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HYBRID – Welsh Hydrogen Train Project

Rail Cymru Conference 2022

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Project Overview

The project will support the deployment of hydrogen fuel cell powered trains in Wales, providing a technical and operational route to market for replacing existing diesel-powered fleets on key routes, providing a zero emission connections for communities across the region.

- Project sponsor SBRI & HYBRID - Strand 2, Four-month research and development project,
- Ballard Motive Solutions (formerly Arcola Energy) and Arup partnership, bringing advanced hydrogen technology and deep rail domain knowledge to the project,
- Established partnership – Scottish Hydrogen Train project presented during COP26.



Llywodraeth Cymru
Welsh Government

SBRI Government challenges.
Ideas from business.
Innovative solutions.

HyBRID

*Hydrogen Business Research &
Innovation for Decarbonisation SBRI*

HYBRID - Welsh Hydrogen Train Project



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Project Overview

Meets objective 5 of the Wales Hydrogen Pathway – Deployment of hydrogen fuel cell trains in Wales.

Segment 1

Welsh Hydrogen Train Feasibility Study:

- Literature Review – TDNS & Hydrogen initiatives,
- Route corridor study,
- Rolling stock review,
- Power demand modelling,
- Feasibility report – ‘The Future for Hydrogen Trains in Wales’.

Segment 2

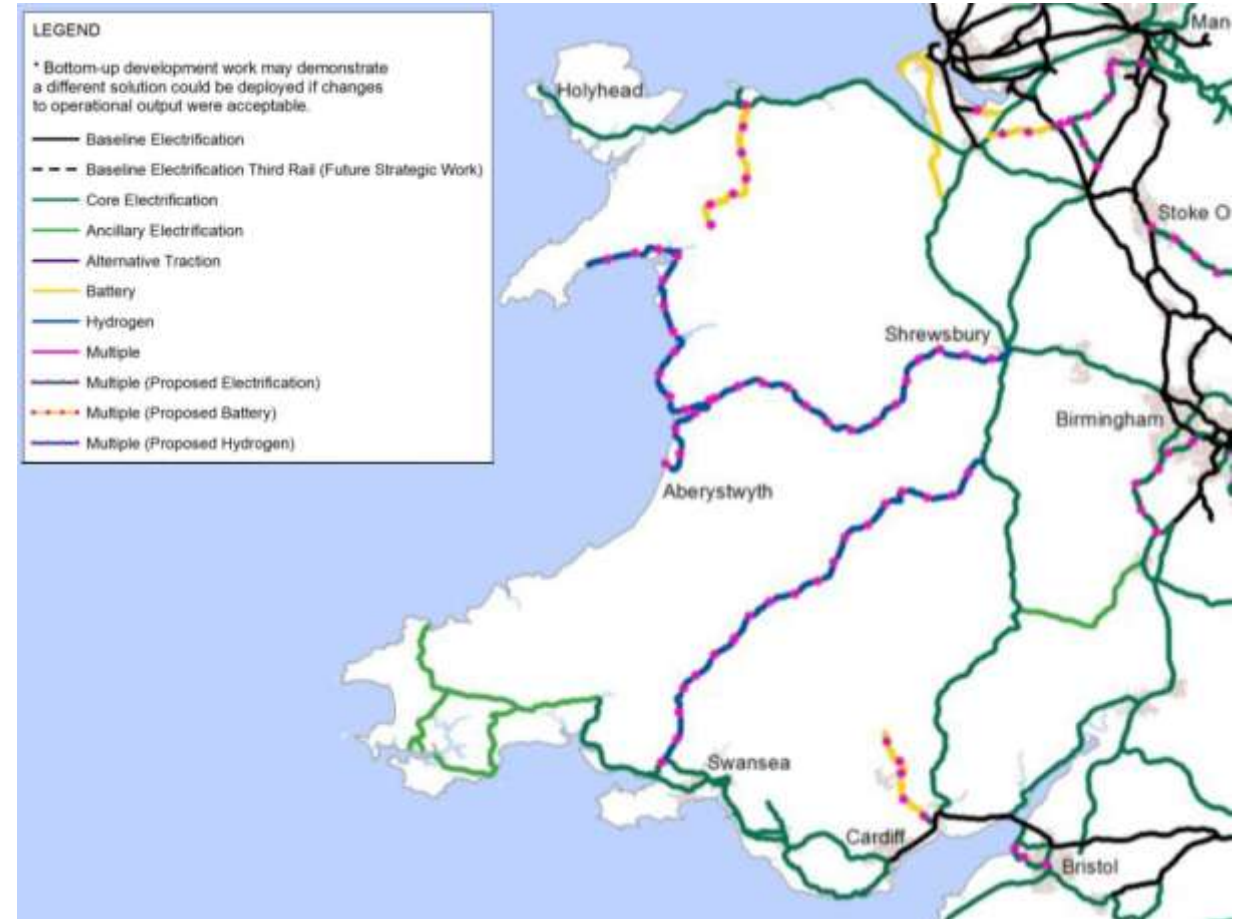
Preliminary development and Route to Market Strategy:

- Hydrogen System Packaging study,
- H2 Preliminary design development,
- Report – ‘Welsh Hydrogen Train Route to Market Strategy’.

Segment 1 - Literature Review

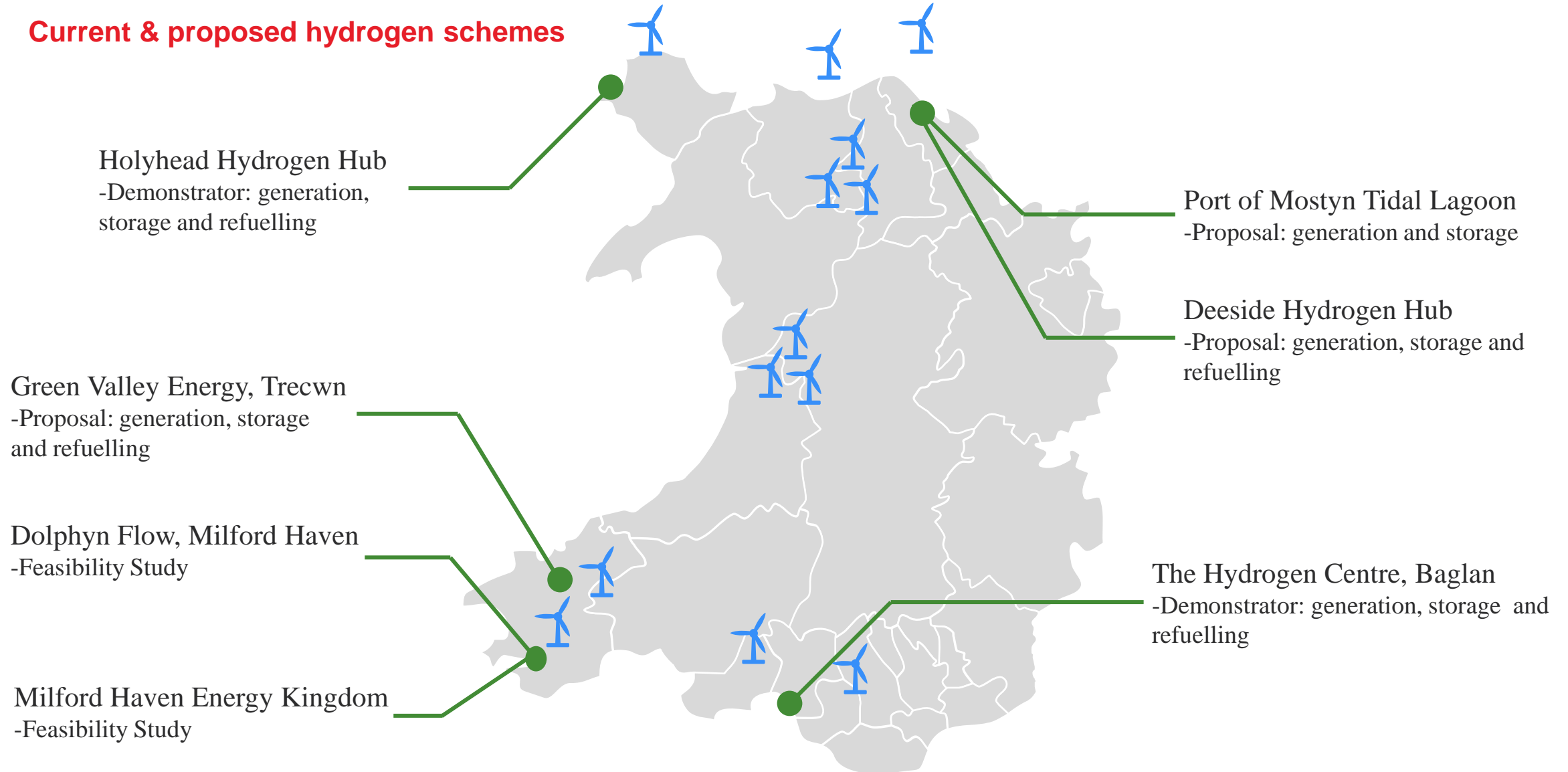
Network Rail - Traction Decarbonisation Network Study

- TDNS primary focus was to identify opportunities for the expansion of the electrified rail network,
- Where this is not feasible (either technically or financially), zero-emission alternatives are proposed,
- Hydrogen or Battery powered traction systems identified by route length & service frequency,
- No operational or power demand modelling undertaken to validate the assumptions.



Segment 1 - Literature review

Current & proposed hydrogen schemes





Segment 1 - Rolling stock review

Identifying potential fleets for Hydrogen conversion

Rolling stock database created to identify all appropriate rolling stock for conversion, focussing on existing TfW fleets, new TfW fleets and cascade options.

- Opportunities and barriers for conversion,
- Industry-wide issues considered:
 - Crashworthiness / driver safety,
 - Passenger experience,
 - Accessibility,

Suitability assessed on qualitative criteria:

	Existing TfW Fleets							New TfW Fleets				Cascade Fleets					
Criteria	Class 150/2	Class 153	Class 158	Class 170/2	Class 175	Class 769	CI 67 / Mk.4	Class 197	Class 231	Class 756	Class 230	Class 158	Class 185	Class 196	Class 321	Class 365	Class 379
Passenger experience	2	2	2	3	3	2	2	4	4	4	2	2	3	4	3	2	4
Vehicle condition	1	2	2	3	4	2	2	4	4	4	3	2	3	4	2	2	3
Technical compatibility	2	2	3	3	2	2	1	3	3	4	2	2	2	2	2	3	4
Project & commercial risk	2	2	3	3	3	2	1	2	1	1	1	2	2	2	3	2	2
Equipment space availability	2	3	2	3	2	2	2	2	1	3	1	2	3	2	3	2	2
Route compatibility	3	3	4	3	3	3	1	3	3	3	2	3	2	3	2	2	2
Fleet availability	4	4	4	1	3	1	1	4	2	2	2	3	2	2	3	4	3
Qualitative Cost Impact	2	2	3	2	3	2	2	4	3	3	2	2	2	2	2	1	3
Total / 32	18	20	23	21	23	16	12	26	21	24	15	18	19	21	21	18	23

Segment 1 - Rolling stock options



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TfW Class 158
Qualitative Score 23



Class 175 Coradia
Qualitative Score 23



TfW Class 197 Civity
Qualitative Score 26



TfW Class 756 Flirt
Qualitative Score 24



Class 379 Electrostar
Qualitative Score 23

Conclusions:

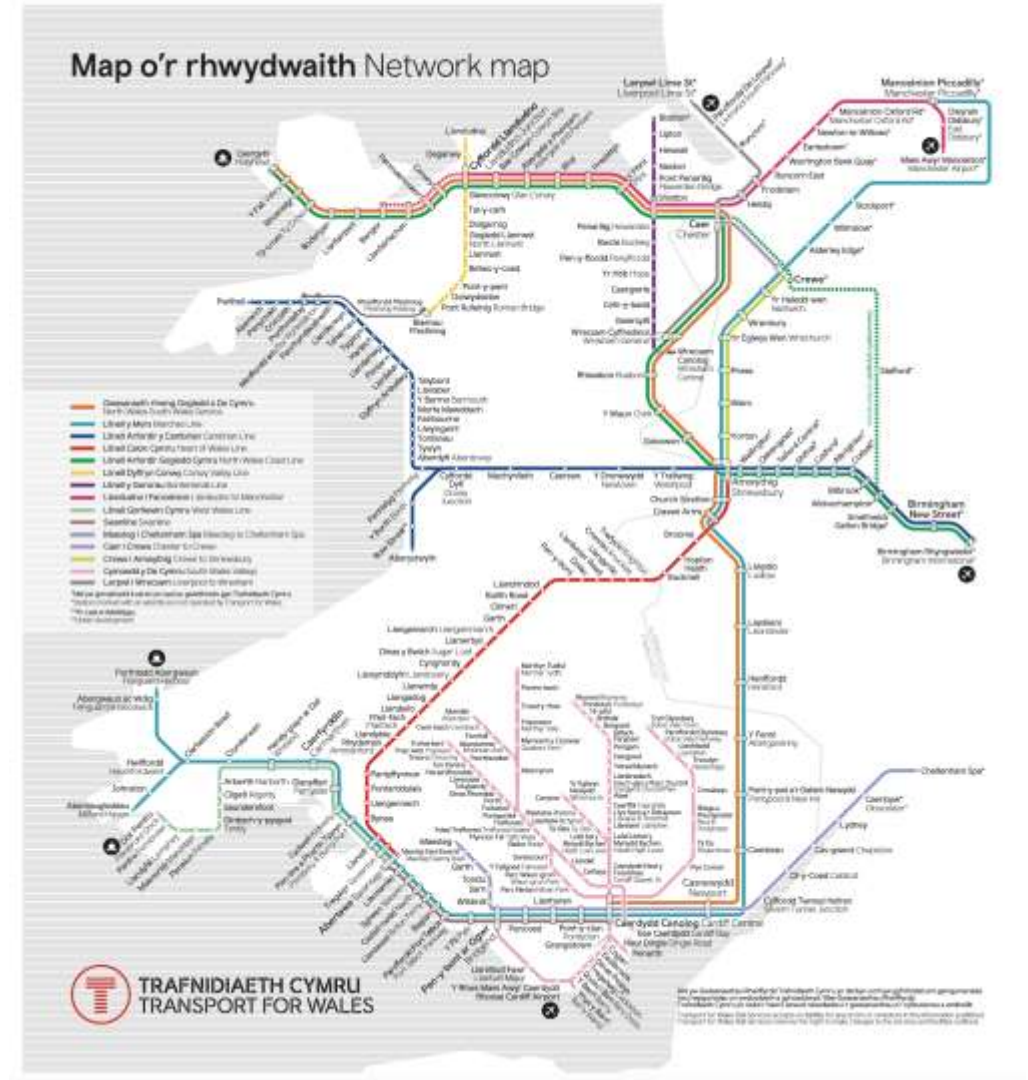
- Access to TfW owned fleets and engineering information, extremely valuable and reduces project risks,
- Access to new build fleets is likely to be contractually complex,
- Modification of existing fleet preferable to reduce driver / crew/ maintenance training burden,
- Fleet availability and 5-7 years remaining asset life essential for development programme, commissioning and progression from trials to passenger service,
- TfW preferred hydrogen conversion option Class 158.

Segment 1 - Route Corridor Analysis

Potential routes for Hydrogen-powered trains in Wales

Route corridor analysis has been undertaken on the following TfW routes:

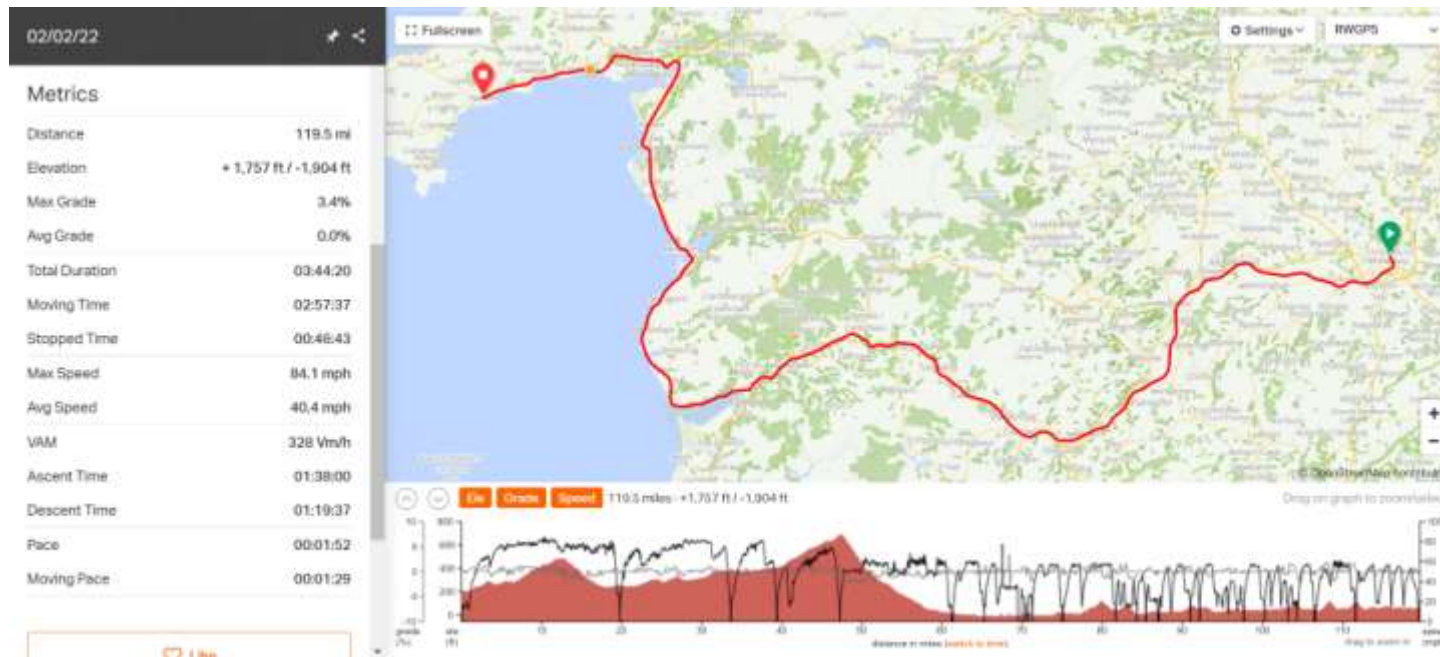
- Conwy Valley Line, Llandudno to Blaenau Ffestiniog,
- North Wales Coast Line, Chester to Holyhead,
- Heart of Wales Line, Shrewsbury to Swansea,
- Cambrian Line, Shrewsbury to Aberystwyth/ Pwllheli,
- West Wales Line, Swansea to Pembroke Dock,
- South Wales Valleys, (Ebbw Vale Branch).



Segment 1 - Route Corridor Analysis

Route Database & GPS data gathering

Database developed to capture key route information, additionally GPS data recorded along identified routes.



The screenshot shows a table with route information. The table has columns for Line Reference, Location and Station, Station Miles, Station Separation, Location Line, and Previous Line. The data is highlighted in red.

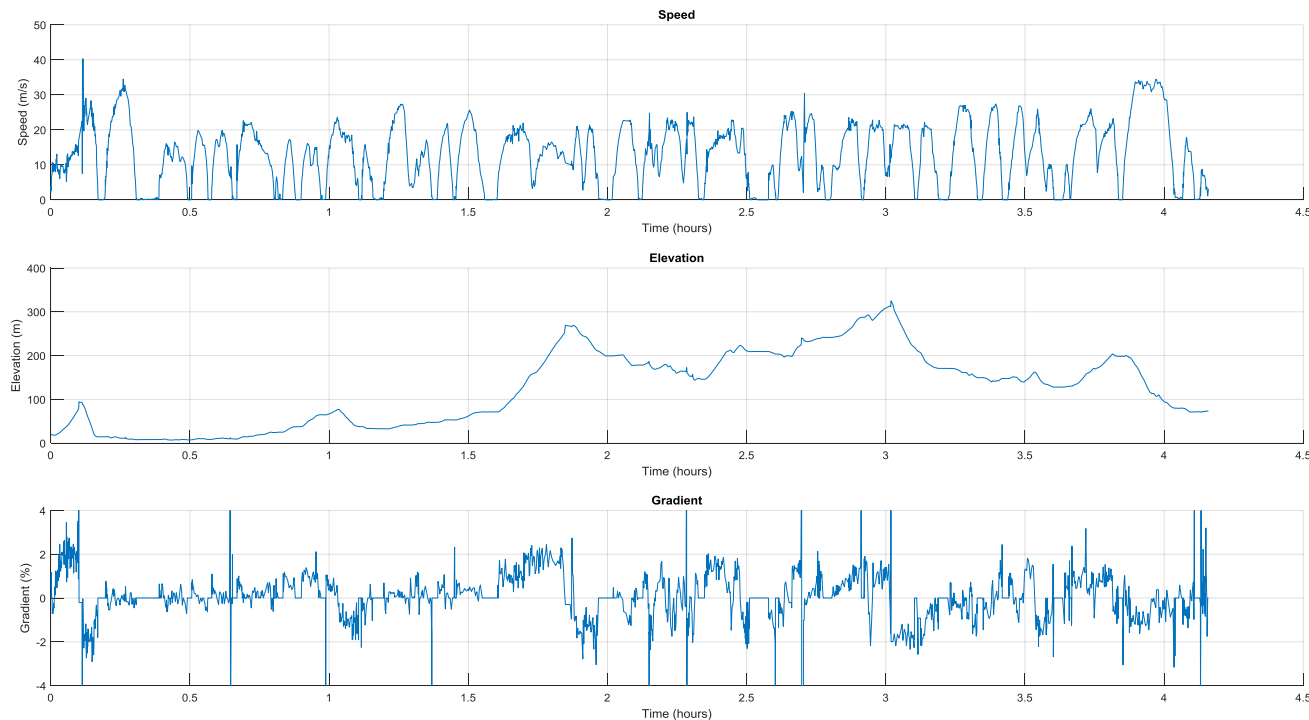
Line Reference	Location and Station	Station Miles	Station Separation	Location Line	Previous Line
45	WELLS	25.1	0.0	45	45
46	WELLS	25.125	0.025	45	45
47	WELLS	25.15	0.05	45	45
48	WELLS	25.175	0.075	45	45
49	WELLS	25.2	0.1	45	45
50	WELLS	25.225	0.125	45	45
51	WELLS	25.25	0.15	45	45
52	WELLS	25.275	0.175	45	45
53	WELLS	25.3	0.2	45	45
54	WELLS	25.325	0.225	45	45
55	WELLS	25.35	0.25	45	45
56	WELLS	25.375	0.275	45	45
57	WELLS	25.4	0.3	45	45
58	WELLS	25.425	0.325	45	45
59	WELLS	25.45	0.35	45	45
60	WELLS	25.475	0.375	45	45
61	WELLS	25.5	0.4	45	45

Trip Information	HoW - Swansea-Shrewsbury
Distance Travelled	196.76 km / 122.97 miles
Moving	03:25
Stop	00:43
Average Speed (without stop)	57.39 kph / 35.87 mph
Total Ascent	847 m

Segment 1 - Power demand modelling

Heart of Wales Line - Overview

- GPS data provides - speed, elevation and gradient,
- Determining likely H₂ consumption,
- 34.8kg H₂ for two car unit (single trip – 197km /122 Miles).





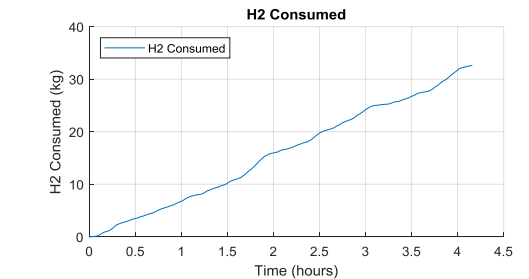
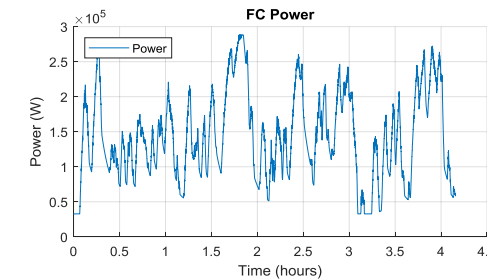
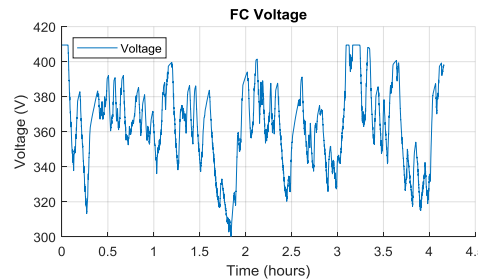
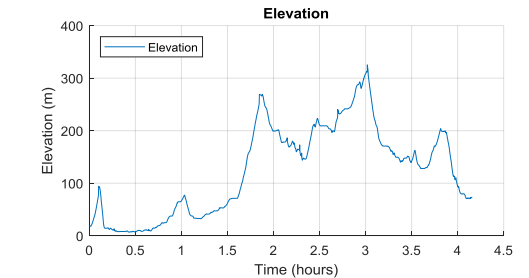
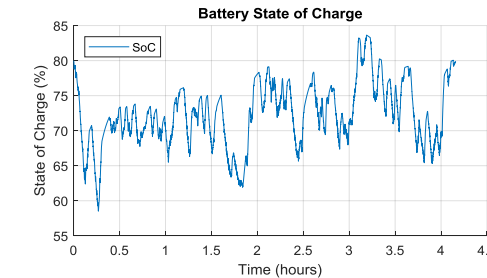
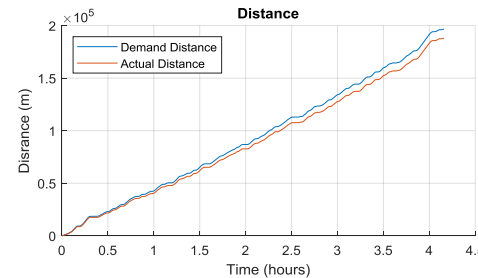
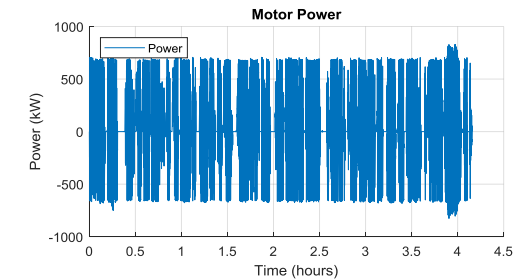
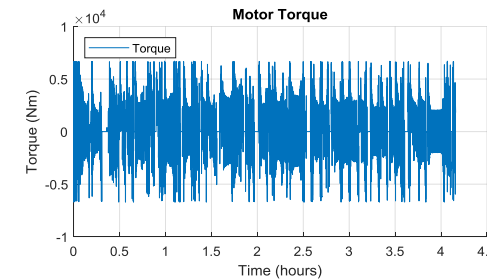
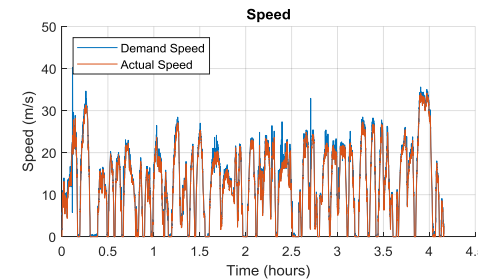
Segment 1 - Power demand modelling

Heart of Wales Line – detailed power metrics

Software used to establish:

- Motor Torque,
- Motor Power,
- Fuel Cell Voltage,
- Fuel Cell Power,
- Traction Battery state of charge,
- H2 Consumed

34.8kg H₂ for two car unit
(single trip – 197km /122
Miles).



Segment 1 - Feasibility report



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The Future for Hydrogen Trains in Wales

Feasibility report issued 25th February, agreement with Welsh Government and TfW Rail the direction for Segment 2.

Focus on Class 158 hydrogen sub-fleet for trial operations on the Cambrian Line, based upon the following attributes:

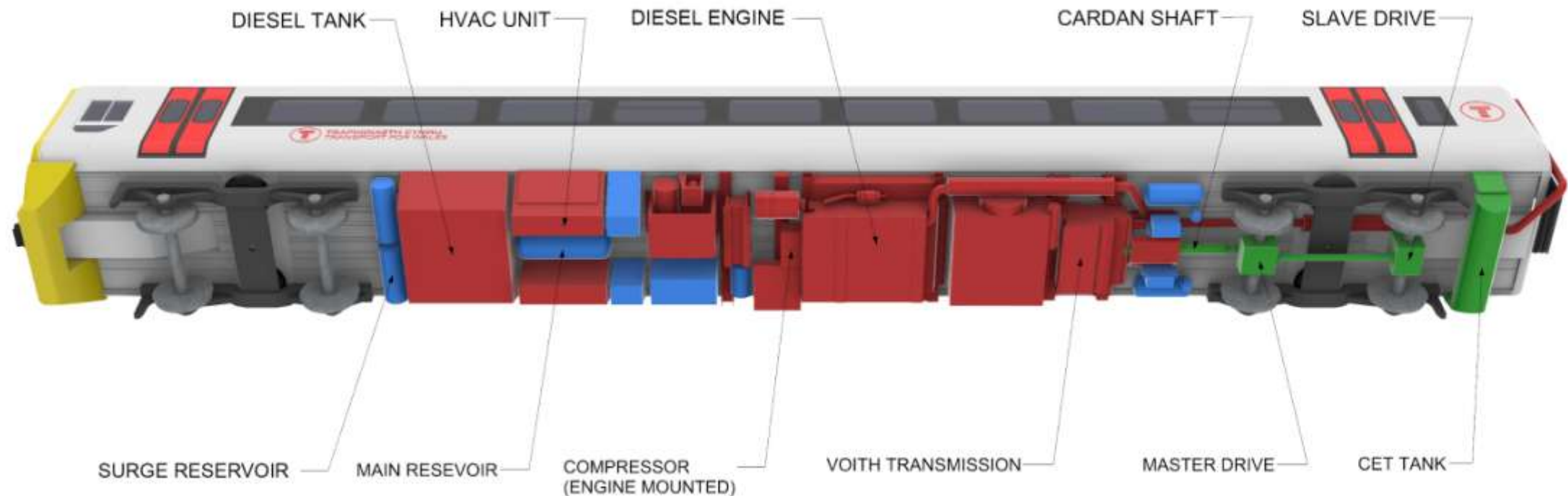
- Class 158 is proven on the Welsh network and cleared for all routes,
- Reliable baseline for demonstration of the technology, with potential for future deployment on other DMU's, such as the replacement CAF Class 197 fleet,
- Reduces the operational burden in terms of driver / crew training and maintenance competence,
- Class 158 recently refurbished fleet,
- ETCS system upgrades underway on Cambrian Line and Class 158 Fleet.

Segment 2 - H2 System packaging study

High-level overview of existing underframe components

H2 conversion highly complex, combining new systems with legacy equipment / systems.

Colour coded as follows, components to be retained (green), likely to be relocated (blue) and redundant components that will be removed (red), including fuel tank, diesel engine and transmission.

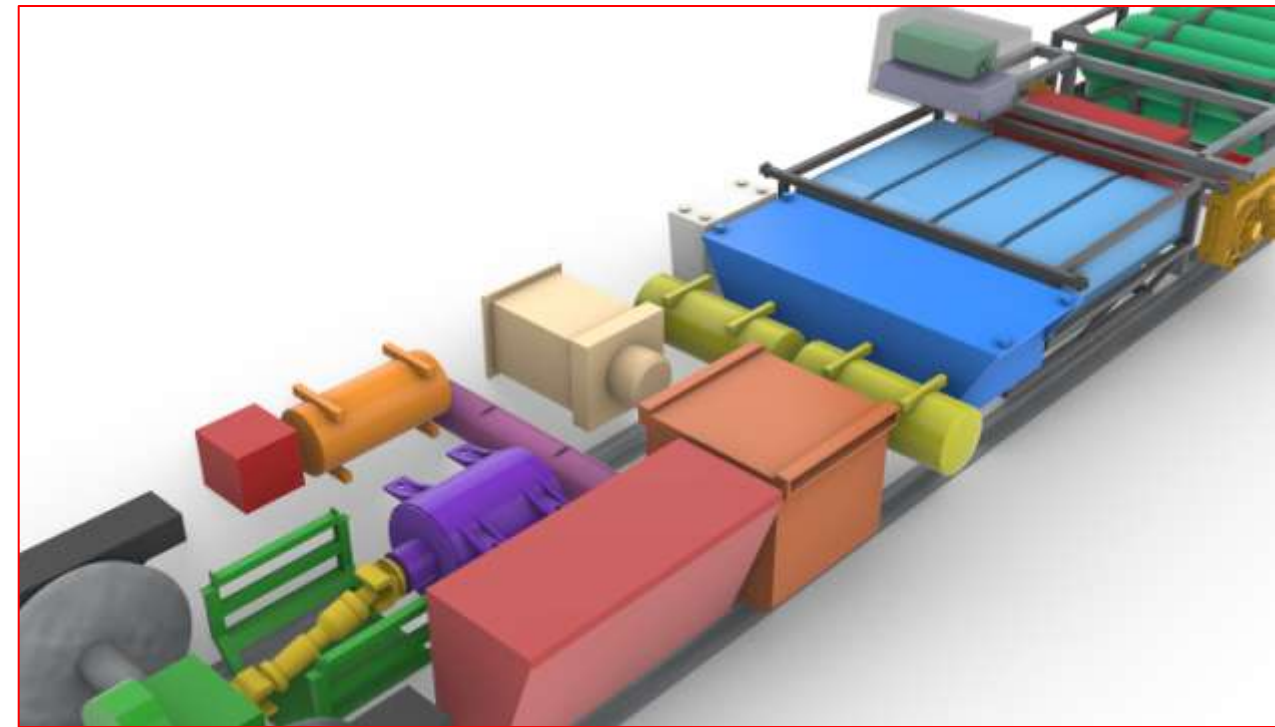


Segment 2 - H2 System packaging study

Hydrogen conversion packaging considerations

Overview

- Underframe installation, roof and interior compartment locations,
- Balancing equipment capacity and provision of sufficient access for installation and maintenance,
- H2 Capacity range = 63 - 100kg/car & 126 - 200kg /unit,
- Highly complex engineering changes, requiring;
 - Structural assessments,
 - Vehicle dynamics and gauging,
 - Control and safety system interfaces.





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Segment 2 - Route to market strategy

Operational Concept

Route to market strategy currently being developed for Class 158 H2 sub-fleet, operating dedicated unit diagrams on Cambrian line for trials and service operations.

Proposal Highlights:

- Conversion of 3 x Class 158's 2 car units,
- Operating out of Machynlleth depot, with a single H2 refueller,
- Exploring Hydrogen production either on site or close proximity (24 miles by road),
- Estimated operational demand for up to 400kg H2 /day,
- Supported by wider commercial and road applications to create further local demand in the area.



Segment 2 - Route to market strategy

Project deliverables

Providing the Welsh Government with technical concepts for H2 conversion. Route to market outlines strategy for next steps, challenges to overcome and necessity for integration with wider Hydrogen supply and network strategies.

Detailing the following aspects:

- Constraints and Assumptions,
- Overall Project Management,
- Operational Deployment Strategy ,
- Infrastructure Compatibility Strategy,
- Procurement Strategy,
- Design, Conversion and Approvals Strategy,
- Maintenance Strategy,
- Depot Strategy,
- Overnight Servicing & Fuelling Strategy,
- Training Strategy,
- Implementation Programme,
- Financial Strategy,
- Stakeholder, Media and Customer Engagement Strategy,
- Post Deployment Evaluation.



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