



Flexible Railway Energy Hubs

Nov 2025



UNIVERSITY OF LEEDS



GE VERNOVA

SP Energy Networks, part of ScottishPower, owns four regulated electricity network businesses in the UK:

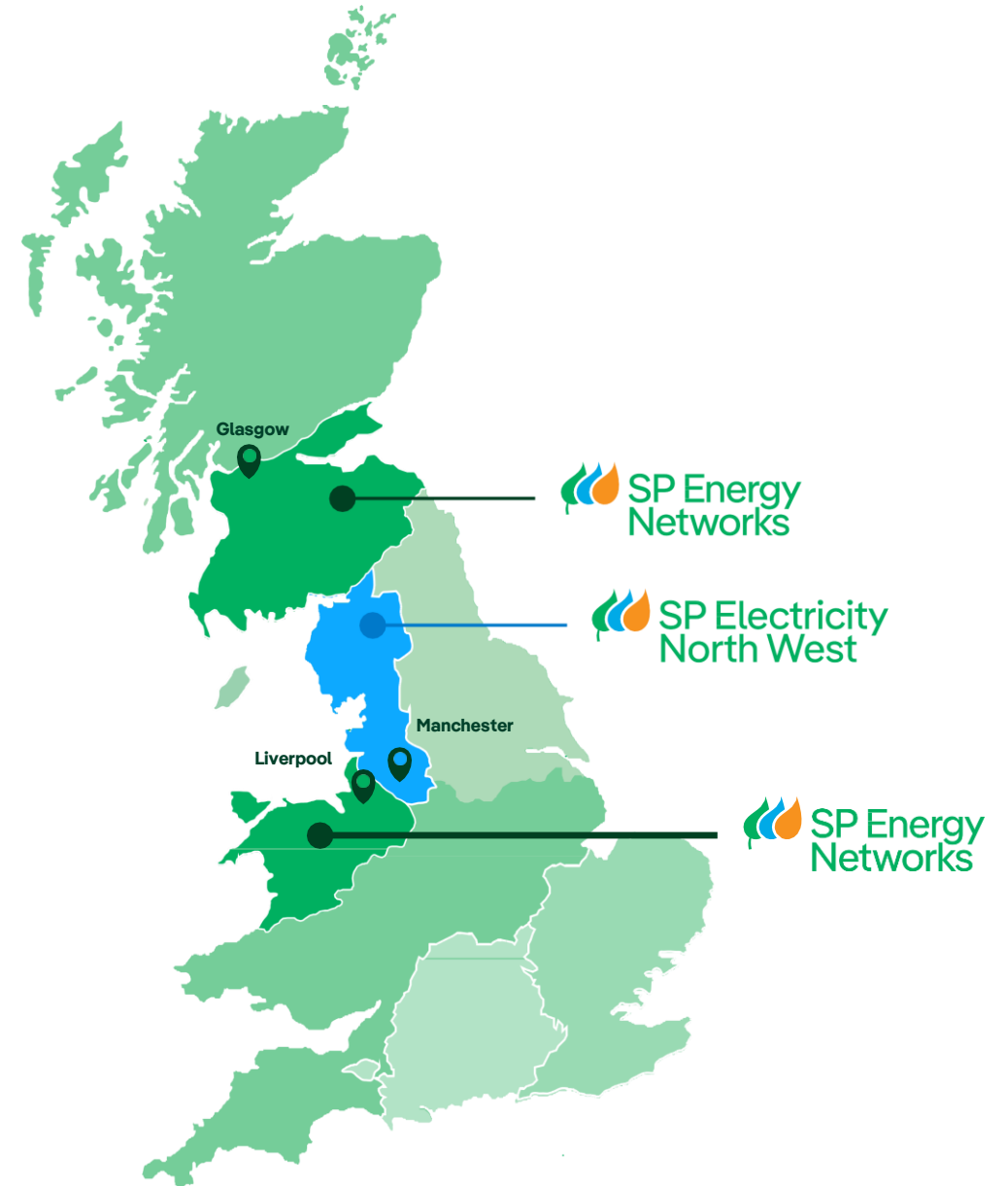
- SP Distribution plc (SPD)
- SP Transmission plc (SPT)
- SP Manweb plc (SPM)
- SP Electricity North West (SP ENW)

Together we keep electricity flowing to over **12 million** people across a network spanning more than **172,000 kilometres**.

Operating in some of the UK's largest cities as well as significant rural areas. It's our job to move electricity to and from homes and businesses over our network.

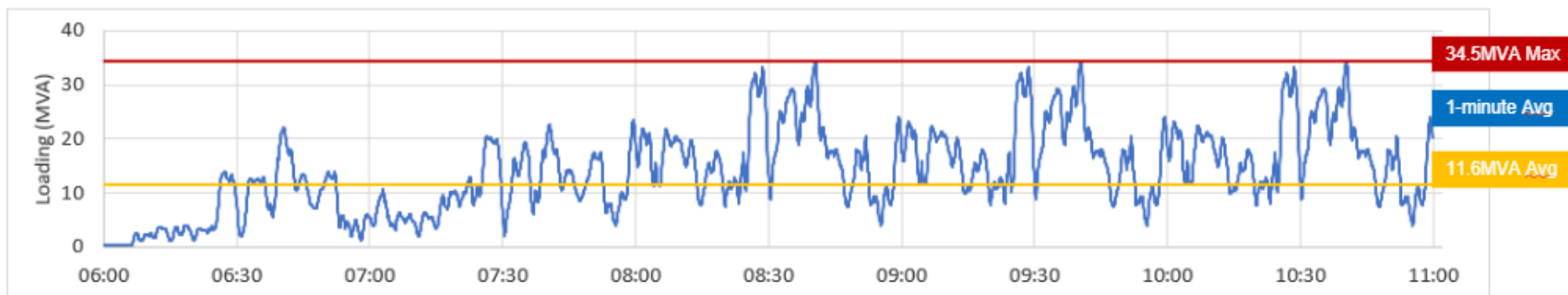
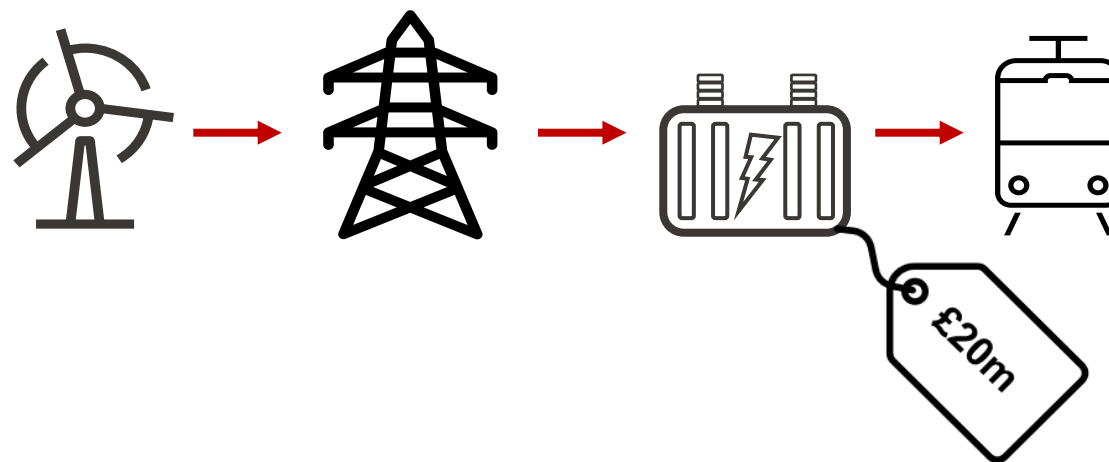
Our aim is to deliver a safe and reliable electricity supply 24 hours a day, 365 days a year whilst providing exceptional value for money.

It's a role that puts us right at the heart of the UK's Net Zero carbon emissions ambition.



Problem Statement

- **Network Rail** is a significant consumer of electricity, using approximately 1.2% of electricity demand in the UK, consuming over ~4TWh annually (=1.5 million homes)
- **“Inflexible” Power Demand:** driven by rail timetables
- Only **38%** of rail routes are currently electrified
- **Railway Decarbonisation** entails ~3TWh increase in demand
- **Wind Constraints** - **8.3TWh** of wind generation was “constrained” in 2024, at a cost of **~£1bn** in payments and congestion management.
- **New connection lead times** are up to 15 years, and the process is heavily regulated.

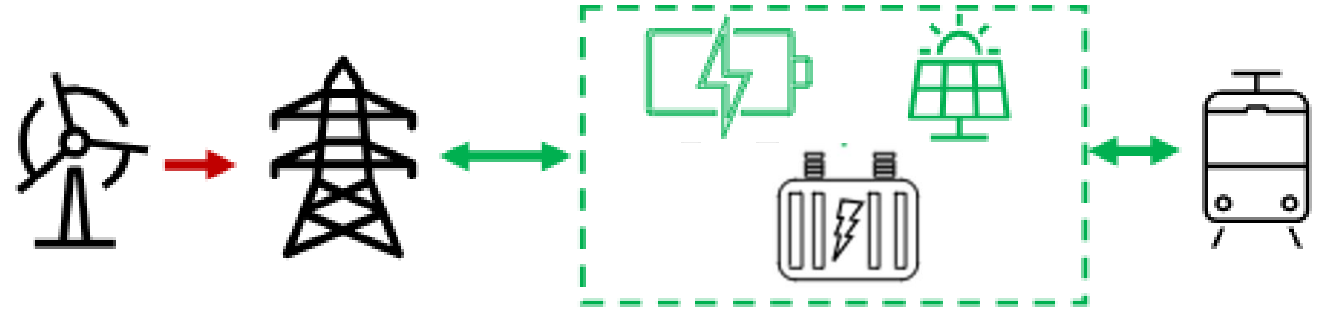


The Solution

- First microgrid technology to interface cross-sector with both railway network and power grid,
- Configurable, flexible, controllable

Use Cases:

- Power quality issue mitigation
- Renewable Wind curtailment reduction
- Flexibility and Ancillary services
- Traction Power Voltage Regulation
- Rail Demand Balancing



Consumers

- Making significant consumer of electricity 'flexible' reduces constraint payments, avoids network upgrades, and can reduce consumer bills



Network Operators

- Reinforcement works to cater for future railway demand can be avoided, potential savings for electricity and rail customers

Internal Use



The railway

- Access flexible tariffs and time-shifting demand reduces NR energy bills
- Smooth the peaky single-phase loads on 25kV networks
- Opens option of large-scale solar PV across the railway network

Flexible Railway Energy Hubs: Summary

Key Innovations

Connection of battery storage to traction power line

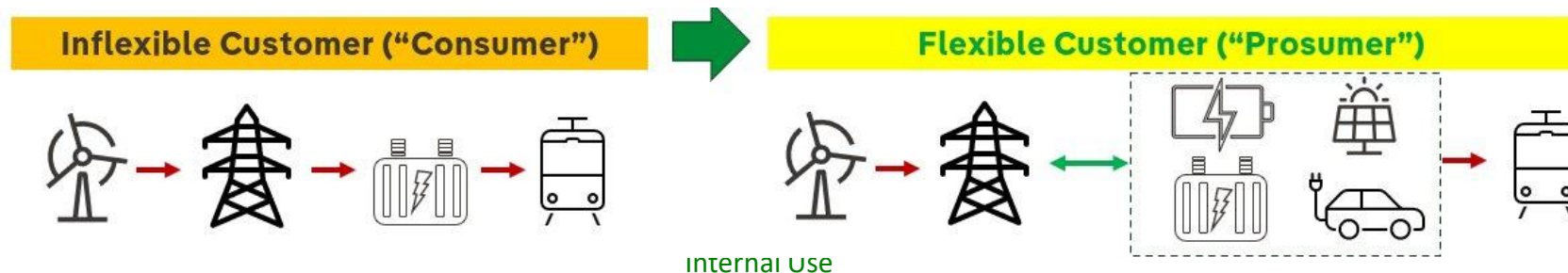
Traction power line as a conduit to deliver services to the power grid

Hubs simultaneously support both rail network and power grid

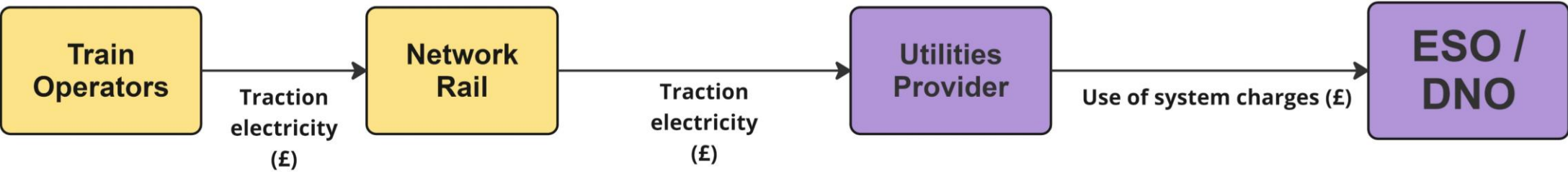
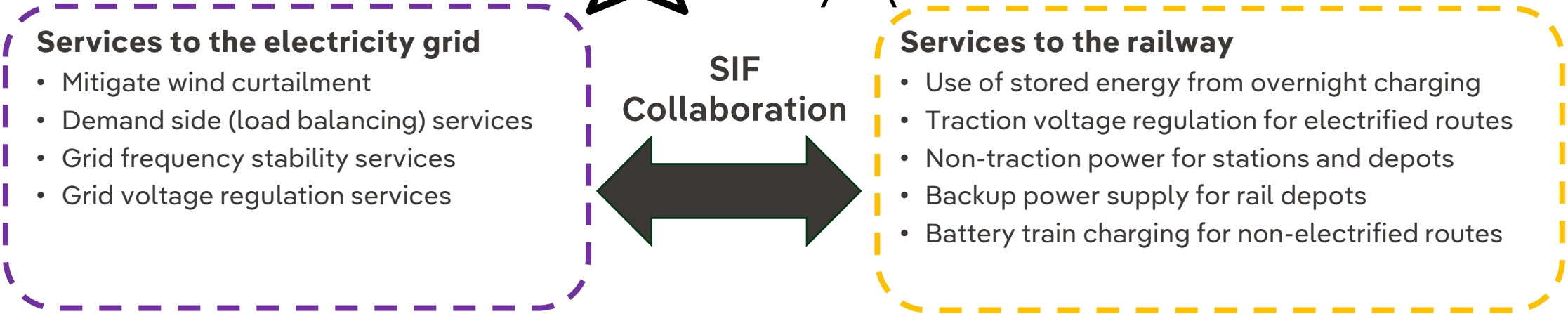
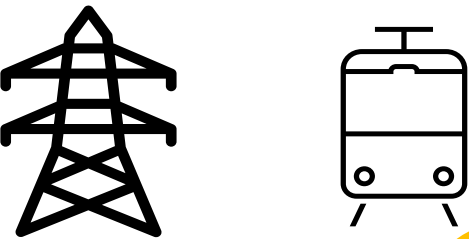
Prospect of co-ordinated control of nationwide network of Hubs...

...large scale distributed storage: significant impact on wind power curtailment...

Rail network transformed into flexible, electrical load



Hubs will simultaneously benefit two sectors:



Hubs Demo

Connection: Via a SPT 132kV transmission sub-station – 18 miles away

Battery: 2MW/2MWh

Land: Owned by Network Rail



“Beta” selection criteria

Constrained area of the electricity grid where SPEN are tendering flexibility

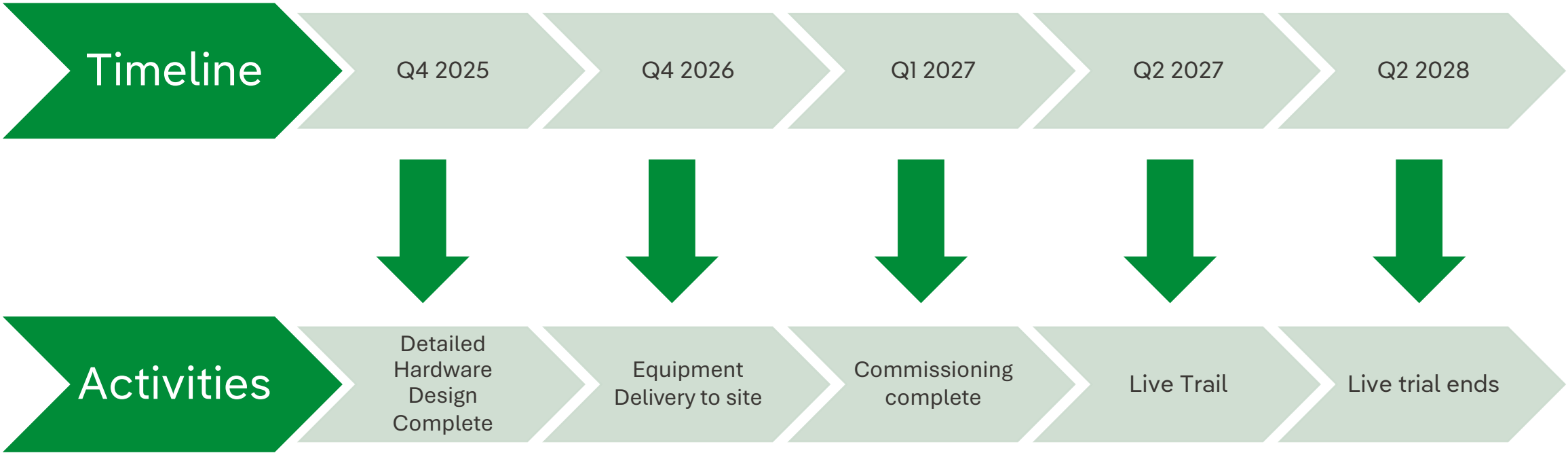
Ayr is at the end of the rail line and voltage quality can be poor

20 miles of railway need to be kept live to serve the depot overnight

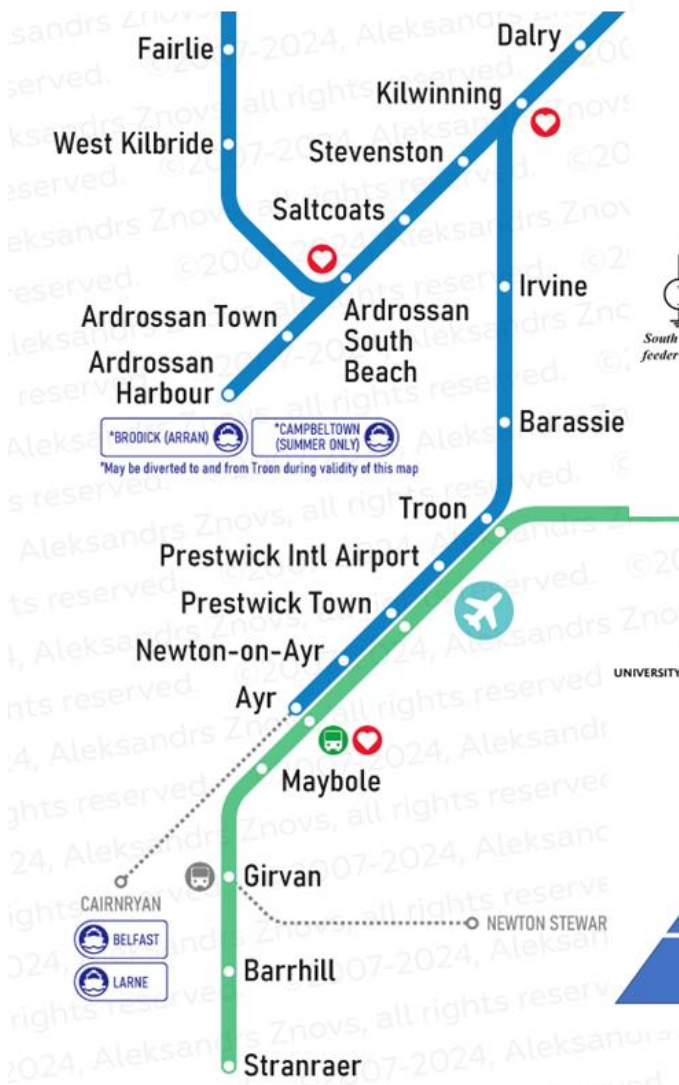
Network Rail owned land has permitted development rights

Operational criticality of Ayr aligns with scope of demonstration

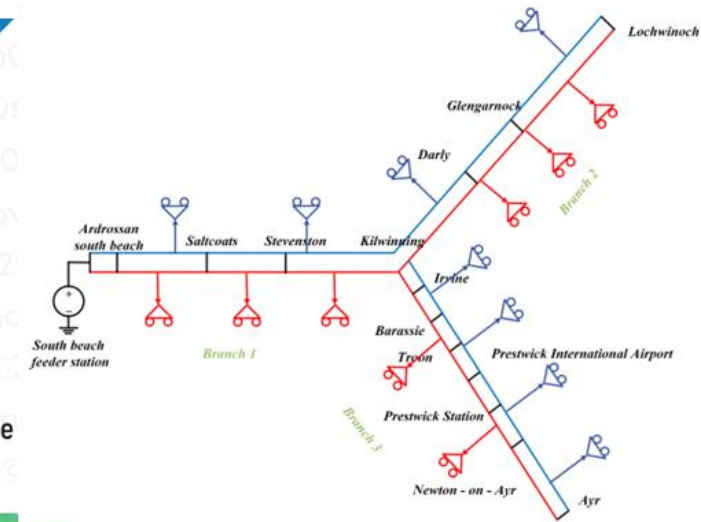
Project timeline



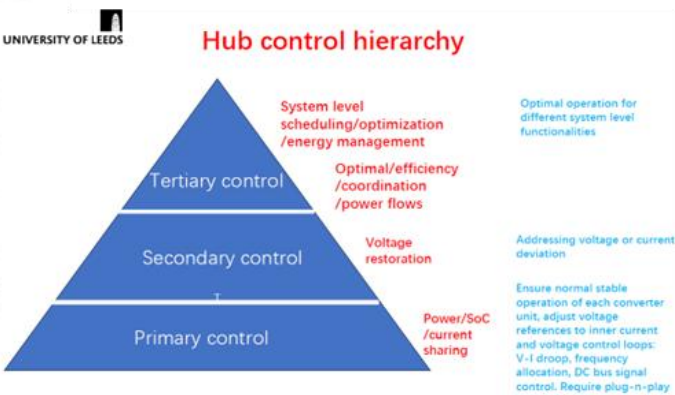
Modelling and Control Results



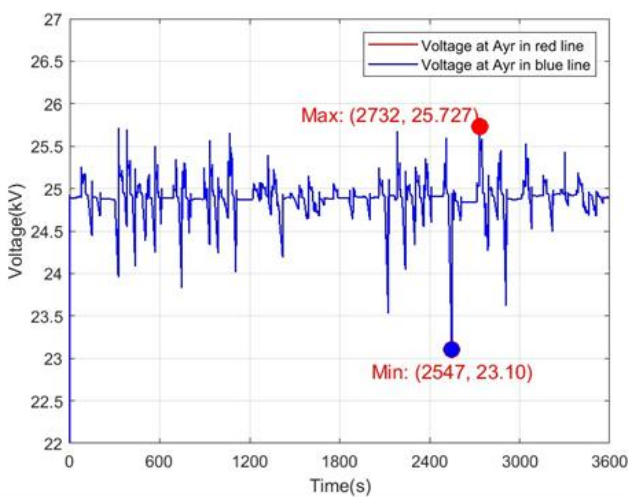
Ayrshire traction network diagram.



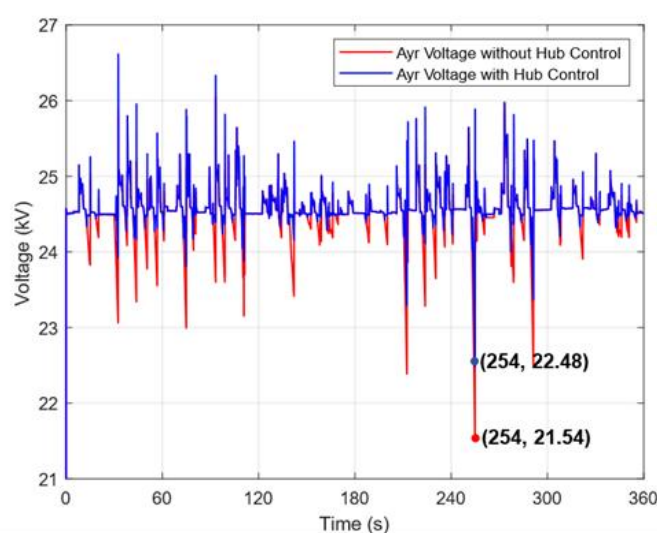
Traction network model



Control hierarchy



Modelling results



Control results

Progress and Highlights

- Modelling and control results
- Preliminary design prepared
- Common Safety Method (CSM) Hazard Identification (HAZID) workshop conducted – renew from Network Rail acceptance panel – “Non-significant”
- Undertaken stakeholder engagement, focusing on technical, commercial and regulatory aspects.
- Hubs use cases and proposed ownership models identified – to be reviewed through project



GE Technical meeting Rugby

Conclusion



The Energy and Rail Networks require significant collaboration to ensure full decarbonisation.



Hubs has the potential to deliver significant value to electricity and rail customers and operators, the Strategic Innovation Fund and the wider Industry



Hubs has the potential to advance the ongoing collaboration between rail and energy, collectively minimising the impact of rail decarbonisation on the transmission network



The engineering design for the demo will be completed by end of year, and the procurement of key equipment will begin going into 2026.

