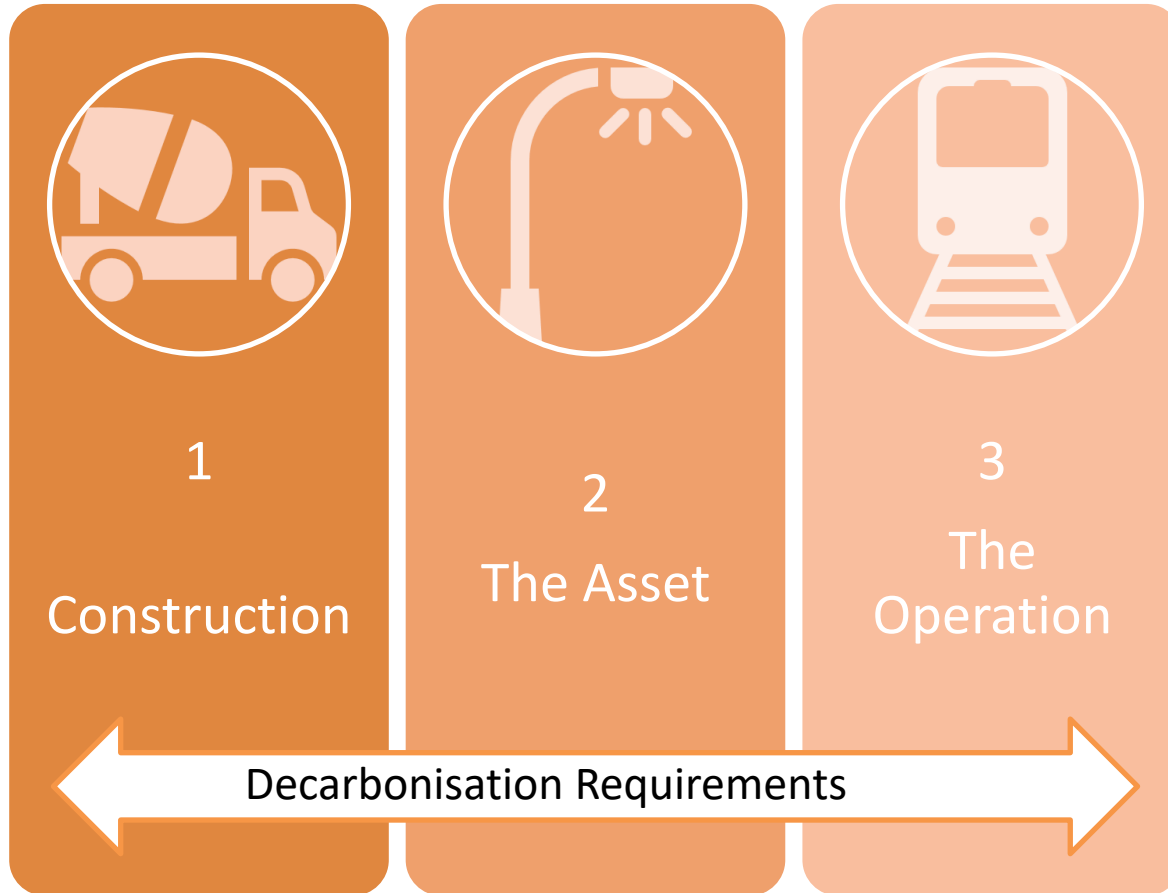


Significant acceleration or additional measures are required if we are to achieve 2040 and 2050 decarbonisation targets

**Between April 2021 – March 2022
552m litres of Diesel used on the Rail Network**

Decarbonisation of Rail

How Hydrogen can provide Practical solutions to help the Rail industry decarbonise:



in 2018 the DfT challenged the rail industry remove all diesel-only trains from the network by 2040. The Scottish Government has set a target to decarbonise domestic passenger rail services by 2035



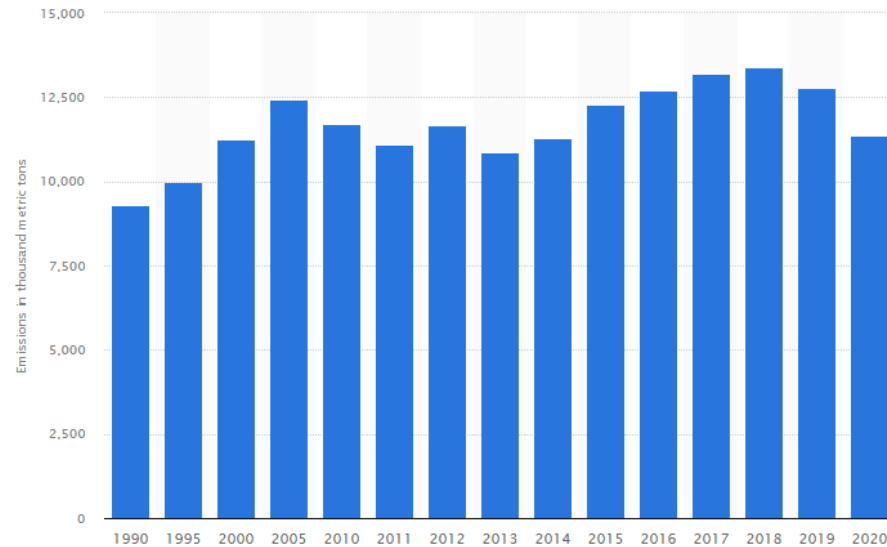
• We will minimise energy use at the offices, depots and stations that we manage and look for innovative ways to reduce energy throughout our infrastructure.

Decarbonising Rail Construction



Construction

it is logical that Diesel needs to be removed from rail construction processes in addition to the Network. The industry requires a satisfactory, business as usual alternative to Diesel.



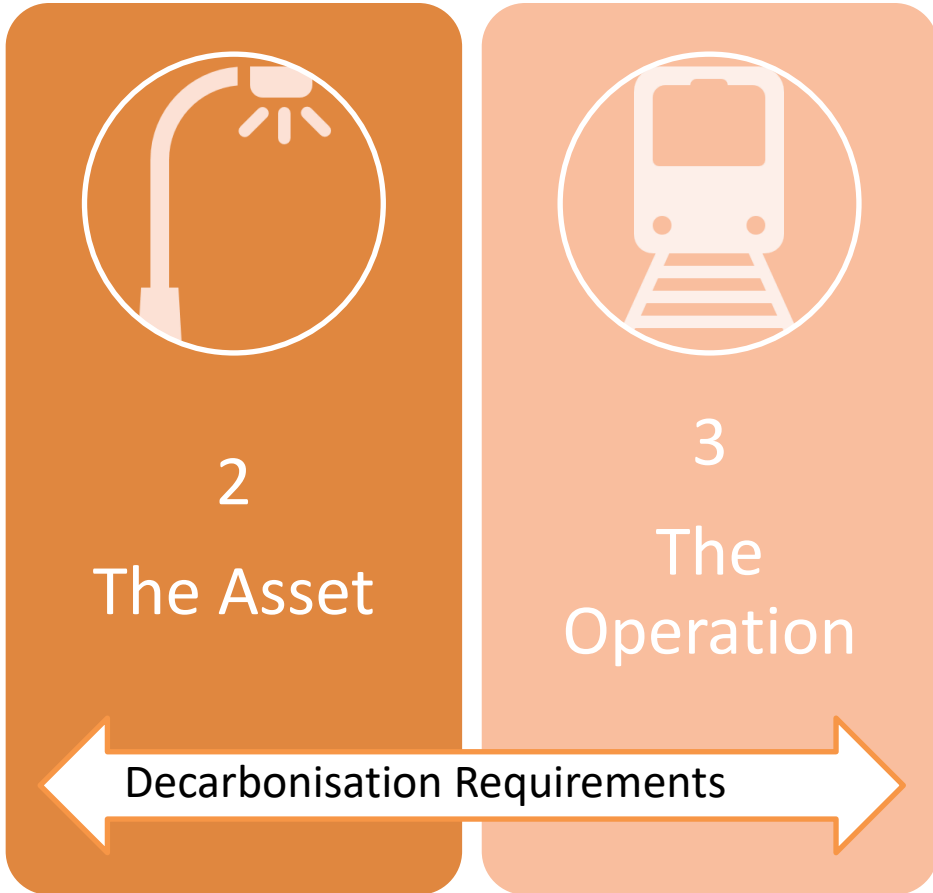
The UK construction industry produced approximately 11.4 million metric tons of carbon dioxide emissions in 2020



Decarbonising Construction Plant is a priority for the industry – the Rail industry is a key sector to support accelerated adoption. By facilitating hydrogen plant, can the infrastructure be used to leave a positive legacy for Assets and Operation?

Decarbonising Rail Assets & Operation

Hydrogen solutions and technology were embedded into the proposal for £570m Curzon St Station to support direct Net Zero and wider decarbonisation benefits



Rail emissions April 2021 to March 2022



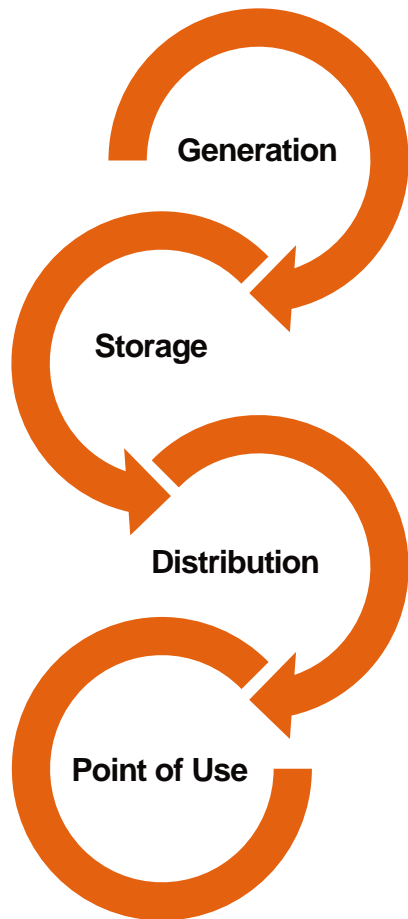
Type	Electric emissions	Diesel emissions
Passenger	358g CO ₂ e per electric vehicle km	1400g CO ₂ e per diesel vehicle km
Freight	211g CO ₂ e per electric vehicle km	598g CO ₂ e per diesel vehicle km

April 2021 to March 2022
1,080,000 tonnes CO₂e
Diesel emissions

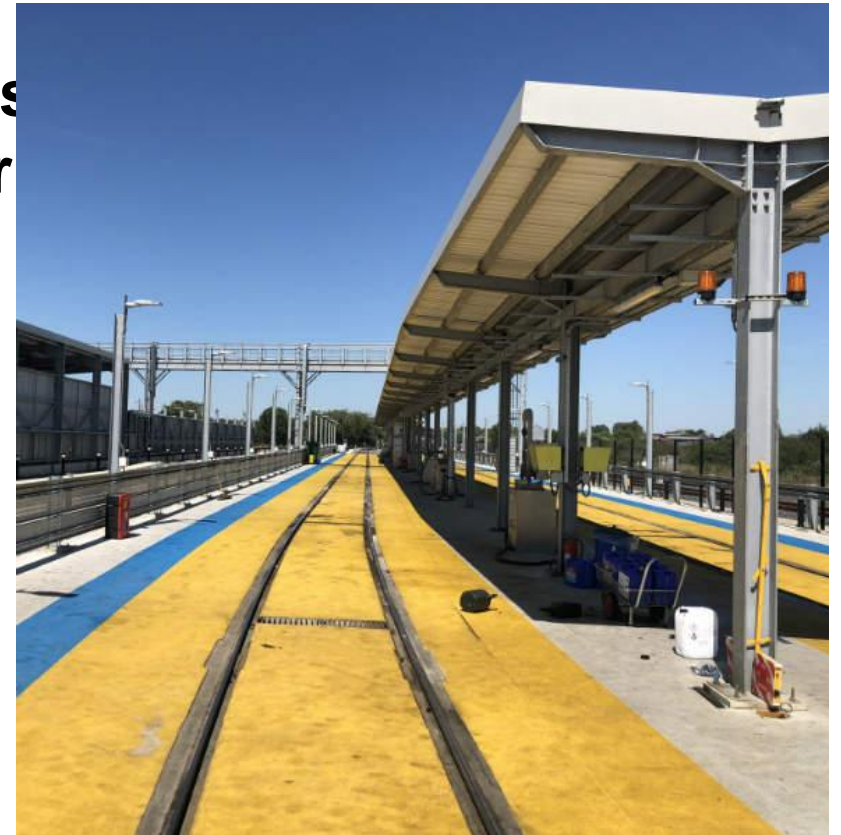
Hydrogen technology can support the decarbonisation of Rail Assets & Operation

Hydrogen Value Chain Considerations

To accelerate decarbonisation and adopt hydrogen in rail, all elements of the value chain need to be satisfactorily demonstrated suitable to replicate Diesel



Train Operators require a business as-usual, resilient replacement for Diesel.
Store sufficient quantities of hydrogen in a safe and suitable manner
Hydrogen or associated carriers need to be distributed at scale
Obtain the hydrogen rolling stock with appropriate refuelling solutions



Hydrogen Rail Evidence in Action



Stadler's FLIRT H2 in Colorado – 20th March 2024 - has achieved a Guinness World Record for the longest distance of over 1,700 miles, running for over 46 hours without refuelling.



CRRC Changchun Railway Vehicles Co. – 21st March 2024 has developed China's "first" home-grown hydrogen-powered urban train, completing a test run at a speed of 160kph (99mph). The test was completed on a CCRC test track in China's northeast Jilin Province. The train is reported to have a maximum cruising range of over 1,000km.



Hydroflex was the first hydrogen powered train has run on the UK mainline. Delivered in partnership with the University of Birmingham and Porterbrook. During 2023, it reached speeds of 90mph and travelled up Lickey Hill, the steepest mainline incline in the UK. Also, the first UK Hydrogen train to safely travel through a tunnel.

Hydrogen Rail Evidence in Action



In February 2024, California announced it was expanding hydrogen passenger Rail fleet to 10

Toks Omishakin, California Transportation Secretary stated “California continues to lead the way to a cleaner, more connected transportation system. By expanding our fleet of hydrogen-powered passenger trainsets, we are showing we are serious about deploying innovative and sustainable transportation options for the people of this state.”



Puglia, Southeastern Italy Two of Alstom's Coradia Stream H models will replace the region's current diesel trains.

Lombardy, in northern Italy, is expanding its hydrogen train fleet. Ferrovie Nord Milano has ordered two additional Coradia Stream H trains, bringing their total to eight. This builds on a previous framework agreement for up to 14 hydrogen trains

Technology Considerations

**Hydrogen
Combustion
Produces Heat**

E.g.: HICE / hydrogen boilers

Hydrogen Combustion can tolerate lower grades of hydrogen fuel purity. There are zero carbon emissions, however NO_x is potentially generated from the process

**Hydrogen
Fuel Cell
Produces
Electricity
& Heat**

E.g.: Fuel Cell Vehicles (like the Toyota Mirai)

Hydrogen Fuel Cells require 99.97% pure hydrogen fuel. Fuel Cells are more efficient than combustion and the by-product of fuel cells is water i.e. completely emission free

Fuel Origin Considerations

**Grey
hydrogen**

**Blue
hydrogen**

**Green
hydrogen**

Ammonia

SAF

Electrification

Note: It is 3x cheaper per kW to distribute hydrogen down a pipe than it is electricity down a cable

Carbon Intensity

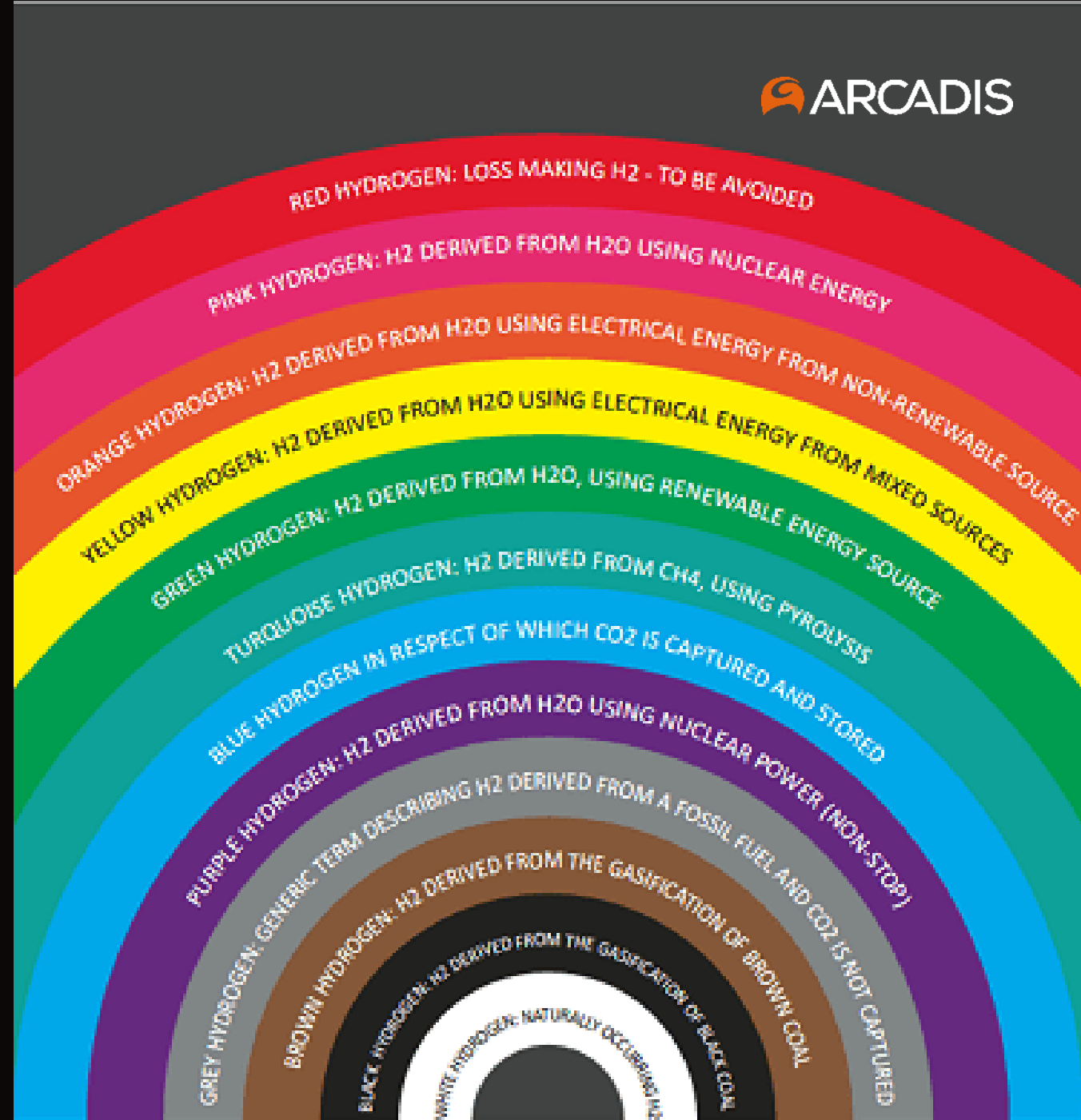
Definitions

WBCSD / Hydrogen Council Definitions

- **Reduced-carbon hydrogen**
 $\leq 6 \text{ kg CO}_2\text{eq/kg H}_2$ or c. $50 \text{ g CO}_2\text{/MJ}$
- **Low-carbon hydrogen**
 $\leq 3 \text{ kg CO}_2\text{eq/kg H}_2$ or c. $25 \text{ g CO}_2\text{/MJ}$
- **Ultra-low carbon hydrogen**
 $\leq 1 \text{ kg CO}_2\text{eq/kg H}_2$ or c. $8 \text{ g CO}_2\text{/MJ}$

UK Government (BEIS)

- **Low-carbon hydrogen** $< 20\text{g CO}_2\text{e/MJLHV}$



Summary

- Accelerated solutions to decarbonise Rail projects. Hydrogen & Alternative Fuels can help facilitate this acceleration.
- Change mindset from lowering carbon emissions to eliminating carbon emissions across construction, assets and operation.
- Add value to projects and challenge conventional solutions – we can provide business as usual zero emission hydrogen solutions
- Clear plans and roadmaps to remove Diesel rolling stock by 2040 and the Rail industry achieve Net Zero by 2050

Thank you



Paul Aspinall
Project Director |
Global Hydrogen Lead
e paul.aspinall@arcadis.com
m + 44 (0) 7799 131 832