

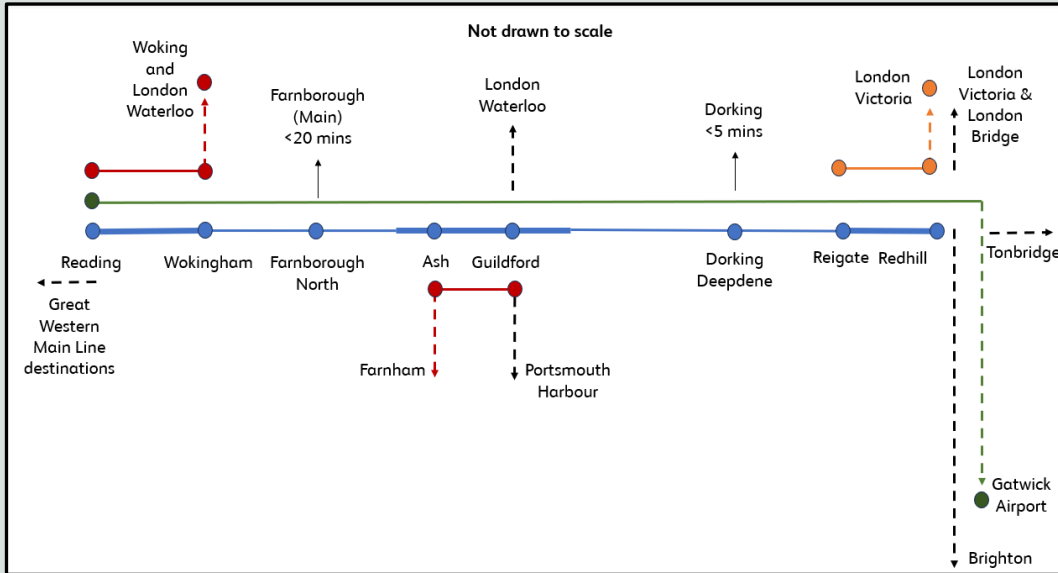


North Downs Line

Traction Decarbonisation Strategy

The North Downs Line - Context

The North Downs Line (NDL) is a 46-mile route between Reading and Redhill. The route is partially DC electrified but has 29 miles of unelectrified track.



Symbol	Description
	NDL route (blue) and stations; the line in bold is electrified
	GWR services (green) run across the full NDL; SWR services (red) and Southern services (yellow) also run on parts of the NDL
	Services running partly on the NDL and joining another route
	Rail lines accessed via the North Downs Line
	Rail stations in walking distance from the NDL

Rolling stock

- Great Western Railway (GWR) run a 2 train per hour (tph) service across the NDL to Gatwick Airport. Class 165/166 diesel trains are used to bridge gaps in electrification.
- The fleet is resourced from Reading and is small (7 units), limiting timetabling options.
- South Western Railway (SWR) and Southern also run across parts of the NDL; they use DC electric rolling stock as they only use electrified portions of the route.
- Diesel-electric trains were trialled from 2020 but were not adopted due to industry affordability challenges.
- GWR advise that **the Class 165/166 fleet needs to be replaced by 2035**, meaning there is an upcoming decision point to inform future rolling stock requirements.

Strengths

The NDL is an orbital corridor, meaning that it provides east-west connections without interchanging in London. This benefits demand centres along the route, but also supports regional connectivity, including to Gatwick Airport.

The route runs parallel to roads including the A25 and A31, where there are known congestion issues. Improving the rail offer could encourage modal shift, supporting sustainable economic growth.

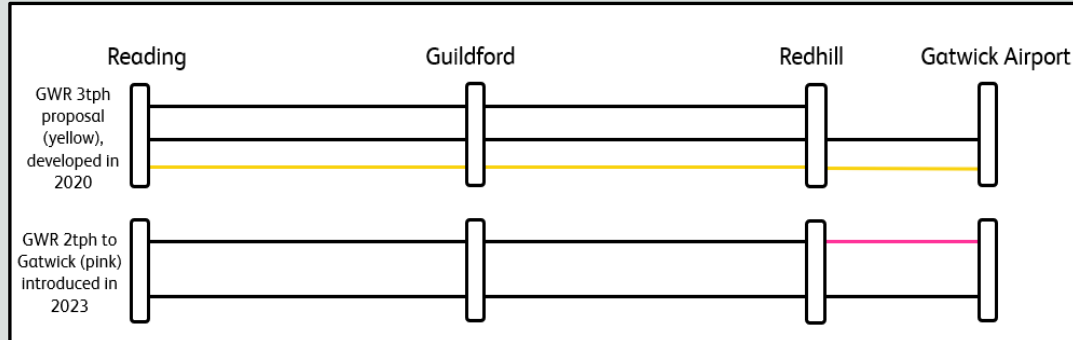
Successes

A congested infrastructure notice was removed from the NDL in 2023, following the successful delivery of enhancements. This has included work at Reading, Redhill and Gatwick Airport stations and level crossing mitigations.

In December 2023 GWR altered the timetable to extend a half-hourly service to Gatwick Airport. As of May 2024, this pattern now operates 7 days a week.

Strategic opportunities

A 3tph timetable proposal (yellow) could not progress today as the existing fleet is too small. GWR has maintained momentum by introduced a revised timetable (pink) in 2023 to realise the key ambition of running 2tph to Gatwick Airport.



Rolling stock replacement

The need to replace the current diesel trains in the 2030s presents the opportunity to procure trains fit for the future of the line. While not all benefits are assessed here, procurement of a new fleet could also secure:

- A larger fleet to enable future service ambitions
- Decarbonised traction technology and improved service reliability
- Improvements to the onboard passenger experience
- Longer trains to mitigate crowding
- Level boarding

Study approach

This study focuses on identifying the **optimal traction decarbonisation solution** for the NDL. The methodology is presented below, taking account of services:

Decarbonisation



- The Transport Decarbonisation Plan advises that diesel rail traction should be phased out by 2050.
- The NR Southern Region is 81.7 % DC (third rail) electrified, but with remaining diesel-pockets, including the NDL.
- A zero-emission traction technology on the NDL would remove 10 % of remaining passenger emissions, or 5,236 tonnes of carbon annually.
- This study provides industry advice on the use of different traction technologies on the NDL, focusing on the 2tph 2023 timetable (see second timetable diagram, left)

Service enhancements

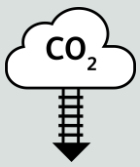


- Stakeholders want to better utilise the orbital corridor by improving service frequency and journey times to encourage modal shift.
- The study reviews the case for 3tph and considers other options to improve the rail offer.
- This can inform decisions made about a new fleet for the 2030s and long-term planning, but no final service recommendations are made.
- The outputs are used to understand whether improved connectivity on the NDL is dependent on electrification or another traction technology.

Combined appraisal

The introduction of a new traction technology could change the case for higher -frequency or longer-distance services on the NDL and vice versa. A combined appraisal therefore ensures that decisions made now do not preclude long-term ambitions for improved connectivity on the NDL.



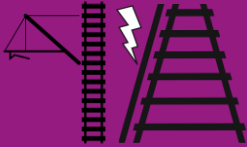


Decarbonisation appraisal inputs



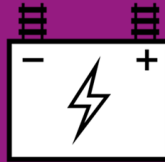
This appraisal informs industry advice on the use of different traction technologies on the NDL, using the 2tph 2023 timetable as a base.

Core Options



Electrification – DC (third rail) infill would be operationally simpler, but as the appraisal is based on a wide capital cost range it does not distinguish between AC (overhead wires) or DC.

Battery – a proven option for short journeys away from electrified track, as is the case on the NDL. The appraisal does not assume a particular battery design, define a charging approach, or distinguish between AC or DC power supply.



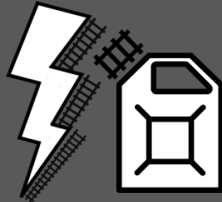
Capital costs

Electrification: a low, medium and high estimate was used, reflecting uncertainty about cost at this early stage of development.



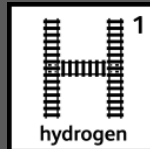
Battery: the appraisal assumed that battery would not require infrastructure investment, but this is a risk and would require development work to confirm. A cost sensitivity scenario has therefore been included to test the robustness of the case.

Other Options



Diesel-electric – multi-mode trains were not examined as a core scenario, as they would not fully remove diesel emissions. Funders might consider this as an interim solution if the preferred solution were not affordable.

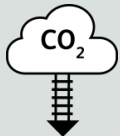
Hydrogen – technology has been excluded due to high operating costs. As the gaps in electrification are relatively short, battery is a more credible self-powered traction option.



Operational costs

- Used Department for Transport averaged data for leasing and wider operational costs, reviewed by operators.
- 3rd generation diesel was used as a theoretical baseline for comparison, as older and cheaper units like the Class 165/166s (2nd generation) will be unavailable. There could be a risk in securing 3rd generation diesel units due to national demands, which would further improve the comparative case for the options below.
- Battery trains and EMUs were assumed to have similar operational costs, excluding leasing. GBR-TT provided conservative assumptions for battery train lease costs, which could be improved on by the market.
- Fleet reliability was assumed to differ by technology, with cost adjustments applied.





Decarbonisation outputs

The results of the decarbonisation appraisal are high-level but indicate the **potential value for money (VfM)** of traction technology options on the NDL.



Electrification economic case

- The electrification option achieved an indicative **'very poor'** VfM rating across all cost scenarios.
- Electric rolling stock would deliver ongoing operational savings from lower leasing and maintenance costs.
- However, the small size of the NDL fleet, relatively low mileage, and the high number of single-track kilometres to electrify with unavoidable disruption, means benefits are heavily offset by costs.
- Even if ambitious costs of £0.8 million per single track kilometre (2024 prices) could be achieved, this would still only result in a **'poor'** VfM rating.



Battery economic case

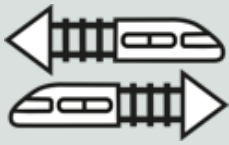
- The battery option could potentially achieve a **'very high'** VfM rating, giving this option the strongest indicative case.
- The cost increase relative to future diesel was small, alongside delivering the same carbon and similar operational benefits as electrification.
- This case has a level of uncertainty, as operational costs are unknown, and further development is required to confirm infrastructure requirements.
- Further benefits may be secured in a rolling stock procurement strategy that are not captured here.
- The analysis estimates that £27 million (2024 prices) could be incurred on capital expenditure before the option became **'poor'** VfM.

Strategic benefits of traction technologies

- Electric rolling stock could allow integration with other fleets in the region, reducing industry operational costs. For example, because fewer spare units may be required overall.
- A sensitivity found that removing one unit on the NDL whilst maintaining the current timetable would bring benefits, but the VfM for electrification would remain **'very poor'**.
- Using electric rolling stock could also facilitate journey time reductions on the NDL due to faster acceleration times, particularly for stopping services.
- A five-minute time reduction sensitivity for electrification still achieved **'very poor'** VfM.
- However, depending on technology decisions made elsewhere, there could still be integration options with battery or bi-mode fleets; development work could also demonstrate journey time savings with either solution.

Conclusions

- Battery is an operationally viable option and could deliver very high VfM, subject to confirming infrastructure requirements. It could also secure strategic benefits for the NDL.
- Full electrification infill is unlikely to offer VfM or be affordable in the medium-term.
- The strategic benefits associated with electrification could be realised with another credible technology solution, meaning electrification is also not a strategic priority.
- Diesel-electric bi-modes were also examined as a sensitivity. These could deliver VfM and reduce carbon emissions - but would not deliver full decarbonisation. Moreover, battery had a stronger potential case than bi-modes and would deliver full decarbonisation, making this the preferred technology option.
- Depending on traction technology decisions made in the wider region, funders may also consider resourcing efficiencies as part of the rolling stock procurement process.



Service enhancement appraisal inputs



The study examined the case to better utilise the orbital corridor and encourage modal shift through higher-frequency and longer-distance regional passenger services across the NDL. This is to see if there is **any case to influence rolling stock decisions**.

The study examined the following service enhancement scenarios against a baseline of 2tph between Reading and Gatwick Airport (December 2023 timetable).

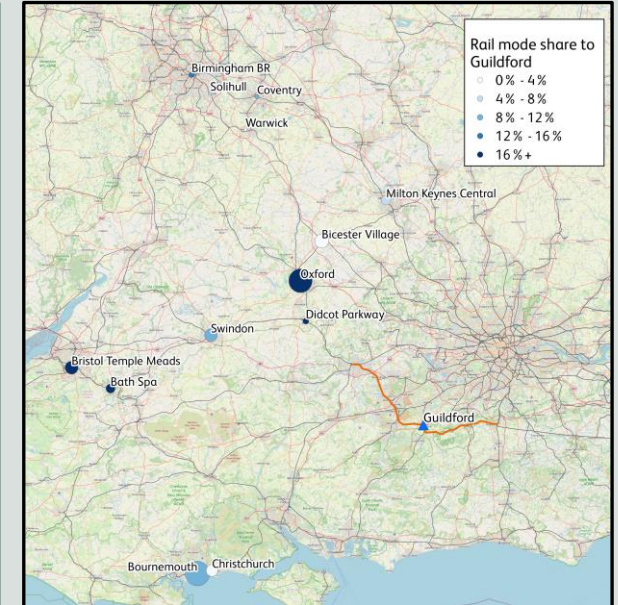
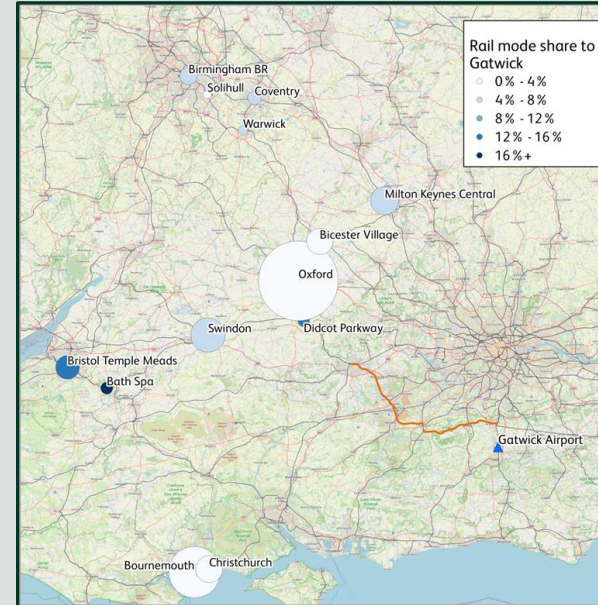
- 1) **3tph timetable** – higher frequency and improved journey times to Gatwick
- 2) **Oxford to Gatwick** – extending a direct NDL train onwards to Oxford
- 3) **Reading to Brighton** – extending a direct NDL train onwards to Brighton
- 4) **Reading to Portsmouth** – running an additional train between Reading and Guildford on the NDL and onwards to Portsmouth.

The study used Mobile Network Data (MND) to prioritise long-distance options.



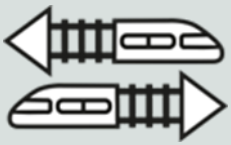
- MND uses anonymous phone data to infer start to end journeys and the transport mode used.
- MND outputs were not used in the appraisal, just to understand the relative demand between locations and mode share (see diagram, right).
- This information was used to prioritise credible options with high potential for modal shift today.
- There may be other options for the NDL in future that are not examined here, including national passenger and freight. This is discussed in the **combined analysis**.

Scenario	Number of units assumed
December 23 (2tph) timetable	7 units
3tph proposal (2020)	+3 (10 units)
Oxford to Gatwick	+3 (10 units)
Reading to Brighton	+2 (9 units)
Reading to Portsmouth	+4 (11 units)



The MND maps above show the market to Gatwick Airport (left) and to Guildford (right) from the west, and the rail mode share today with current service levels.

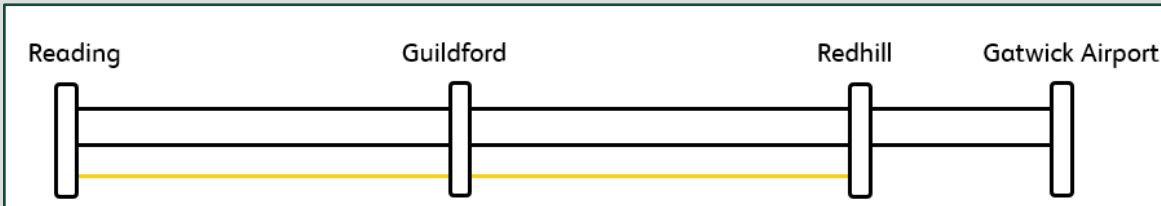
Additional rolling stock would be required relative to a 2tph timetable. The rolling stock requirement assumptions (see table, left) were made in collaboration with operators, who also advised on the potential staffing requirements.



Timetable inputs

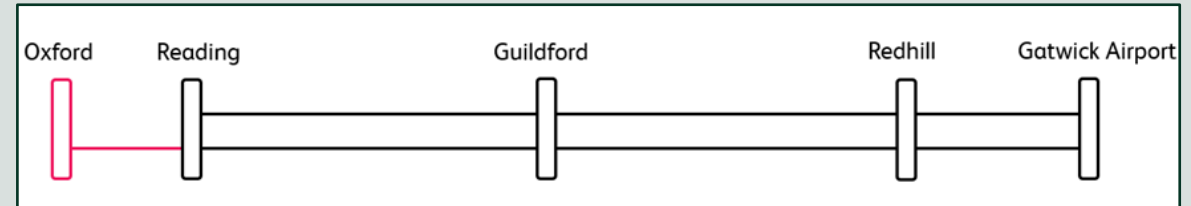


A baseline of 2tph between Reading and Gatwick Airport was assumed (black), with timetable inputs building on this baseline. The study also assumed that longer-distance options would extend an existing GWR train path to simplify outputs; a future service could also consider a combination of higher-frequency and longer-distance options.



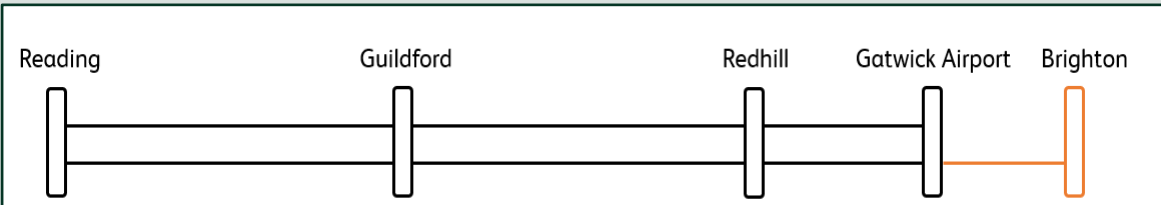
Scenario 1: 3tph; faster North Downs services

The study uses the 2020 3tph timetable proposal (yellow) to examine the case for a higher frequency of services. Unlike the 2020 proposal, this is against a baseline of 2tph to Gatwick Airport.



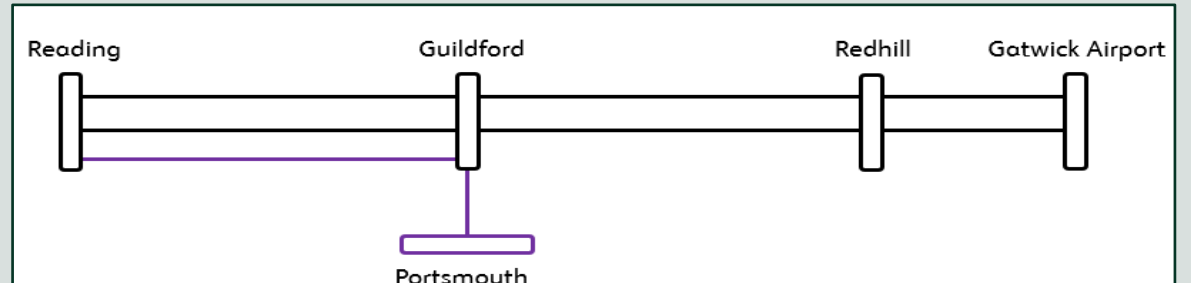
Scenario 2: Oxford to Gatwick

The December 2023 timetable was extended to also call at Didcot Parkway and Oxford (pink). No changes were assumed to the NDL timetable.



Scenario 3: Reading to Brighton

The December 2023 timetable was extended to also call at Haywards Heath, Burgess Hill and Brighton (orange). No changes were assumed to the NDL timetable.



Scenario 4: Reading to Portsmouth

A train calling at the main stations between Portsmouth Harbour and Guildford was planned in (purple), running in addition to the NDL 2023 timetable towards Reading. No journey time benefits have been assumed for Gatwick services in this scenario.





Appraisal outputs

Scenario 1 represented *marginal value for money* but could deliver *strategic priorities*.

Scenario 1 3tph; faster North Downs services

Showed the case for introducing a higher-frequency service, with stations between Reading, Wokingham and Guildford, and between Dorking and Reigate, particularly benefiting. Faster journeys from Reading to Gatwick also brought some additional benefits beyond the 2tph solution introduced in 2023.

However, the estimated operational cost increase from additional rolling stock currently offsets the benefits.

Scenario 2 Oxford to Gatwick

Delivered significant journey time savings from Oxford to Gatwick but from a low base of rail demand, meaning benefits were insufficient against additional operational cost. Benefits were also largely due to additional connectivity between Reading and Oxford.

Scenario 3 Reading to Brighton

Delivered journey time benefits between Brighton and Redhill / Guildford / Reading. This also supported onward connections, improving links between Brighton and Bristol / Cardiff. This option had the strongest case of options examined, but was still marginal due to the estimated increase in operational cost.

Scenario 4 Reading to Portsmouth

Improved connectivity between Reading and Portsmouth but benefits were significantly offset by the increased operational cost from the high number of additional units required. The option also showed the benefits of an increased frequency between Reading and Guildford.

These outputs can inform decisions taken for fleet procurement and long-term planning for the ND. The **combined appraisal** then explores whether improved connectivity on the ND is dependent on electrification.

Outputs reflection

- Scenario 1 demonstrated that higher-frequency services and faster journey times could secure modal shift. The benefits of Scenarios 1&4 suggests that a Reading to Guildford shuttle could encourage modal shift, potentially with a lower number of units compared to Scenario 1 in full.
- Some of the benefits of regional options (Scenarios 2-4) could be delivered by increased service levels on e.g. Great Western Main Line, and through interchange improvements. Similarly, journey time benefits could be realised with a new traction technology and/or through efficient infrastructure decisions to realise modest line-speed increases.
- Scenario 1 is operationally credible within the existing timetable. The regional options would involve additional services on routes which have capacity and performance challenges at the current level of service. Rolling stock replacement should consider the case for a larger fleet to allow for a higher frequency service in the future.
- There is no strong case for services west of Reading today, suggesting that ND rolling stock would not have to be AC capable as a core requirement.

GWR service priorities

- GWR and Gatwick Airport are developing a case for overnight services to connect with the 40 % of flights that take off outside of current operating hours.
- They retain the ambition to introduce a 3tph service between Reading and Guildford to deliver modal shift to rail, subject to addressing affordability and rolling stock challenges.
- They also aim to improve the onboard passenger experience through replacing the fleet and improving performance.



Combined appraisal

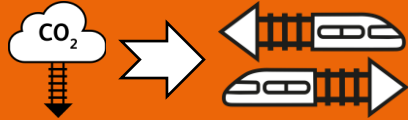


A combined appraisal ensures that decisions made now on **traction technology do not preclude improved connectivity** on the NDL.



If service changes had already been introduced would the case for electrification change, and could it therefore alter the decarbonisation recommendations?

- Increased diesel miles compared to the baseline across scenarios meant that the case for decarbonisation improved for all technologies.
- An increase in the fleet size and mileage across options meant that greater benefits were felt from electric rolling stock, which has the best operational savings.
- However, none of the service scenarios examined substantially changed the case for electrification.



If the route was already electrified would the case for new services improve? And would this therefore influence the decarbonisation recommendations?

- Sensitivities including fleet efficiencies and journey time savings were not applied, meaning the benefits delivered by each service did not change.
- Costs were reduced across all scenarios compared with diesel.
- However, all the cases for new services remained marginal – only scenario 3 moved from an indicative 'very low' up to 'low' VfM.



Photo taken by Network Rail at West Ealing, June 2024

GWR is conducting a fast-charge battery trial on the Greenford branch line in 2024.

Network Rail will continue to work with operators to support new traction technology proposals, including for the North Downs Line.

The combined appraisal suggests that traction power choices are independent of any strategic service choices. A rolling stock technology decision can be made for the 2030s without full in-fill electrification being progressed, as traction power choices did not materially affect the case for new services and vice versa.

Should a new service be proposed in future then this could change the case for electrification. For example, if a national passenger or freight service was required to run across the NDL. However, the strategic objectives for the route today do not require electrification with fixed infrastructure.

Rolling stock procurement processes should consider the strategic case to increase journey frequency to facilitate modal shift, assuming the affordability challenge can be overcome. Consideration should also be given to any potential resourcing efficiencies.



Conclusions and next steps



Reigate station - view of the DC rail, 2023 (NR)



Two GWR services and an SWR service at Reading station, 2023 (NR)



Merseyrail Battery powered trains at Headbolt Lane station, 2023 (LCRCA)

Decarbonisation

- Battery trains are a credible option and could deliver high value for money, subject to confirmation of any infrastructure requirements.
- Full electrification is unlikely to be value for money, a strategic priority, or affordable in the medium-term.
- Interim solutions such as diesel-electric trains have a weaker case than battery but could deliver value for money and reduce carbon emissions.
- Battery or diesel-electric trains both have potential to deliver strategic benefits such as journey time savings.
- Resourcing efficiencies may emerge as traction technology decisions are taken for the wider region.

Future services

- Traction power choices did not materially affect the case for new services and vice versa, and so decisions can be made independently of future service ambitions.
- No extended or enhanced service options had a strong economic case due to higher operating costs. However, a higher frequency service will be important for realising modal shift, if the affordability challenge is overcome.
- There are also other ways to deliver journey time benefits on the route, potentially including improvements from battery or bi-mode rolling stock, but also through making efficient infrastructure decisions and improving interchange.

Next steps

- GWR and NR are working on options to deploy battery-electric units to the route, which includes coming to a common understanding on infrastructure requirements.
- While a battery solution would be optimal, DC-diesel also remains a proven solution for the route and the 'do minimum' as the Class 165/66s need to be replaced.
- Industry will continue to make the case for modal shift. This could be enabled through new trains and additional services between Reading and Guildford, a new traction technology and/or efficient infrastructure decisions.
- The procurement process should consider the level of service for the route, to ensure that the future service levels and capacity requirements are reflected in the fleet ordered.



Stakeholder engagement



- GWR and Network Rail are publishing this industry advice jointly and have used a consultative approach.
- Stakeholders reviewed the study proposal, appraisal options and assumptions, and have endorsed the conclusions.
- It was agreed that the study would not make recommendations on detailed design for rolling stock or on procurement strategies.
- This gives the direction of travel for proposals made for the 2030s and informs long-term planning.
- If you have any questions, please contact South East Strategic Planning at: sestrategicplanning@networkrail.co.uk
- Or speak with Southern Region Public Affairs: southernregionstakeholders@networkrail.co.uk

