

Rail Carbon Accounting Framework

Methods for setting targets and calculating carbon reductions

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Glossary

RCAF Term	Definition
Activity data	Any data that measures or helps measure the level of an activity that results in carbon emissions. For example, tonnes of fuel used, kilometres travelled, kilowatt hours of electricity used.
Air quality damage cost	The estimated monetary value of the harm caused by air pollution to human health, the environment, and the economy.
Base year (carbon target)	The specific year against which future GHG emissions are compared to measure progress toward decarbonisation goals.
Base year (price and discount)	The specific year to which all monetary values—costs and benefits—are adjusted to ensure consistency in economic appraisal.
BEMU	Battery electric multiple unit
BCR	Benefit-cost ratio
Carbon dioxide equivalent	The unit of measurement used to indicate the global warming potential different greenhouse gases, relative to the global warming potential of carbon dioxide CO ₂ e
Commitment period	The length of time a target will continue to be met.
Decarbonisation action	Any specific measure, intervention or investment undertaken by a rail organisation to reduce GHG emissions from its operations or value chain.
Deflator	An index used to adjust nominal monetary values to real terms by removing the effects of inflation.
Emission factor	A factor that estimates the total emissions arising from a single unit of activity (per tonne of fuel consumed, per kilogram of product produced, for example), expressed in carbon dioxide equivalent.
EMU	Electric multiple unit
Environmental Performance Declaration (EPD)	A document that sets out the environmental impact of a product, calculated following certain standards (most common standards are EN 15804 and ISO 14025). From a GHG perspective, this document provides information on the products embodied emissions, as well as the likely emissions from use and disposal.
Financial control	The ability of an organisation to direct the financial and operating policies of an operation with a view to gaining economic benefits from its activities
Freight operating company (FOC)	A business operating freight trains and providing rail freight services
GHG	Greenhouse Gas. A gas that contributes to global heating when released into the atmosphere. There are six such gases covered by the UNFCCC/Kyoto Protocol: carbon dioxide (CO ₂), methane (CH ₄), nitrous oxide

	(N ₂ O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF ₆), and nitrogen trifluoride (NF ₃).
GHG Protocol Corporate Standard	The GHG Protocol Corporate Accounting and Reporting Standard provides requirements and guidance for companies and other organizations preparing a corporate-level GHG emissions inventory.
Green Book	HM Treasury's central guidance on how to appraise policies, programmes, and projects. It provides a framework for evaluating the costs and benefits of government interventions, including environmental and carbon-related impacts.
HVO	Hydrotreated vegetable oil
Influence	The ability of an organisation to influence the operating policies and practices of a third-party and its emissions.
Infrastructure managers	Organisations that operate rail infrastructure.
Magenta Book	HM Treasury's official guidance on policy evaluation. It provides a comprehensive framework for designing, managing, and using evaluation before, during, and after policy implementation.
Non-traction energy	Energy (fuels and electricity) used to power all other assets related to rail operations other than traction energy powering rolling stock. It includes buildings (stations, depots and offices), road vehicles and mobile machinery and plant.
Operational control	The authority of an organisation to introduce and implement operating policies over an asset, facility or other operation. Operational control means the company has the ability to direct the financial and operating policies to ensure that greenhouse gas reduction strategies are implemented.
Organisational boundary	The boundary that delineates all operations controlled by the organisation, this means all operations the organisation has operational control over are said to fall within the organisational boundary.
Passenger rail operations	Operation of trains to transport passengers. These activities are presently carried out by train operating companies.
Policy Procurement Note (PPN) 06/21	A UK Government policy that mandates carbon reduction plans for suppliers bidding on major government contracts.
Rail infrastructure	The structures, networks, tracks, electrification systems and supporting facilities that allow for the operation of passenger and freight rolling stock on the British rail network.
Rail organisation	A company or organisation providing services primarily involved with the provision of passenger or freight rail services, rolling stock companies, or operation and maintenance of railway infrastructure.
Rolling stock company (ROSCO)	Rolling stock companies are the organisations who primarily own and maintain rolling stock/trains.

Scope 1 emissions	An organisation's direct GHG emissions.
Scope 2 emissions	Indirect emissions arising from the generation of electricity, heating and steam purchased for the organisation's own consumption.
Scope 3 emissions	An organisation's indirect emissions, excluding those in scope 2
Traction energy	Energy (fuels and electricity) used to power trains (for both passenger and freight train movement).
Train operating company (TOC)	Organisations which operate passenger rail services. TOCs may operate under a franchise agreement or as an open access operator.
Transport Analysis Guidance (TAG)	DfT's official guidance for appraising transport projects and policies. It provides a consistent framework for assessing the economic, environmental and social impacts of transport interventions.
Well-To-Tank (WTT)	Emissions associated with the extraction, refining, processing and the transport/distribution of primary fuels
Well-To-Wheel (WTW)	Emissions associated with the full life cycle of a fuel, including extraction, refining, processing and transport/distribution, as well as combustion of the fuel during use.

1 Introduction

1.1 Structure of Rail Carbon Accounting Framework

This Rail Carbon Accounting Framework (RCAF) sets out requirements and recommendations for calculating, sharing and reporting carbon data in the rail sector, and consists of seven documents as described in Table 1.

Table 1 Structure of RCAF

Document name	Purpose	Explanation
General Approach to Carbon Accounting	General method	Introduction and overview of RCAF, applicable to all rail operations and organisations
Carbon Accounting Method for Passenger Rail Operations	Specific method	Specific requirements for annual carbon footprints and guidance on how to meet those requirements, for passenger rail operations
Carbon Accounting Method for Rail Freight Operations	Specific method	Specific requirements for annual carbon footprints and guidance on how to meet those requirements, for rail freight operations
Carbon Accounting Method for Rolling Stock Organisations	Specific method	Specific requirements for annual carbon footprints and guidance on how to meet those requirements, for rolling stock organisations
Carbon Accounting Method for Rail Infrastructure Management	Specific method	Specific requirements for annual carbon footprints and guidance on how to meet those requirements, for infrastructure management
Methods for setting targets and calculating carbon reductions (this document)	Calculation method	Guidance on target setting and decarbonisation, applicable to all rail operations and organisations
Carbon accounting supplementary information	Supplementary Information	Background and additional technical information to support organisations in completing their organisational carbon assessments

Further introduction to RCAF is provided in Section 1 of **General Approach to Carbon Accounting**.

1.2 Purpose of this guidance

The focus of this guidance document is to provide support to rail sector organisations in relation to planning for and delivering decarbonisation. This document builds upon the **General Approach to Carbon Accounting** and **Carbon Accounting Method** documents. Those documents focus on establishing and reporting a rail sector organisation's carbon footprint that is consistent and coherent, whereas this guidance focuses on the forward-looking aspects of decarbonisation, especially on tractable target setting and then planning and developing defensible decarbonisation plans and investment decisions.

1.2.1 Structure of this guidance

This document has two parts:

Part one provides guidance for rail organisations on setting targets and building decarbonisation plans:

Section 2 – Targets and decarbonisation overview

Section 3 – Target setting process

Section 4 - Target setting under the Science Based Targets Initiative (SBTi) and Policy Procurement Note (PPN) 06/21

Section 5 - Decarbonisation planning

Part two contains additional information and resources to support the rail industry in decarbonisation, and to provide context for individual rail organisations on the interaction of different organisations in planning and funding major decarbonisation projects:

Section 6 - Understanding the rail decarbonisation context

Section 7 - Information to support decarbonisation investment decisions

Section 8 – Further resources and illustrative examples

Part one

2 Targets and decarbonisation

A carbon reduction target is a quantified reduction in annual carbon emissions that the organisation aims to achieve by a certain future date.

Organisations choose to set reduction targets for a number of reasons, including minimising risk, improving green credentials, energy and cost savings, complying with legislation, and delivering on corporate responsibility. Setting targets will enable rail organisations to meet the range of ambitions identified in the Sustainable Rail Blueprint¹ that collectively will enable the rail industry to make a substantial contribution towards achieving the UK's net zero commitment.

Different targets can be set based on the level of climate ambition. An achievable target can be set based on a set of planned decarbonisation measures and the predicted emissions reductions from the cumulative impact of those measures. Alternatively, an organisation may set a stretch target, with no set path in place to achieve it, in order to drive ambition and innovation within the organisation. Stretch targets can be risky, however, as they may fail without internal frameworks and governance in place to support their success. Many organisations may have high climate ambitions, but these should be realised via realistic and quantified carbon reduction targets.

Target values can be arrived at in three ways:

- A target(s) can be set based on the estimated emissions reductions of the organisation's decarbonisation plan.
- A decarbonisation plan can be developed to hit a target(s) based on the organisation's climate ambition.
- The target and decarbonisation plan can be developed iteratively and in tandem, with one feeding into the other as the target and plan are finalised.

Targets may also be imposed externally, for example by a governing organisation, public body, or through legislation. Organisations may choose to publicly commit to the target(s) they set, and may strengthen that public commitment through a voluntary accreditation scheme, such as the Science Based Targets Initiative (SBTi).

Organisations may choose a combination of internal and external targets, as well as planned targets and stretch targets. Each target serves a different purpose within the organisation, and not all targets need to be developed or planned with the same level of rigour.

This **Methods for setting targets and calculating carbon reduction** assumes the organisation is wanting to set a quantified, achievable target based on the predicted outcome of a decarbonisation plan, built around

¹ <https://www.rssb.co.uk/sustainability/sustainable-rail-blueprint>

implementable reduction measures. Organisations wanting to set a target under SBTi should see Section 4 of this document, or directly consult [SBTi guidance](#).

3 Target setting process

There are three common target setting frameworks an organisation in the GB rail industry can use to set carbon emission reduction targets:

- The GHG Protocol Corporate Standard
- The Science Based Targets Initiative (SBTi)
- Policy Procurement Note (PPN) 06/21 Carbon Reduction Plans.

It is possible to align targets across all three of these frameworks and targets need not be mutually exclusive. Many rail sector organisations may already have established targets, either using one of these frameworks, or developed independently for internal purposes. It is important that organisations first develop a robust GHG Protocol-aligned carbon footprint following guidance provided in the **General Approach to Carbon Accounting** and **Carbon Accounting Method** documents from which targets and decarbonisation trajectories can be developed and performance tracked.

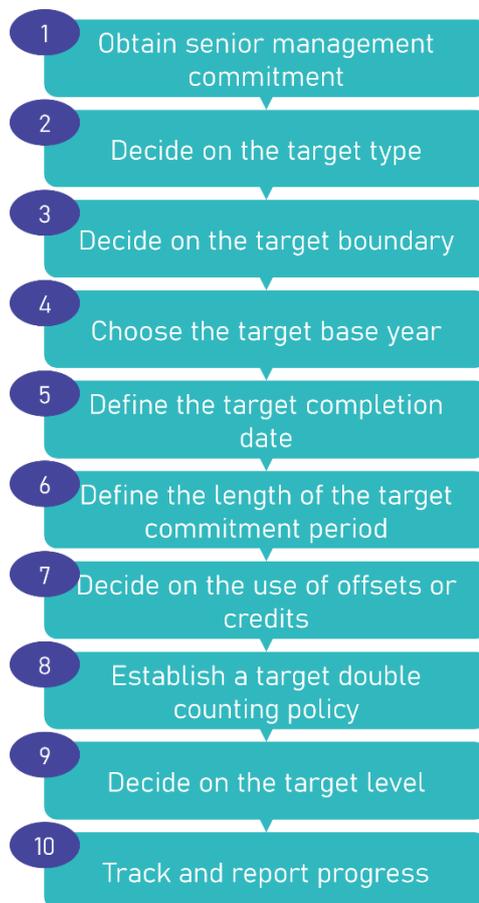
Within the GB rail industry, there are a number of other specific frameworks relating to project-level target setting. For example, the use of PAS 2080² for infrastructure construction or the National Calculation Methodology³ for new buildings. This document provides the overarching framework that draws together sectoral target setting.

This RCAF decarbonisation guidance sets out the target setting process for GB rail industry organisations following the process described in the *GHG Protocol Corporate Standard*. The step-by-step process is tailored to GB rail organisations. Information on setting targets following SBTi and PPN is available in Section 4.

² <https://www.bsigroup.com/en-GB/insights-and-media/insights/brochures/pas-2080-carbon-management-in-infrastructure-and-built-environment/>

³ <https://www.uk-ncm.org.uk/>

Target setting following the GHG Protocol Corporate Standard involves the following steps:



Each of these steps, and the requirements and relevance for rail industry organisations, are detailed in Sections 3.1 to 3.10 below.

3.1 Obtain senior management commitment

Senior management buy-in and commitment should be obtained and maintained throughout the target-setting and decarbonisation process. This is important for:

- the top-down establishment of priorities and culture within the organisation
- driving necessary changes to processes, policies, and roles and responsibilities
- securing and allocating funding, technical expertise and other internal resources to decarbonisation projects
- proactively working with DfT, HM Treasury and other rail bodies to obtain funding streams for projects that can't be directly funded by the organisation
- ensuring targets are monitored and decarbonisation plans are progressed long-term, regardless of staff changes
- long-term commitments to decarbonisation beyond the immediate financial cycle.

Due to the unique way the GB rail industry is structured, funded and regulated, and the way it is evolving with the return of passenger rail services to public ownership under Great British Railways (GBR), decarbonisation funding will be heavily controlled by DfT. Therefore it is critically important to understand government priorities and funding decisions for decarbonisation and other project investments (which will have linked benefits).

3.2 Decide on the target type

There are two types of emissions reduction targets:

- absolute targets, where the rail organisation aims to reduce its total emissions
- Intensity targets, where the rail organisation aims to reduce its emissions per unit of service provided.

An *absolute* reduction target motivates the rail organisation to reduce its total emissions. If the organisation undergoes a restructure or other significant change, the base year may need to be recalculated to ensure the target is still appropriate (see Section 3.4.2 on recalculating the base year).

An *intensity-based* reduction target motivates the rail organisation to reduce its emissions on a per-unit basis. This allows absolute emissions to align and track other KPI's for the rail organisation. For example, a TOC can aim to reduce its emissions per passenger kilometre, aligning to user numbers on the network over time.

Guidance on developing suitable carbon intensity metrics is provided for rail organisations in the relevant **Carbon Accounting Method** documents.

It is recommended that rail organisations consider an intensity target in addition to absolute targets (as defined in Table 2 of Section 3.3) as this allows flexibility to track decarbonisation performance independently of growth or contraction in the rail services provided.

Example: A passenger rail operator is adding additional services to its schedule due to high passenger demand. This would result in an increase in absolute emissions from fuel and energy consumed in operating the additional services. However, when normalised against a carbon intensity of passenger km travelled, emissions may reduce due to the additional passengers transported and potential energy efficiency improvements.

3.3 Decide on the target boundary

The target boundary sets out which emission sources should be included in the emissions reduction targets. Table 2 sets out what the target boundaries should be for rail organisations. The emissions boundaries should be aligned to those defined in the **Carbon Accounting Method** documents.

Table 2 Target boundaries

Rail organisation	Target name	Boundary
<i>Absolute targets</i>		

All rail organisations	Scope 1 and 2	All scope 1 and 2 emissions reported as per the Carbon Accounting Method documents
All rail organisations	Scope 3	All scope 3 emissions reported as per the Carbon Accounting Method documents
<i>Intensity-based Targets</i>		
Passenger rail organisations	Emissions per passenger kilometre	<i>Scope 1 and 2</i> boundary, as defined in Section 6.1 of the Carbon Accounting Method for Passenger Rail Operations
Rail freight organisations	Emissions per tonne kilometre	<i>Scope 1 and 2</i> boundary, as defined in Section 6.1 of the Carbon Accounting Method for Rail Freight Operations
Rolling stock organisations	Emissions per vehicle kilometre, OR Emissions per rail seat kilometre, OR Emissions per passenger kilometre	<i>All scopes</i> boundary, as defined in Section 6.1 of the Carbon Accounting Method for Rolling Stock Organisations
Infrastructure managers	Emissions per single track kilometre	<i>Scope 1 and 2</i> boundary, as defined in Section 6.1 of the Carbon Accounting Method for Rail Infrastructure Management

In addition to the targets set out in Table 2, rail organisations are welcome to set additional targets, with their own defined target boundaries, if desired. An example additional target might be emissions per train km that would include the impact of different rolling stock types. Target metrics can be tailored to enable comparison of particular services benchmarked against such services using other transport modes, for example small package freight.

3.4 Choose the target base year

A base year⁴ defines the emissions level the target is relative to.

Rail organisations should use **Carbon Accounting Method** documents to complete their carbon footprint and define a base year. For some organisations this will be the first year for which they complete a carbon footprint assessment in accordance with the relevant **Carbon Accounting Method**, although for others the base year may be different:

- Organisations with a well-developed carbon footprint, which is already well aligned to emissions boundaries defined in the relevant **Carbon Accounting Method** (or can be updated to align well with the emissions boundaries defined in the relevant **Carbon Accounting Method**); or

⁴ The term ‘base year’ in the context of carbon footprints and decarbonisation should not be confused with the price and discount ‘base year’ used in the DfT TAG when comparing the benefits and costs of investment cases (see Section 7).

- When the quality of the scope 3 emission footprint obtained is insufficient for the purposes of target setting and decarbonisation planning (see Section 3.4.1)

When the base year has previously been determined, the rail organisation may either:

1. Update the base year to be the first year for which they complete a carbon footprint assessment in accordance with the relevant **Carbon Accounting Method**; or
2. Keep the previously determined base year, but assess the emissions footprint against the base year recalculation policy in Section 3.4.2.1, and recalculate the base year emissions, if necessary.

Note that organisations such as Network Rail have fixed base years, and as such base year(s) may be mandated by rail industry regulators in the future, in which case all organisations will need to comply. An example of this would be to align the industry base year to the start or end of the 5-year control period cycle.

Example target: TOC A has set a scope 1 and 2 emissions reduction target defined as a reduction in absolute Scope 1 and 2 emissions of 60% by 2035, relative to a 2025 base year.

3.4.1 Scope 3 data quality and absolute target base year setting

When an organisation initially calculates its carbon footprint, it may find that the scope 3 emissions are of insufficient quality to set meaningful decarbonisation targets. For example, if the majority of scope 3 emissions are calculated using spend-based data and spend-based emission factors, decarbonisation targets cannot be meaningfully set and tracked. This is because the major variable driving the emission outcome will be the influence of financial variables (inflation, commodity prices, cost of capital etc), not the carbon intensity of the product or service being monitored.

When the scope 3 emission footprint is of insufficient quality, the rail organisation should:

- For scope 1 and 2 absolute and intensity-based targets:
 - a. Set the base year as per Section 3.4 above.
- For a scope 3 absolute target, the organisation may either:
 - a. Set the base year as per Section 3.4 above regardless of quality, but recalculate the base year emissions in a future year, once the data quality is sufficient (see Section 3.4.2); or
 - b. Wait until the emissions footprint is of sufficient quality, before setting a base year. Note that this option is only permitted for a scope 3 absolute target.

Note that this means that an organisation may have different base years for its scope 1 and 2 absolute target, and for its scope 3 absolute target.

The focus of individual rail organisations should be on setting robust and achievable targets for the scope 1 and 2 emissions that are more directly within an organisations control and influence, and setting

decarbonisation plans to support these targets. Scope 3 targets may take a lower priority, but should as a minimum be aligned to the Government's net zero 2050 target.

A rail organisation's scope 3 emissions footprint may be considered of *insufficient quality* for absolute scope 3 target setting if more than 50% of its scope 3 emissions data are of Tier 3 or lower, as per the scope 3 data hierarchy set out in the **Carbon Accounting Method** documents.

3.4.2 Recalculating the base year

Base year emissions may need to be recalculated to reflect changes in the rail organisation that mean the base year emissions are no longer a comparable or representative baseline with which to compare current emissions. These changes may be:

- structural, such as acquisitions, mergers, or divestments
- operational, such as the outsourcing or insourcing of business functions
- updates to the methodology of how emissions are calculated, including updates in data sources, data accuracy, or the inclusion or exclusion of different emission sources
- due to the identification of calculation errors in the original base year footprint.

For example, the switch by Network Rail from a fully nuclear electricity tariff for EC4T to an electricity tariff from mixed generation sources means traction electricity carbon intensity has increased from zero carbon to the grid average carbon intensity for market-based electricity emissions. This may have re-basing implications for some operators. (There would be no change if using location-based electricity carbon intensity reporting.)

Recalculation can occur via two methods:

- Measured data is available for the change in base year, and can be used to update the base year emissions estimate; or
- Measured data is not available for the change in base year, so emissions need to be estimated by using more recent data, and adjusting as necessary, for example to reflect different activity levels, different emission factors, or different operating practices.

When the base year is recalculated due to methodological changes, emissions should also be recalculated for all years from the base year to the most recent year of emissions assessment.

Organisations can assess whether recalculation is necessary by following the recalculation policy set out in Section 3.4.2.1.

When recalculation of the base year is not possible, the rail organisation may re-baseline by choosing a new base year. This may be a historic year, or the year of the most recent emissions assessment.

Note that following **Carbon Accounting Method** to calculate emissions for the first time may trigger recalculation.

Rail organisations should adopt the base year recalculation policy set out in Section 3.4.2.1.

3.4.2.1 Base year recalculation policy

This recalculation policy defines the scenarios and thresholds for recalculating base year emissions for rail industry organisations, as well as the timing of the recalculation.

Changes to base year emissions assessment may be due to:

- organisational structural changes, including acquisitions, mergers, divestments, outsourcing and insourcing
- changes in data sources, measurement and accuracy, boundary changes, and changes in methodology
- identification of calculation errors in the original base year footprint.

Base year emissions, and the emissions of all subsequent years, will be recalculated when the change, or culmination of changes, results in a variation in the base year emissions of 5% or more, for any given target boundary.

If a baseline year recalculation has been determined necessary, the timing of the recalculation will coincide with the most recent emissions assessment, so that any changes are published and communicated in conjunction with the release of the most recent emissions footprint.

If the change is less than 5%, the organisation may still choose to recalculate base year emissions. The organisation may also choose to recalculate emissions earlier than the publication of the next annual assessment of emissions data.

Note that organic growth and decline do not constitute an organisational change, and base year emissions should not be updated based on future organic changes in activity levels.

3.5 Define the target completion date

The target completion date is the year the organisation will achieve its target.

Rail organisations should as a minimum set 2050 emission reduction target completion dates for all targets to align with government targets for national emissions including the transport sector and rail industry.

In addition to the 2050 targets, rail organisations may also choose to set intermediate targets. The Sustainable Rail Blueprint lists industry milestones of 46%, 65%, 79% and 90% reductions in operational carbon by 2029, 2034, 2039 and 2044, respectively. Such aims may or may not be practical for individual rail organisations. Organisations should consider the emissions reductions they can implement and have control over as part of decarbonisation planning (see Section 5) and set targets to hold themselves accountable for what they can achieve. Part two of this document provides more commentary on target setting and decarbonisation planning.

Examples:

The electrification of 50% of TOC A's network is planned for 2038. TOC A sets an intermediate reduction target for 2039, corresponding with forecasted emissions resulting from the increased electrification.

FOC B has a decarbonisation plan that includes several planned small-scale decarbonisation investments by 2030, and a one-off large-scale investment in 2035. FOC B sets a 2030 target accounting for its planned small-scale investments and another target for 2035 which accounts for the large-scale investment. The trajectory of emissions for FOC B from its base year to 2035 would not be expected to be linear, and the targets would be set to reflect this.

3.6 Define the length of the target commitment period

The commitment period is the length of time the target will continue to be met. A single year commitment period means the organisation aims to hit the target in the target year, with no specification of any commitment beyond that timeframe.

Rail organisations should aim to commit to achievement of each target from the target date and each year thereafter.

3.7 Decide on the use of offsets, credits, or other measures

Rail organisations should not use offsets or credits to meet emission targets established under the GHG Protocol. Targets should be set to account for actual reductions in emissions only. However, results of other GHG impacts such as avoided emissions, offsets or insets can be managed and reported separately.

A combination of measures can be used to reduce carbon emissions that outside the boundary of a company's GHG emission inventory (Scope 1,2, and 3 emissions). These measures include:

1. avoided emissions (such as modal shift)
2. carbon offsets, including removals to meet SBTi obligations
3. insetting.

If implemented, quantified and reported properly in accordance with relevant best practice and standards, these measures can offer valid and important measures for reducing an organisation's GHG impact and removal offsets are an important measure in meeting SBTi obligations. They can form part of an organisation's carbon strategy, and an organisation may set targets that include these measures.

However, while carbon impacts achieved by these measures can be reported, the values should not be combined with an organisation's GHG inventory or be used to meet its emission reduction target.

Organisations should reduce their own emissions to the extent possible and apply offsets to mitigate residual emissions.

Information on offsetting and insetting is available in the **Carbon Accounting Supplementary Information**.

3.8 Establish a target double counting policy

The GHG Protocol Corporate Standard includes 'Establish a target double counting policy' as a target-setting step. This step is intended to address double counting in offsets, mainly under traded emissions scenarios. However, as emissions from GB rail are non-traded, target double counting policies are not relevant.

3.9 Decide on the target level

Deciding the actual value of the emissions reduction targets requires consideration of two aspects:

- the decarbonisation the organisation can practically achieve (established following guidance in Section 5)
- the decarbonisation required for the UK to achieve net zero emissions by 2050.

3.9.1 Target levels based on decarbonisation plan

In order to set emissions reduction targets, rail organisations should build decarbonisation plans which include a list of decarbonisation measures, their funding, implementation schedules, and predicted emissions reductions. Organisations should also take into account emission changes that will occur irrespective of decarbonisation initiatives, such as changes in service demand and changes in the emissions of purchased energy and other goods, including changes in the national electricity grid mix emissions over time.

More detail on how to develop a decarbonisation plan is provided in Section 5.

The forecasted emissions reductions set out in the organisation's decarbonisation plan can then be used to set target levels for each of the organisation's emissions targets. It should be noted that this can be an iterative process which starts with an initial target and decarbonisation plan, which is then iterated and further defined as the level of detail in the plan is built up.

Rail organisations should set targets based on projected emissions reductions applying measures and initiatives over which they have control as calculated in the organisation's decarbonisation plan.

3.9.2 Target levels to achieve net zero by 2050

Rail organisations need to be ambitious in building their decarbonisation plans and setting their emissions targets, in order for the UK to achieve net zero emissions by 2050.

The UK Climate Change Committee's (CCC) Seventh Carbon Budget sets a target emissions level for surface transport in the UK of 1.07 MtCO₂e, against a baseline 2025 value of 104 MtCO₂e⁵. Achieving this will require a mixture of sector decarbonisation and mode-shift, so that by 2050, a larger share of freight and passenger transport activities will occur using low-emissions modes, including rail transport.

⁵ The Seventh Carbon Budget - Climate Change Committee

In the 2024 financial year, rail traction emissions were 2.36 MtCO₂e⁶. To meet the 2050 CCC target, the rail industry will need to more than halve its emissions, both traction and non-traction for both operational and infrastructure/overhead emission sources, all while accommodating increased passenger and freight volumes. This reduction needs to occur at an industry-wide level. The exact reductions required by individual operators, infrastructure managers and ROSCOs will depend on various factors, which are discussed in Section 5.

Rail organisations need to be aware of the scope of decarbonisation required by the sector, but they should set their individual targets based on what is achievable for the organisation. If the emissions reductions levels predicted by the decarbonisation plan do not align with the reductions required by the sector as a whole, the organisation should reassess its decarbonisation plan, to determine if additional decarbonisation measures are possible.

Note that in addition to setting a 2050 target, the CCC Seventh Carbon Budget also sets out a pathway of emissions reductions for the surface transport sector to achieve annually. While it is important that the sector as a whole adhere to this pathway, individual rail organisations will decarbonise at different rates (see Section 4.1.2). Individual rail organisations should therefore consider their ability to hit a 2050 target that aligns with the sector's carbon budget, if they have adequate information they to consider how their emissions contribute to the sector-wide pathway when designing their organisation's decarbonisation plan.

3.10 Track and report progress

Rail organisations should monitor their progress against their targets by annually evaluating their carbon footprint following the relevant **Carbon Accounting Method**.

Once the rail organisation has set emissions reduction targets, the organisation may choose to communicate those targets and its progress towards meeting them (for example, as part of its annual emissions reporting.) Reporting and communication of emission and reduction claims should be made in alignment with relevant standards and guidance, which may include any of the following:

- ISO 14021 Environmental labels and declarations – Self declared claims
- ISO 14064
- GHG Protocol
- SBTi
- Streamlined Energy and Carbon Reporting framework (SECR)
- EU Green Claims Directive
- Corporate Sustainability Reporting Directive (CSRD)
- UK Green Claims Code (by the Competition and Markets Authority)
- Advertising Standards Authority (ASA) and Committee of Advertising Practice (CAP) guidance.

Organisations are advised to review case studies of environmental claims and consider legal advice on the wording of claims when appropriate.

⁶ Rail Environment, April 2023 to March 2024

4 Target-setting under SBTi and PPN06/21

The guidance in this document has been on setting targets as required by RCAF, following the GHG Protocol Corporate Standard. This section talks to setting targets specifically under SBTi and PPN.

4.1 Science-based targets

The Science Based Targets initiative is a voluntary carbon target setting mechanism, which requires organisations to set ambitious near-term and long-term carbon reduction targets aligned to science-based pathways to reach net zero by 2050. Although voluntary, it is a contractual requirement of some TOCs (set by DfT) to develop science-based targets for SBTi validation. Network Rail also have SBTi-validated targets.

4.1.1 Overview of SBTi required targets

Setting Science-Based Targets (SBTs) for decarbonisation in the land transport sector involves aligning emissions reductions with the level of decarbonisation required to limit global warming to well-below 2°C, preferably 1.5°C, as defined by the Paris Agreement. This involves setting two types of targets: Near-Term and Long-Term SBTs:

- **near-term SBTs** are targets over a 5–10-year timeframe.
- **net-zero (long-term) SBTs** must align with SBTi's Corporate Net-Zero Standard and include deep decarbonisation of at least 90–95% of emissions by 2050. Any residual emissions at 2050 would be neutralised through carbon removals.

Both near-term and net-zero (long-term) targets must cover at least 95% of scope 1 and 2 emissions and follow a linear trajectory with emissions reductions of at least 4.2% year-on-year.

For SBTi target setting if scope 3 emissions are less than 40% of overall emissions then no scope 3 target is required, although SBTi encourage it as best practice. If scope 3 emissions are 40% or more of overall emissions, then organisations must set one or more emission reduction targets and / or supplier / customer engagement targets that collectively cover(s) at least 67% of total scope 3 emissions in conformance with the GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard. Scope 3 target(s) only need to align with well-below 2°C pathways rather than 1.5 °C and targets achieved within 5-10 years from the date the target is submitted to the SBTi for validation. Long-term scope 3 target setting requires an increase from 67% to 90% coverage of baseline scope 3.

For the rail industry, SBTi dictates a linear trajectory of at least 4.2% reduction in emissions year-on-year, in conformity with its land transport guidance default pathway. However, a linear reduction trajectory is not mandatory in SBTi and is virtually impossible for rail passenger freight operators to achieve. The reasons for this, and a proposed solution, are set out in Sections 4.1.2 and 4.1.3 below.

4.1.2 Non-linearity in rail decarbonisation

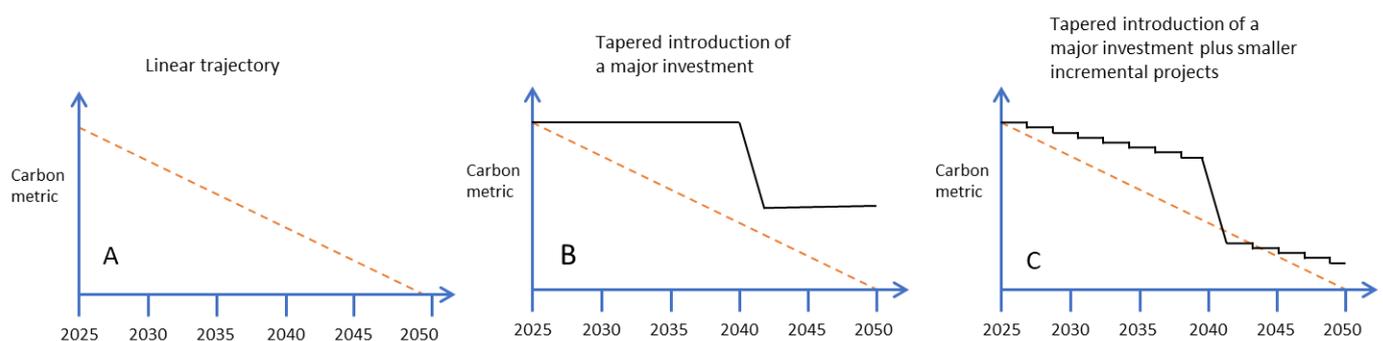
While the national trajectory to net zero may be linear overall, different sectors (and parts of sectors) will proceed at different rates, with large initial potential reductions or else large later potential reductions. This is because some measures in some sectors are easy and more cost effective to action with clear choices among the available options, while for other sectors and measures the technology is not fully mature yet. For instance, some technologies, such as solar panels (which can be installed on station or depot roofs), have already reached a sufficient level of maturity and scale to make their costs manageable and to achieve a rapid payback period.

Many rail investments are large-spend items that require government funding and therefore may not occur for a given rail organisation for a number of years. When the investment does take place, for example the electrification of a network or the replacement of a fleet, the impact on emissions is large and immediate. This ‘lumpy’, non-linear progress in rail differs from other sectors. For example, for road-based transport it is easier to achieve a linear, rolling trajectory since around a seventh of the heavily utilized HGV fleet is replaced each year.

Exactly when these stepped changes in carbon emissions occur depends on where an organisation is in the national priority order for rail investments, which will depend on the scheduling of major infrastructure improvements and/or how replacements of life-expired diesel rolling stock are handled.

Figure 1 shows a series of idealised trajectories. Plot A is a simple straight-line trajectory. Plot B shows the tapered introduction of a major investment, for example a full or partial route electrification with associated EMU or BEMU deployment. Plot C shows the addition of smaller incremental measures that are under the direct control of the organisation, and which can be implemented relatively quickly. Such ‘drip-feed’ or ‘slow-burn’ actions can ensure a slow but steady downward trajectory is achieved in the absence of large-scale initiatives that may well be outside the organisation’s control.

Figure 1 Example idealised trajectories



For most rail organisations it will not be possible to plan for a simple linear trajectory.

4.1.3 Target boundaries to achieve linear decarbonisation

As many of the large decarbonisation investments in the rail industry are outside the control of individual rail passenger and freight operators, those operators should define their target boundaries to include emission sources for which they have both operational and financial decision-making abilities over their decarbonisation. If target boundaries are set to align with operational control boundaries defined in the GHG Protocol, most TOCs and FOCs will not be able to achieve near or medium-term targets required by SBTi, as Network Rail and government have control over track electrification and the EC4T emissions intensity, rather than the TOCs and FOCs themselves.

4.1.4 Target resetting and base year recalculation under SBTi

To ensure targets remain aligned with the most recent climate science, companies are required to review if their targets continue to meet SBTi criteria, and if necessary, update and revalidate their targets every five years from the date of the original target approval.

Companies should then review their existing, approved target(s) and assess if they are affected by the base year emissions recalculation. The affected target(s) must be assessed to be in line with SBTi criteria. For example, do targets still meet the minimum ambition and coverage requirements?

- If the targets do, then the company does not need to submit for a formal target(s) update to the SBTi. In this instance if the base year remains the same, as well as the target ambition, method and target year, then the company is simply updating its base year emissions.
- If the targets do not, then the company needs to update their target(s) and revalidate. This would be subject to the latest version of the SBTi criteria at the time of submission.

SBTi encourages companies to maintain their original base year, but in some instances this may no longer be representative of current business activities, and / or historic data may not be available. If necessary, companies can select a new base year which represents current business activities and has verifiable data but will need to explain the rationale for the proposed changes. Companies should then resubmit their affected target(s) to the SBTi, as the targets have significantly changed. As non-open access TOCs are gradually nationalised and eventually transferred to GBR oversight, it is likely that GBR as the highest parent company will take over carbon reporting, resulting in the need for individual TOCs to align on a new base year to allow GBR to do the reporting.

4.2 Policy Procurement Note (PPN) 06/21

PPN06/21⁷ requires all organisations bidding for government procurement contracts to develop a Carbon Reduction Plan and carbon targets. PPN06/21 requires organisations to set a 2050 net zero target, but it is otherwise less prescriptive than SBTi in terms of nearer term targets. PPN06/21 captures some TOC owners and parent companies.

⁷ https://assets.publishing.service.gov.uk/media/6800e32d90d0846c19e287e7/2025-02-04_PPN_006_Taking_account_of_Carbon_Reduction_Plans.docx.pdf

The purpose of PPN06/21 is to align government contactors with the National net zero targets. It is only a requirement of organisations that are supporting the government on contracts greater than £5 million. All companies who operate within this framework would already have targets in place.

The process of setting targets defined in Section 3 provides an approach that aligns with the wider PPN06/21 Carbon Reduction Plan requirements.

5 Decarbonisation planning

This section sets out how to build a decarbonisation plan. It covers:

- Determining which measures and projects the organisation will undertake, and when;
- Forecasting emissions reductions over time;
- Setting target levels based on the plan; and
- Refining the plan and targets over time.

The guidance presented here is laid out in a linear series of steps, but in practice organisations will iterate on these steps as they build, refine and finalise their decarbonisation plan.

5.1 Determine decarbonisation measures

Rail organisations first need to identify potential measures that will lead to emissions reductions. For individual organisations there will be a mix of:

- Measures that are dependent on government prioritisation and funding;
- Measures that require third party buy-in or approval; and
- Measures that can be self-funded and implemented without external buy-in or approval.

A list of potential decarbonisation measures is provided in Section 5.55.5.

5.1.1 Assessing decarbonisation measure viability and cost-effectiveness

As well as emissions reductions, different measures will also have different financial, social and environmental costs and benefits. For each potential measure, the costs, financial and non-financial benefits, and potential emissions reductions should be assessed, so that the most suitable measures that will be viable to receive funding are progressed to form part of the decarbonisation plan. Part two of this document provides further information and resources to help with this process.

The exact route for determining which individual measures will form part of an organisation's plan is outside the scope of this guidance. It will involve planning and decision-making processes internal to the organisation, collaboration with government, asset owners, and other stakeholders, including as suppliers, with consideration of funding mechanisms, the likelihood of project approval, and other factors.

5.1.1.1 Marginal abatement costs

A marginal abatement cost (MAC) is the cost of reducing a unit of pollution, such as one ton of CO₂e through a particular measure. The relative costs of different measures can be compared against each other to enable assessment of the most economically efficient measure or group of measures, so forming the cornerstone of decarbonisation decision-making and multi-parametric optioneering.

Often a particular measure will have a limited scope (for example, solar panels on station roofs cannot directly address traction diesel usage) so its MAC will have a limited impact on reducing an organisations carbon

footprint. Sometimes measures can overlap with other potential measures or in other cases they can be mutually exclusive. Furthermore, for a given set of circumstances there may not be many available measures. However, the process of compiling and assessing MACs can greatly help develop understanding of effective decarbonisation strategies available to an organisation.

5.1.1.2 Marginal abatement cost curves

Marginal Abatement Cost Curves (MACCs) are a visual representation of multiple MACs that ranks carbon reduction measures by their cost-effectiveness. A MACC is relevant in situations where there is a large number of available potential options. It will rank measures in cost order, but it will not address factors such as tractability of implementation (including what is under the control of an organisation). For certain parts of an organisations' carbon footprint measures may not be applicable or measures may not be independent (i.e. they may overlap so application of MACCs should be treated carefully).

Other challenges are that a significant number of assumptions underlie MACCs and these may not be well documented, and that a MACC is focused on a single metric (typically CO₂e) and other impacts on other pollutants (such as NO_x, PM_{2.5}) are not considered.

The RSSB Project T1228, *Enabling Supply Chain Decarbonisation*, developed a comprehensive methodology for constructing MACCs to support business decision-making and long-term strategic planning. It shows the cost per tonne of CO₂e abated on the vertical axis and the potential carbon savings on the horizontal axis. This helps identify which interventions offer the best value for money. The T1228 project provides step-by-step instructions for building MACCs using carbon cost data.

MACCs can be introduced as a visual and quantitative tool to:

- Rank interventions by cost-effectiveness (£/tCO₂e);
- Highlight 'low-hanging fruit' and high-impact measures; and
- Support transparent, evidence-based investment decisions.

MACC outputs can be used to support and justify funding requests, communicate trade-offs to stakeholders, and to help align with national decarbonisation priorities. However, a challenging issue for most rail organisations will be the limited number of available decarbonisation options compared to other sectors so a comprehensive MACC analysis may not be viable in many cases.

5.2 Forecasting the decarbonisation trajectory

Once organisations have a list of decarbonisation measures, they can forecast how their emissions will change on an annual basis, based on the timing of implementing particular measures.

This sub-section provides guidance on forecasting the effect of measures on relevant carbon activity data, and on using this information to create a year-on-year emissions forecast.

Forecasting emissions requires consideration of the two components of the emissions trajectory:

- The 'Business as usual' (BAU) trajectory; and

- Emissions reductions from planned decarbonisation measures.

5.2.1 Understanding your BAU trajectory

In the absence of any decarbonisation investment, a rail organisation's emissions will nonetheless change over time. This will be due to:

- Changes in activity levels, such as changes in passenger or freight demand;
- Changes in the emissions intensity of purchased goods and energy, including changes in the emissions intensity of the electricity grid mix; and
- Baked-in changes, such as investment decisions that have already been made, where the impact is not yet fully realised.

5.2.1.1 Changes in activity levels

Changes in passenger or freight demand will impact the emissions of the organisation in ways that are likely to be non-linear. Hence the importance of assessing carbon with the appropriate metrics for example per passenger-km or per tonne-km.

The **Passenger Demand Forecasting Handbook (PDFH)**⁸ summarises three decades of research into many separate aspects of rail demand forecasting, providing guidance on aspects such as the effects of service quality, fares and external factors on rail demand.

The Handbook provides guidance on applying this understanding to the preparation of forecasts for DfT, Transport Scotland and ORR to input into DfT's Transport Analysis Guidance (TAG) for:

- investment appraisal;
- ticket pricing decisions;
- timetabling and operating decisions; and
- business planning and budgeting.

The PDFH is regularly updated, to ensure all research is both relevant and based on the latest available evidence, however for the last ~15 years it has underestimated growth in rail usage both with and without improvements in service quality^{9, 10} resulting in low estimates for increases in revenue, thus making developing viable business cases harder.

Network Rail works with industry partners to establish **long-term forecasts**¹¹ of market growth for the rail freight sector. These provide an informed picture of potential future demand, but not the full supply side economics.

⁸ <https://www.raildeliverygroup.com/pdfc/about-the-pdfh.html>

⁹ <https://assets.publishing.service.gov.uk/media/5a82d6afed915d74e6237e37/phase1-rail-demand-forecasting-estimation-study.pdf>

¹⁰ <https://assets.publishing.service.gov.uk/media/5a82d78ded915d74e6237e7c/phase2-rail-demand-forecasting-estimation-study.pdf>

¹¹ <https://www.networkrail.co.uk/industry-and-commercial/rail-freight/freight-growth/> and <https://www.networkrail.co.uk/running-the-railway/long-term-planning/>

5.2.1.2 Changes in electricity emissions intensity

Unlike other fuels, the emissions associated with a unit of grid electricity can vary greatly depending on the source of electricity generation. It is also important to distinguish between the average and (long-run) marginal electricity emissions factors. Whereas the average emissions factors should be used to account for emissions for the purposes of emissions foot printing, the marginal emissions factor should be used for analysing sustained changes in energy consumption, either increases (for example swapping to electric traction from existing diesel traction) or decreases (such as improvements in energy efficiency), for the purposes of cost-benefit analysis, including policy appraisal. Since the reduction in marginal electricity carbon intensity currently forecast in the Treasury Green Book and TAG lags the reduction in average till 2035, deferring traction decarbonisation that involves switching from diesel to electricity (including battery) may make some business case benchmarks appear better if there is a slight deferral.

The carbon intensity of the electricity depending on where the electricity is being obtained from (and the frame of reference: average or marginal discussed above).

- **Location-based emissions** are calculated using the average carbon intensity of the electricity at the point of consumption. For GB Rail organisations, this will include traction electricity and use the average intensity of the UK electricity grid for foot printing purposes or the marginal grid intensity for assessing sustained changes in electricity demand (used in Green Book and TAG business cases).
- **Market-based emissions** are calculated using carbon intensity of the specific energy contracts purchased by the organisation. For most GB Rail organisations, this will include station or depot electricity use. Market-based emissions can therefore take account of levers such as renewable energy certificates and green energy tariffs or self-generation (such as solar panels on depot or station roofs) in the assessed carbon intensity.

With the recent Network Rail move away from a fully nuclear traction electricity supply contract, it is important to understand how the average carbon intensity will evolve over time. In forecasting electricity grid changes, rail organisations should use the **Treasury Green Book**¹².

Rail organisations should nonetheless be aware that other grid emissions projections are also used by different parts of the government:

- The **Treasury Green Book** is the UK Government's official guidance on how to appraise and evaluate policies, programmes, and projects. It is issued by HM Treasury and is widely used across public sector bodies to ensure that decisions are made based on sound evidence and consistent economic principles.
- **TAG**¹³ is the UK Department for Transport's official framework for appraising transport projects and policies based on the Treasury Green Book. It provides a consistent, evidence-based approach to assessing the economic, environmental, and social impacts of transport interventions.

¹² <https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government>

¹³ <https://www.gov.uk/guidance/transport-analysis-guidance-tag>

- **Department for Energy Security and Net Zero (DESNZ) energy and emissions projections¹⁴** that analyse and project future energy use and greenhouse gas (GHG) emissions in the UK.

These curves may not align for a number of reasons including different forecasting methodologies, different timing when forecasts are updated, and different recent outturns.

. In recent years the reduction in carbon intensity in grid electricity has not been as high as expected, therefore progress against expected trajectories has not been as good as anticipated. However, for 2025 and probably 2026 and 2027 reductions are now expected to be much larger than previously forecasted. This means rail organisations will need to periodically recalculate electricity decarbonisation trajectories.

The Green Book should be used for forecasting electricity grid emissions for location-based emissions calculations. For market-based electricity emissions, rail organisations may be able to obtain forecast information from providers of their power purchase agreements (PPAs), or they can make forecasts based on planned PPA purchases.

5.2.2 Forecasting emissions reductions from planned decarbonisation measures

Decarbonisation measures primarily impact emissions by:

- Efficiency changes: a change in the energy that is required per unit of activity;
- Demand changes: an increase or decrease in passenger or freight volumes;
- Supply-chain changes: procured goods and services have lower or higher emissions; and
- Direct emissions changes: a change in the energy source required for an activity.

A given decarbonisation measure may impact absolute emissions and/or emissions intensity in one, some or all of these ways.

Example: The purchase of bi-mode rolling stock by a TOC operating on a non-electrified route will:

- Change the total energy requirements of passenger transport
- Change the energy source mix from fully diesel to a mixture of diesel and electricity
- Result in a one-off increase in scope 3 emissions from procuring the new rolling stock
- Change passenger demand, for example if the trains are quieter or have more capacity, passengers will be more likely to use the service than before, all else being equal.

Rail organisations should account for all the ways a measure will impact emissions when projecting the emissions reductions of a given decarbonisation measure.

¹⁴ <https://www.gov.uk/government/collections/energy-and-emissions-projections>

Forecasting emissions requires access to granular detail of the current activity and emission intensity, along with the use of a calculation approach that fully incorporates all the relevant drivers and mechanisms to accurately forecast the expected carbon reductions for a particular measure or item. A simple projection of a reduction in total electricity or fuel consumption will not be sufficient. Calculations will need to show the before and after volumetrics to identify the expected emissions differences that can be assigned to the particular decarbonisation action.

For instance, if new vehicles are added to an operator's fleet both the activity (number of vehicles) and emission factors will need to be accounted for. However, the calculation may be complex in that a new service pattern and/or frequency may be introduced and the new vehicles may have a lower (or higher) emissions intensity on a distance travelled basis.

If growth in traffic and/or loadings is assumed, then relevant carbon intensity metrics on a per passenger.km, train.km or vehicle.km basis will be needed.

Where accurate forecasting is required, calculations should be based on actual usage and expected specific future changes, a full bottom-up model should be used that will calculate the saved emissions in each year, and which can be easily refreshed if a different start/implementation date is chosen.

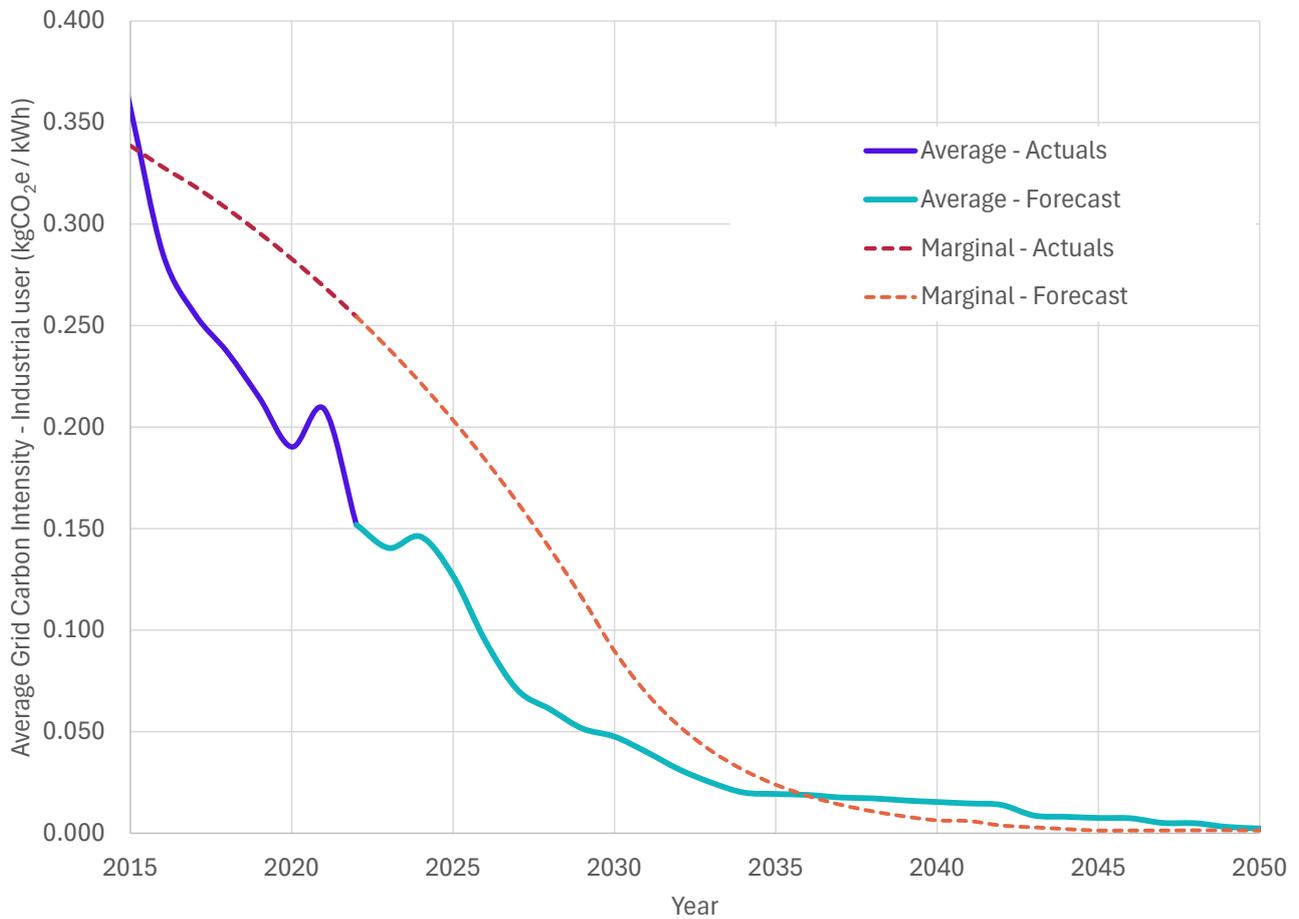
Note that detailed forecasts are not always required. 'Back of the envelope' calculations may be suitable for early assessments in the iterative process that is the development of a decarbonisation plan. The level of rigor in quantifying decarbonisation measures should be relevant to the need of that point in the decision-making process. Initially assumptions, proxy values, and estimates can be made and refined with time as more precision is required.

5.2.2.1 Electricity emissions intensity and reduction measures

It is important to distinguish between average and (long-run) marginal electricity emissions factors. *Average* emissions factors should be used to account for emissions for the purposes of emissions footprinting, and *marginal* emissions factor should be used for analysing sustained changes in energy consumption (either increases, for example swapping to electric power from existing traction diesel, or decreases, such as improvements in energy efficiency).

Figure 2 below show the Average and Long Run Marginal electricity carbon intensities used in the Treasury Green Book. Existing traction electricity use would be assessed using the Grid Average values but changes in traction electricity use (either additional through new electrification and/or introduction of battery electric multiple units (BEMUs), or reduction due to energy efficiency improvement) are assessed using Long Run Marginal carbon intensities. Before circa 2035 actual and forecast Marginal carbon intensities are noticeably higher than the Grid Average resulting in additional traction electricity usage effectively being slightly penalised in the near and mid-terms (though still substantially better than diesel usage) but is more advantageously treated in the long term.

Figure 2 Actual and forecast UK grid average and long run marginal carbon intensity (in kgCO₂e/kWh) for industrial users (for traction electricity use)



For Traction electricity usage:

Average emissions factors should be used to account for emissions for the purposes of emissions footprinting.

Marginal emissions factor should be used for analysing sustained changes in energy consumption such a switch from diesel to electric traction power.

5.2.3 Building an emissions forecast

Once the rail organisation has an understanding of the business-as-usual emissions trajectory, and the projected emissions reductions of each planned decarbonisation measure, it can build the emissions forecast. This is a projection of the total emissions of the organisation on a year-by-year basis, taking into account all forecasting business activities, and changes in emissions intensities of purchased goods, services and energy.

5.3 Set decarbonisation target levels

The rail organisation should set decarbonisation targets based on the projected emissions reductions identified in the decarbonisation plan. This can include predicted emissions reductions at the 2050 endpoint for the targets as described in Table 2 of this guidance, as well as any intermediate targets the organisation may choose to set. These could be annual, or following significant investment milestones, for example.

5.4 Refine plan and targets over time

The decarbonisation plan is a living document, and the plan and targets set based on the plan will evolve over time. This can be due to:

- Government policy;
- Updates in predicted emissions intensities, for example of the electricity grid mix;
-
- Technology innovation and maturity;
- Investment case and capital availability; and
- Stakeholders' needs.

As a result, rail organisations should regularly reassess their decarbonisation plan and emissions targets. This could be on an annual basis to coincide with annual emissions reporting, at another frequency, or on an ad-hoc basis.

The decarbonisation plan should be transparent and fully understood by the organisation so it can be easily reassessed, and its associated emissions targets can be easily recalculated and updated. This is especially important for when recalculating the base year becomes necessary (see Section 3.4.2). The underlying data and calculations used to set emissions targets should be available to the rail organisation and not dependent on third-party or proprietary datasets or models.

Decarbonisation plans and associated emissions targets should be fully understood and easily updateable by a rail organisation.

When targets are reset, rail organisations should communicate both the old and the new target, and the reasons for the change in target, in their annual carbon report.

5.5 Potential decarbonisation measures

A list of potential decarbonisation measures available to different rail industry organisations is provided in Table 3. This list is not exhaustive, but provides rail organisations with project ideas, as well as an indication of their potential impact on emissions levels and ease of implementation (which encompasses complexity and the magnitude of investment needed). Indicative emissions reductions figures for particular measures are based on expert knowledge and discussion with key industry stakeholders during this and other projects. The table also indicates whether the involvement or approval of other organisations may be needed. For example,

enhanced engagement and coordination between Network Rail and TOC leaseholders will be needed regarding roof access to install solar panels at stations and depots. Other measures may be under the direct, sole control of the organisation.

The measures within Table 3 fit within two main themes for each type of rail organisation:

- First, reducing fuel and energy consumption, including implementing energy efficiency measures; and
- Second, measures to reduce the carbon intensity of the energy that is consumed.

For infrastructure managers, addressing embodied carbon will be another main theme. The feasibility of implementing particular decarbonisation measures will require careful, detailed consideration in conjunction with engineering and operations colleagues.

Quantification of the overall net reduction in carbon emissions, especially for investment decisions, may require detailed calculations taking into account multiple factors affecting a specific measure. For instance, the general efficiency of new rolling stock may be worse for new rolling stock than the older rolling stock they replace. New trains are typically heavier (because of crash protection requirements) and with higher hotel loads (such as air conditioning, power sockets). Conversely, new rolling stock could be more energy efficient overall with more efficient transmission and more effective auxiliary load shedding during prolonged stationary periods, among other features.

Note that some measures, such as improved transmissions, will only be effective when a train is in motion and will not save energy when a train is stationary in a station or depot (and when energy may continue to be consumed for hotel loads). Such aspects will be important when linked to activity metrics, such as energy and emissions per train or vehicle kilometre travelled.

In addition to the list of potential measures in Table 3, a set of illustrated examples of decarbonisation in practice is provided in Further Resources in Section 8.

Table 3 Example decarbonisation measures

Org. type	Measure type	Specific measure	Impact on carbon emissions	Ease of implementation	Involvement of other organisations?	Notes
Passenger operator	Reduce diesel rolling stock energy consumption	Install LED lighting	Low	Easiest	ROSCO, DfT	Up to 3% of traction energy consumption
		Window filming	Low	Easiest	ROSCO, DfT	May disrupt mobile phone signals
		Window replacement	Low	Medium	ROSCO, DfT	
		Improve HVAC efficiency	Low	Medium	ROSCO, equipment supplier, (OEM), DfT	
		Address other auxiliary loads	Low	Medium	ROSCO, equipment supplier, (OEM), DfT	Auxiliary loads can be easier to manage if these are electrically, rather than mechanically, driven
		Reduce avoidable idling (at long layover and terminating locations)	Medium	Medium	Varies	Could save up to 9% of traction energy consumption, requires a range of behavioural, operational and engineering solutions
		Eco-driving	Low	Medium		Supported by driver training or Driver Advisory Systems (DAS); for example, harder acceleration to maximum speed followed by more coasting
		More efficient service pattern	Low	Medium	DfT, ORR	Extra station stops may increase passenger loadings but will also increase emissions
		Replace hydraulic transmission in DMUs	Medium	Medium	DfT, ROSCO, equipment supplier, OEM	New mechanical transmissions are significantly more efficient than previous hydraulic transmissions at medium and lower speeds. However, this measure will only save energy when the train is in motion and the saving are dependent on the stopping pattern of the trains and the speeds the trains run at. For services with more stops and lower average speeds the savings were up to ~15% however on services with very

Org. type	Measure type	Specific measure	Impact on carbon emissions	Ease of implementation	Involvement of other organisations?	Notes
						few stops and higher average speeds the saving were ~8%.
	Reduce electric rolling stock energy consumption	Install LED lighting	Low	Easiest	ROSCO, DfT	Replacement of fluorescent lights with LEDs can save up to 3% of traction energy consumption as well as yield maintenance savings because LEDs have a much longer life.
		Improve HVAC efficiency	Low	Medium	ROSCO, equipment supplier, (OEM), DfT	
		Refining policies and procedures for shutdowns at long layover and terminating locations	Low	Medium		Opportunities may be limited; requires a range of behavioural, operational and engineering solutions
		Use of standby power / load shedding	Low	Medium	ROSCO, relevant equipment supplier(s), OEM, DfT	Reducing auxiliary load requirements when rolling stock is not in passenger service and is stationary for prolonged periods
		Eco-driving	Low	Easiest		
		More efficient service pattern	Low	Medium	DfT, ORR	Extra station stops may increase passenger loadings but will also increase emissions
		Reduce station/depot energy consumption	Install LED lighting	Low	Easiest	DfT
	Insulation		Low	Easiest	(Network Rail), DfT	Well understood technology with extensive experience in other sectors. Organisations should refer to the opportunities highlighted in their ESOS Phase 3 energy assessment. Specific projects may depend on building leasing arrangements: as the freeholder Network Rail will be responsible for

Org. type	Measure type	Specific measure	Impact on carbon emissions	Ease of implementation	Involvement of other organisations?	Notes
						station and depot roof maintenance under long-term ('shop-type') leases.
		Improve gas boiler efficiency	Low	Easiest	(Network Rail), DfT	Well understood technology with extensive experience in other sectors. Potential Network Rail ownership of large plant (assets that last for multiple decades) will require coordination
		Install heat pumps	Medium	Medium	(Network Rail), DfT	
	Decarbonise diesel rolling stock energy consumption	Use hydrotreated vegetable oil (HVO)	Medium	Easiest	DfT	For diesel operators with no immediate prospect of electrification or rolling stock fleet replacement may show an immediate decarbonisation impact (under some current carbon accounting rules though RCAF requires full biogenic emissions to be reported) but spending on this measure has to be continuously sustained with an increase in OpEx: it does not have lasting value and does not represent an investment to make further OpEx savings or further carbon reductions. In the UK, Aviation is seen as the principal sector targeted for HVO and sustainable fuel adoption, as evidenced, for example, by dedicated mandates and significant industry investment. Rail does not have comparable national mandates for HVO use.
	Decarbonise station/depot energy consumption	PPAs	Medium	Easiest	DfT, energy suppliers	Switch existing electricity contracts for some station and depot electricity usage to power purchase agreement (preferably with on-site generation). PPAs provide a route for the TOC to add renewable generation (typically solar panels) without financing the capital cost up front. The renewable power generated is shared between the TOC and the financing organisation (recent agreements have been 50 : 50 split).

Org. type	Measure type	Specific measure	Impact on carbon emissions	Ease of implementation	Involvement of other organisations?	Notes
		Install heat pumps	Medium	Medium	(Network Rail), DfT	Well understood technology with extensive experience in other sectors. Potential Network Rail ownership of large plant will require coordination
		Install solar panels	Medium	Easiest	(Network Rail), DfT or possible third-party financing	Well understood technology with extensive experience in other sectors. May depend on building leasing arrangements: as the freeholder Network Rail will be responsible for station and depot roof maintenance under long-term ('shop-type') leases. Installation would need to align with regular roof maintenance or replacement, to avoid Network Rail incurring costs while the operator receives the benefit
	Modify diesel rolling stock	Hybridisation	Medium	Hardest	DfT, GBR, ROSCO, equipment supplier, OEM	The recent Chiltern trials have had limited success
	Modify electric rolling stock	Modification of existing EMU to BEMU	High	Hard	DfT, GBR, ROSCO, (equipment supplier), OEM	Suitability will depend on remaining service life, technical feasibility to install batteries, and route/service pattern. May need investment in electrification islands.
	Replace diesel rolling stock	Replace with newer diesel rolling stock	Low	Medium	GBR, ROSCO	Depends on availability of mid-life stock at other passenger operators. Exact impact will depend on overall efficiency of the newer rolling stock which may have more hotel loads but a more efficient transmission and better energy management (such as load shedding when a train is stationary and out of passenger service for prolonged periods).

Org. type	Measure type	Specific measure	Impact on carbon emissions	Ease of implementation	Involvement of other organisations?	Notes
		New bi-mode	High	Hardest	DfT, GBR, ROSCO	Investment case will depend on whether existing rolling stock is at end-of-life. Exact impact will depend on ability to utilise existing or new electrified route sections.
		Tri-mode	High	Hardest	DfT, GBR, ROSCO	
		New BEMU	High	Hardest	DfT, GBR, ROSCO	Suitability will depend on route/service pattern. May need investment in electrification islands.
		New fully electric rolling stock	Very high	Very hard	DfT, GBR, ROSCO	Requires full electrification of relevant routes
Freight operator	Reduce diesel locomotive energy consumption	Address auxiliary loads	Low	Medium	ROSCO, OEM	Will require a range of behavioural, operational and engineering solutions
		Reduce avoidable idling	Medium	Medium	Varies	
		Eco driving	Medium	Easiest	Operator	The use of electric traction significantly reduces the carbon intensity of energy used currently compared to diesel and will do so more significantly in the future.
		Increase use of locomotives that can use electric traction	High	Hardest	ROSCO, OEM, DfT	
	Reduce electric locomotive energy consumption	New electric or multi-power mode locomotives have higher efficiency electrical equipment	Low	Medium	OEM	New locomotives have higher efficiency electrical equipment which will deliver improvement in energy efficiency; either though using less energy for the same loads, greater load for the same power usage or most likely somewhere between the two, all delivering reductions in energy usage per tonne-km.
	Wagon measures	Covers for open wagons	Low	Medium	OEM, ROSCOs	Fitting covers on open wagon types can improve the wagons aerodynamics reduce energy usage especially when the wagons are empty. (This mirrors findings when road hauliers had to make this change compulsorily.)

Org. type	Measure type	Specific measure	Impact on carbon emissions	Ease of implementation	Involvement of other organisations?	Notes
		Improvements in the aerodynamic of some type of wagons	Low	Medium	OEM, ROSCOs	Changing the design of new hopper wagons to reduce the gaps at the end of specific wagon types to improve the wagons aerodynamics reduce energy usage.
	Decarbonise diesel locomotive energy consumption	Use HVO	Medium	Easiest		In the UK, Aviation is seen as the principal sector targeted for HVO and sustainable fuel adoption, as evidenced, for example, by dedicated mandates and significant industry investment. Rail does not have comparable national mandates for HVO use.
	Replace diesel locomotives	Bi-mode (diesel)	Medium	Hardest	ROSCO	
		Tri-mode	High	Hardest	ROSCO	
		Bi-mode (battery)	High	Hardest	ROSCO	Significant range challenges when off wire
ROSCO	Reduce office energy consumption	LEDs, insulation	Low	Medium	Office lessor	Well understood technologies with extensive experience from other sectors but organisations may have limited control. Organisations should refer to the opportunities highlighted in their ESOS Phase 3 energy assessment.
		Insulation	Low	Medium		
		Improve gas boiler efficiency	Low	Medium		
		Install heat pumps	Medium	Medium		
	Decarbonise office energy consumption	Install heat pumps	Low	Medium	Office lessor	May have limited control
	Rolling stock maintenance	Improve efficiency	Low	Medium	Maintenance organisations	
	Rolling stock procurement	Energy efficiency	Medium	Medium	Depends heavily on TOC and DfT specifications and intended service pattern and route. Joint	Can be addressed by energy consumption per km procurement requirements
		Weight	Medium	Medium		There is now a focus on reducing weight in newer trains
		Bi-mode	High	Hardest		
		Tri-mode	High	Hardest		

Org. type	Measure type	Specific measure	Impact on carbon emissions	Ease of implementation	Involvement of other organisations?	Notes
		BEMU	High	Hardest	procurements (coordinated by GBR) may be more cost effective.	Battery technologies, duty cycles and charging requirements are expected to differ from other sectors.
		Fully electric rolling stock	High	Very hard	DfT, GBR	Requires full electrification of relevant routes
Infra-structure manager	Reduce traction energy consumption	Electrification	High	Very hard	DfT	Requires significant government investment
	Decarbonise traction energy consumption (EC4T)	Utilise PPAs	Low	Easiest	DfT, energy suppliers	Rail traction energy currently represents over 1% of the GB electricity usage and frequently utilises direct EHV connections to the Grid and DNOs. Shifting the purchasing of traction electricity (or other similar large users without self-generation) to low carbon electricity will not increase the rate at which the grid average carbon intensity decreases because this is limited in practice by the rate of construction of low carbon generation and/or investment in extra Grid and DNO capacity to deliver that new low carbon energy to end users. As such switching large users (without self-generation) such as traction electricity to just purchasing low carbon energy increases the price that NR and the hence the TOCs /FOCs (and effectively DfT) without actually increasing the quantity of low carbon electricity used at a national level.
		Install LED lighting	Low	Easiest	DfT	

Org. type	Measure type	Specific measure	Impact on carbon emissions	Ease of implementation	Involvement of other organisations?	Notes
	Reduce station/depot/office energy consumption	Insulation	Low	Easiest	DfT	Well understood technologies with extensive experience from other sectors. Organisations should refer to the opportunities highlighted in their ESOS Phase 3 energy assessment.
		Improve gas boiler efficiency	Low	Easiest	DfT	
	Decarbonise station/depot/office energy consumption	PPAs	Medium	Easiest	DfT, energy suppliers	Switch existing electricity contracts for some station and depot electricity usage to power purchase agreement (preferably with on-site generation). PPAs provide a route for the infrastructure manager to add renewable generation (typically solar panels) without financing the capital cost up front. The renewable power generated is shared between the infrastructure manager and the financing organisation (recent agreements have been 50 : 50 split).
		Install heat pumps	Medium	Medium	DfT	Well understood technologies with extensive experience from other sectors
		Install solar panels	Medium	Easiest	DfT	
	Decarbonise specialist rail fleet	Use HVO	Medium	Easiest	DfT	In the UK, Aviation is seen as the principal sector targeted for HVO and sustainable fuel adoption, as evidenced, for example, by dedicated mandates and significant industry investment. Rail does not have comparable national mandates for HVO use.
		Battery operated vehicles and plant	Medium	Medium	DfT	Battery operated equipment and plant is often at early stage of technological readiness to improvement in performance and reductions in cost expects over the coming years
	Decarbonise road fleet	Zero emission vehicles	Low	Easiest	DfT	Well understood technology with extensive experience from other sectors

Org. type	Measure type	Specific measure	Impact on carbon emissions	Ease of implementation	Involvement of other organisations?	Notes
	Reduce embedded carbon	Infrastructure measures and improvements	High	Medium	DfT	The civil engineering sector and several rail infrastructure managers is working on many potential technological avenues to reduce embedded carbon. The shift from steel produced in blast furnaces to electric arc furnace production will radically reduce the embedded carbon content of steel especially with the increasing decarbonisation of grid electricity. Initiatives typically focus on the choice of material and reducing the quantities of material used.

Part Two

6 Understanding the rail decarbonisation context

This section is intended to be an introduction to a complex topic by presenting key concepts and issues. It will support rail industry's staff in developing a decarbonisation strategy, upskill and to help move their organisation further forward on the journey to net zero. The aim of this section is to provide a high-level overview of the wider rail context to help readers identify and frame key issues for consideration and it is not intended to convey the government's position on the issues discussed. Conditions are subject to change.

The GB rail industry sits in a unique context compared to other industries and sectors. Until recently, TOCs have been operating under management contracts, which involve a high degree of DfT and Treasury scrutiny of annual operational costs and limited multi-year investment planning. TOCs are currently being gradually nationalised under Great British Railways (GBR), a process which is expected to be completed by 2027.

GBR is a new publicly owned body being established to unify the UK's rail system by integrating track and train operations, acting as the 'directing mind' with DfT continuing to provide oversight and direction. Government will still ultimately be providing funding and making the investment decisions, but operators (as part of GBR) will potentially have significantly more influence on infrastructure and rolling stock investment proposals than under the current industry model.

FOCs, although they are private entities, still depend on government investment for electrification schemes. Essentially, then, funding for most decarbonisation measures across the GB rail industry will be heavily dependent on government spending priorities and government scrutiny of business cases, even for low levels of spend.

There is thus a high degree of government involvement in the industry. This is different from the private sector, where investment plans are fully internal to an organisation and organisations can be more in the control of the timing of actions. When preparing rail decarbonisation investment cases it is therefore crucial for rail industry organisations to understand the government's approach to carbon accounting and its prioritisation and scheduling of measures (nationally, within transport, and within the rail industry), as well as how carbon reductions and other benefits are valued across different years.

6.1 Government decarbonisation priorities

Rail is already a carbon-efficient form of transport. It accounts for 1.5% of the UK's total transport emissions, but 9% of all passenger kilometres travelled¹⁵. The transport sector as a whole accounts for 25% of all UK carbon emissions. As such, current rail emissions are about 0.375% of total UK GHG emissions. Furthermore,

¹⁵ <https://dataportal.orr.gov.uk/media/q34mblpr/rail-environment-2023-24.pdf>

Rail has high marginal abatement costs: many other sectors can offer more impact for the same expenditure on decarbonisation measures in the short and medium term. Rail is therefore unlikely to be a high priority for government action on decarbonisation, though it should also be recognised that rail decarbonisation schemes often offer more benefits to customers, the rail industry and broader society than just the decarbonisation itself. The issue of rail decarbonisation not being a top priority was recognised by Andrew Haines, Network Rail CEO, in evidence to the Transport Select Committee on 7 May 2025:

‘...electrification has dropped down the priority list, in terms of political priorities, partly because in a national decarbonisation strategy the railway represents a very small percentage our carbon budget. Therefore, the incremental benefit you get from decarbonisation of the railway is not as great as you get from other parts of the economy.’

Government has set decarbonisation targets at the national level which cascade into different sectors, including Transport. In general, when prioritising and funding decarbonisation measures, the Government will consider the sector as a whole, as well as other benefits that schemes offer. In some cases, mitigation measures (such as subsidies for EV chargers) have lower marginal abatement costs and can generate more carbon reductions at a lower cost, than some capital-intensive rail schemes for example. Defining the marginal abatement costs and co-benefits of proposed decarbonisation schemes may help rail organisations, as well as government, set more impactful targets and gain potential insight into the relative value of those schemes.

Nationally, across all sectors, there are competing influences that dictate whether decarbonisation will become more challenging and expensive after 2035. For example, presently, many organisations are able to achieve reductions through efficiency measures and by taking advantage of grid decarbonisation. By 2035 over 90% of the electricity supply should be decarbonised, a consequence of wind and solar farm construction and newly constructed nuclear power plants coming on line. At this point the availability across all sectors of large, low-cost decarbonisation options is likely to decrease, especially related to power consumption, efficiency measures and affordable lower-carbon materials and design approaches, and in many cases it will be necessary to spend more money for the same amount of carbon reduction. Hence, the cost per tonne of CO₂e emissions abated will tend to increase over time.

However, learning curves, innovation, improved supply chain options, policy instruments and improved systems and decision-making can create some limited opportunities to reduce carbon emissions at a lower cost. For example, improvements in specific technologies such as batteries will lower relative cost and improve performance will improve over time.) Front-loading measures to reduce future costs is an important consideration in strategy development. When possible, organisations should identify opportunities to implement mitigations that will become more complex and expensive with time but also weigh up the benefits of finite short-term reductions (such as procuring low-carbon steel) versus long term ambitions such as fostering a long-term low-carbon steel supply chain.

As battery performance continues to improve and their cost falls, future investment in BEMUs may be more cost effective, and may yield improved emissions outcomes, than similar investments made today. The prospect of solid-state lithium batteries with a step change in battery life and charge rates, plus lower weight and volume, further drives the cost-benefit potential of future investments. Given that rolling stock leases are

priced on payback being around 15 years, new rolling stock could be quickly out of date on a technical basis, yet the leasing costs would be higher than for the replaced rolling stock.

This overall context means that many rail decarbonisation measures may not have a high carbon reduction benefit compared to potential government investments across other sectors in the short to medium term. Consequently, the business cases for decarbonisation action will need to show other benefits in relation to their costs and, ideally, savings (see Section 7.2).

It is important to consider an energy hierarchy when prioritizing actions for reducing energy consumption and carbon emissions: reduction in energy use is preferred over improving the efficiency of that energy usage, which is in turn preferred over sourcing low carbon energy¹⁶. For example, for buildings insulating well first to reduce the overall energy use is preferred over ensuring that the energy is used more efficiently, which is in turn prioritised over the energy having a low carbon intensity. Similarly, it is crucial that the infrastructure carbon reduction hierarchy set out in PAS 2080 is adhered to, beginning with building nothing, or building less and making key carbon decisions early in the project development process.

Another consideration is the effectiveness of decarbonisation investments that yield benefits for the life of assets versus decarbonisation expenditure that may have a limited, short-term abatement impact. GBR offers an opportunity to invest in longer term strategic decarbonisation opportunities such as sending market signals for more sustainable supply chains (such as low carbon steel), implementing the Long Term Rail Strategy or improving rail links to Europe to reduce aviation emissions,

The purchase of HVO fuel may be an interim (bridging) action that results in lower carbon emissions (depending on the feedstock) over the time frame that the fuel is being purchased and used. However, the most sustainable HVO is in limited supply and in the UK, aviation is seen as the principal sector targeted for HVO and sustainable fuel adoption. Consequently, rail decarbonisation will ultimately need to rely upon measures requiring longer-term investment. As evidenced, for example, by dedicated mandates and significant industry investment, whereas rail does not have comparable national mandates for HVO use. Further challenges with HVO adoption by the rail industry, including long-term demand from multiple sectors affecting future pricing and validating the sustainability of HVO feedstocks, are discussed in the RSSB *Low Carbon Fuels for Rail Review*.¹⁷ Consequently, rail decarbonisation will ultimately need to rely upon measures requiring longer-term investment.

Treasury and government departments develop policy, programmes and projects by evaluating options; a strategic case sets out the rationale and objectives for proposed options, and the constraints and dependencies they are under, such as the UK's net zero target. The economic case for an individual option sets out the appraisal of the option against the objectives set out in the strategic case. This leads to the need to develop multiple options for the option selection process. A policy or project that increases or decreases GHG emissions domestically or internationally relative to a 'business as usual' scenario is required to quantify the change in emissions. With assets that are approaching end of their useful life a business-as-usual scenario

¹⁶ <https://www.imeche.org/news/news-article/the-energy-hierarchy-a-powerful-tool-for-sustainability>

¹⁷ Low Carbon Fuels for Rail Review, RSSB

might include replacement of that asset. Therefore, acting at this stage opens up more potential opportunities than at mid-asset life. All changes in emissions should be valued by using the Green Book carbon values¹⁸. This includes emissions captured within trading schemes, such as the UK Emissions Trading Scheme.

While many rail organisations may have already developed decarbonisation plans and set targets, the approaches they have used may not align with the government approach to, and prioritisation of, decarbonisation investments. The government is the funding source for most major projects that will yield a significant reduction of carbon emissions, such as route electrification and/or rolling stock replacement. Therefore, an understanding of current government planning (which does not assume massive and sustained electrification as outlined in the Traction Decarbonisation Network Strategy from around 2020) is necessary to develop realistic decarbonisation plans.

Presently, decarbonisation strategies are developed by individual infrastructure managers and freight and passenger operators (some under SBTi) in the context of contractual and commercial frameworks (including government funding) of these organisations. Under this structure, multiple organisations decisions are made relevant to the interests of each organisation and if applicable to agreed approaches under SBTi.

Under GBR a more holistic approach to decarbonisation and funding can be taken across rail to strategically integrate infrastructure and operations and consider rail and the transport system as a whole (including modal shift). This offers the opportunity to achieve the most benefit at the lowest marginal abatement cost. For some organisations, the future enhanced alignment of the rail industry under GBR may require review and redrafting of their decarbonisation plans with DfT providing more oversight and direction. This may include revising carbon inventories, baselines and targets and establishing a new set of mitigation strategies and timelines.

It is important you ensure that you have an understanding of current government thinking and planning regarding rail decarbonisation and how this may evolve under GBR. Previous decarbonisation plans may need to be updated in light of government priorities which may have a significant impact on decarbonisation trajectories.

6.2 Different organisations will have different decarbonisation options and therefore different trajectories

Rail industry organisations will have different starting points for their decarbonisation journeys, especially as regards existing traction power sources (electric versus diesel traction). And organisations will have different available opportunities and different abilities to implement decarbonisation measures, many of which will depend on government investment priorities across the rail sector. Consequently, organisations will have different trajectories depending on their particular circumstances. There is no 'one size fits all'.

TOCs that run electric train fleets will benefit from gradual grid decarbonisation occurring because of measures in the electricity generation sector. For these TOCs, a large part of the path to net zero will be

¹⁸ <https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal>

achieved through grid decarbonisation (see Section 5.2.1.2). Nevertheless, all-electric TOCs still have to take other decarbonisation actions to fully reach net zero. They can focus on rolling stock energy efficiency measures to reduce the amount of low-carbon traction electricity required, as well as measures to reduce energy usage in stations and depots (see Section 5.5).

For an operator where an existing electrification programme is currently taking place (and likely associated rolling stock replacement), there will be a substantial discrete step in its trajectory. However, this improvement may not address other parts of that operator's route network where there are no currently funded plans and services will remain on diesel for the foreseeable future.

For other, typically predominantly diesel operators, traction-based decarbonisation solutions may not be available for a decade or more. In either of these cases, as for the all-electric TOCs, other measures, such as heating and lighting at stations and depots, that can be implemented early and relatively easily, and which will maintain some form of downward trajectory, should be considered (see Section 5.5).

The assets that an operator uses will come to the end of their working lives at different points, which may or may not coincide with nationally planned infrastructure projects and associated rolling stock fleet investments. Government funding for such major projects is essential, but these large expenditures will be dictated by overall government CapEx limits. This results in a substantial challenge for the timing of such projects – only a limited number can be carried out at any one time and a particular operator may have to wait for some time before benefiting from such projects.

Certain projects will require coordination between multiple rail organisations. The operational requirements and capabilities of operators may vary, and the extent of planned electrified route sections may be suitable for some operators to run on battery but not for others. Informed dialogue and coordination among operators and other stakeholders can be facilitated by GBR to develop cost-effective joint procurement specifications as well as enabling effective shared planning of infrastructure improvements (such as electrification of key route sections). Operator influence and cross-industry coordination should improve under GBR. It will have a longer-term investment horizon that can better align with asset lifecycles and enable more proactive planning of effective rolling stock replacement, energy sourcing and infrastructure investment strategies. Especially, that is, if GBR adopts a more devolved model akin to the regional 'partnerships' which are already being set-up between operators and Network Rail to drive performance improvements on specific routes. For example, Southeastern's partnership with Network Rail Kent.

There will be substantial variation between rail organisations in the type, scope and timing of potential decarbonisation opportunities. However, coordination of initiatives affecting multiple organisations is expected to improve under GBR.

Residual diesel rolling stock asset life can often be beyond 2050 (for example IETs, Class 19x, 231, 75x) therefore there will need to be substantial mid-life investment before 2050, such as conversion to BEMUs, to meet net zero targets.

If a rolling stock asset is currently mid-life and cannot be easily cascaded elsewhere (even with better coordination across fleets by GBR) then the organisation may have to retain this stock until end of working life when the timing will be more optimal for rolling stock replacement. Consequently, some organisations may have very few major decarbonisation options but can focus on smaller decarbonisation measures where they have more direct control, and which may be more tractable (See Section 5.5 for examples). This may include addressing assets with an operating life shorter than rolling stock (for example gas boilers for depot heating, fluorescent lighting at stations, roof maintenance). In these cases, opportunities to implement decarbonisation measures may present quicker than waiting for major rolling stock fleet replacement.

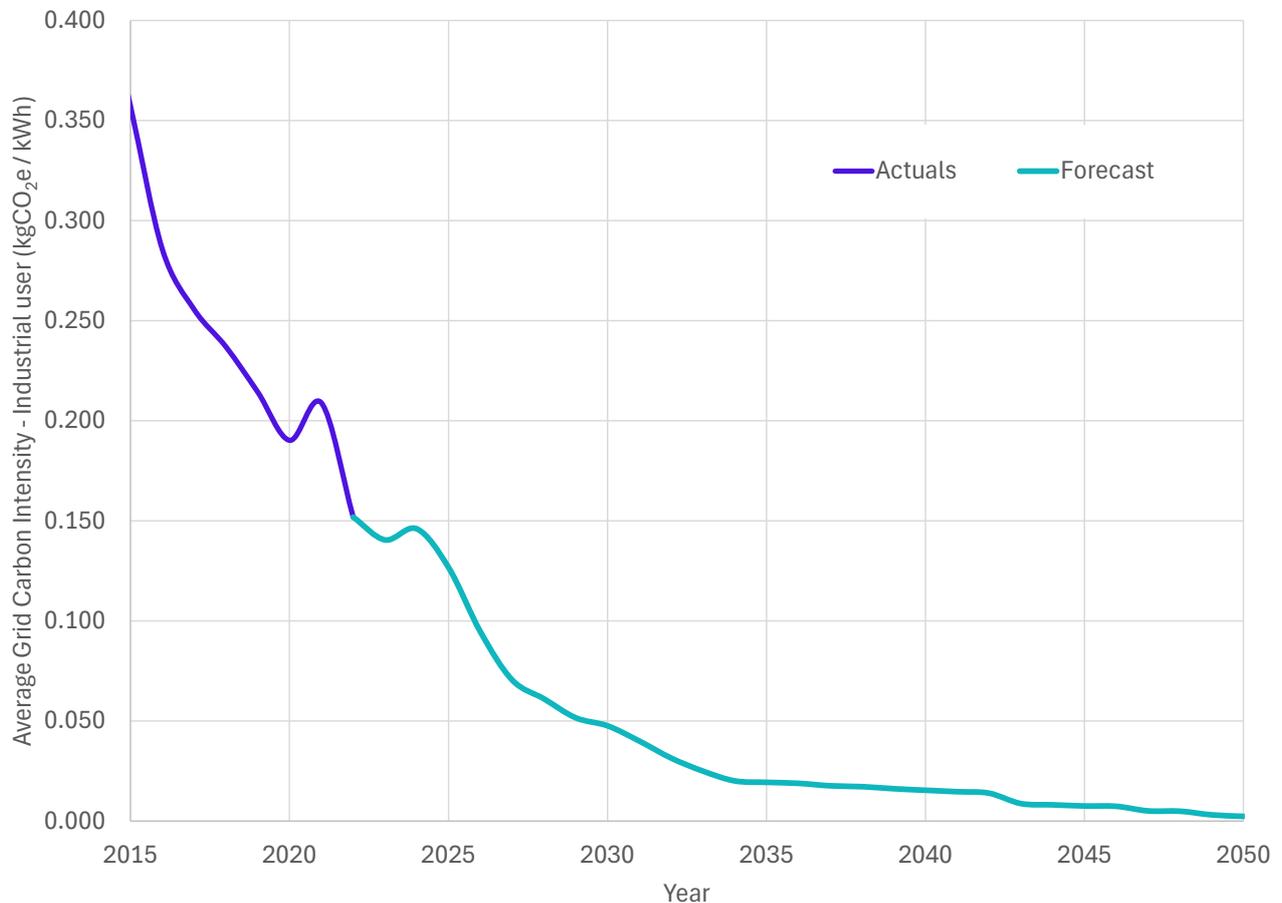
Opportunities naturally exist at the end of life of a rolling stock or infrastructure asset, and as such there is a good opportunity to invest in effective decarbonisation measures at this point. This could include, for example, the installation of solar panels when a roof needs to be replaced, when the incremental cost of the decarbonisation measure is comparatively low.

Carrying out a reasonable number of smaller projects each year would be needed to create a reduction trajectory that supports sector-wide net zero ambitions. Such projects may also reduce an organisation's expenditure, enabling investments to be reinvested in additional reduction projects. Furthermore, some of these measures are more widely understood from experience gained in other sectors, compared to more niche topics such as electrification projects or use of batteries for rail traction.

6.3 Implications of grid electricity decarbonisation

Traction electricity is centrally sourced by Network Rail and its carbon intensity will depend on the current contract, currently follows the national grid average and is expected to decline significantly in coming years. Thus, in practice most rail operators with electric fleets will realise substantial decarbonisation from reductions in the carbon intensity of the electricity they use for traction or non-traction-use, with comparatively little direct effort over the next decade to 2035. For example, the grid average carbon intensity for large industrial users (which is used for traction electricity) is forecast to decline by greater than 85% compared to 2024. Reductions beyond 2035 are forecast to take place at a much lower rate than before 2035. For non-traction electricity some operators may already have moved to purchasing lower carbon intensity electricity and / or some low carbon self-generation, making the overall picture on non-traction electricity carbon intensity more varied by operator. The UK grid average carbon intensity for large industrial users which is used for Traction electricity in Treasury Green Book and TAG analysis is shown in Figure 3 with historic actual data and forecasts.

Figure 3 UK Grid Average Carbon Intensity for Industrial Users (for traction electricity use); Actuals and Forecasts [kgCO₂e /kWh]



Note that the values for historic and forecast grid intensity for large industrial users in the Green Book and traction electricity in TAG should be the same. These values may be out of alignment for a few months if change made in the Green Book has not yet propagated through to the TAG. This is an important reason for being able to easily refresh calculations for investment cases.

Rapid initial electricity decarbonisation will have implications for operators. All operators will gain some decarbonisation benefit from the decarbonisation of the electricity they purchase or self-generate; the scale of the benefit will depend on the individual circumstances of the operator. The earlier the base year for assessing carbon and setting target that is used, the larger the scale of the benefit. Also, if organisations use a base year that is before when they started to actively target reducing the carbon intensity of non-traction electricity they will also benefit from large reductions in traction (grid) electricity carbon intensity. Subsequently moving to a later base year will result in much lower reduction in carbon emissions being calculated.

The relative proportions of traction and non-traction electricity of the total emissions will significantly impact the trajectories of operators in the next decade when setting near term targets.

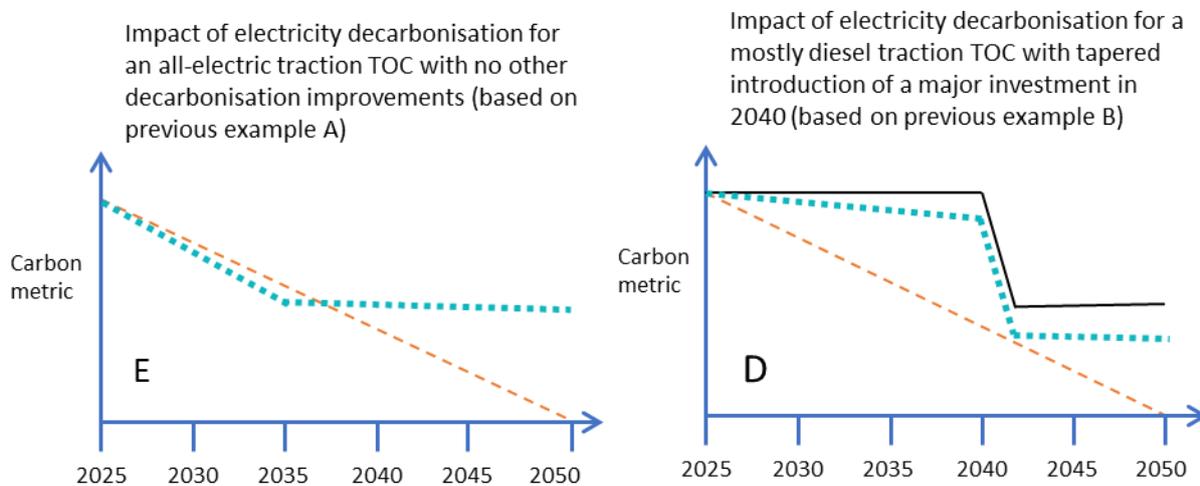
Example: For a TOC with all electric traction and 50% of total emissions being electricity in the base year (including both traction and non-traction) then reducing grid electricity carbon intensity without any other actions by the TOC or their suppliers could reduce emissions by 44% for 2035 and by 48% for 2050.

Hence in many cases the relative ease of reducing carbon emissions without any direct action aligns with the current and previous government strategy prioritising decarbonising electricity production in the near term before 2035 due to its wide-ranging benefits¹⁹. This is illustrated in Example E in Figure 4 with the green dotted line. Note that greater decarbonisation than required by a linear trajectory is achieved before 2035 without any other actions beyond the passive impact of reduction in grid carbon intensity. However, after 2035 reductions will require much more direct action from organisations and at comparatively higher cost.

Example: For a TOC with mostly diesel traction and 8.5% of total emissions being electricity in the base year (including both traction and non-traction) then reducing grid electricity carbon intensity without any other actions by the TOC or their suppliers could reduce emissions by 7.3% for 2035 by 9.2% for 2050; just 15% -20% of the equivalent levels seen at an all-electric traction TOC. However, if this TOC later benefits from electrification and/or BEMU introduction it will realise far greater reductions at that point in time.

The impact of the electrification of a previously diesel fleet is illustrated below in Example D in Figure 4 below with the green dotted line (based on the previous Example B in Figure 3).

Figure 4 Example idealised trajectories



In practice both example TOCs will be taking other decarbonisation actions including reductions in scope 3 emissions similar to the previous Example C in Figure 3 resulting in faster real trajectories than illustrated in Examples D or E above.

6.4 Focus on the decarbonisation measures that an organisation

¹⁹ <https://www.gov.uk/government/news/plans-unveiled-to-decarbonise-uk-power-system-by-2035>

has control over

Planning effective decarbonisation measures involves understanding what areas the organisation has control over and what areas it does not have control over. A rail organisation may currently have limited or no control over major decarbonisation measures such as the scope and timing of electrification projects. However, in the near future operators may gain more influence over fleet procurement, infrastructure upgrades, and energy sourcing under GBR.

Rail organisations will currently typically have more control over locally sourced station and depot electricity (choice of electricity supplier), energy efficiency at those locations, and over the nature of heating in depots (gas boilers versus heat pumps). There will be a strong case for passenger operators taking decarbonisation actions at stations and depots before major government investments that affect their particular operations take place. Such actions are tractable and based on readily available technology.

Essentially, smaller items can be handled more easily by organisations. They can be implemented relatively quickly, and in many cases may yield savings to fund further investments. Ideally a return on simple investments could be achieved within the same financial year, although more complex measures may need interlinked multi-year business cases.

Understand the context your particular organisation is operating in compared to other sectors and to other rail industry organisations, including the likelihood and timeframe of significant infrastructure and relevant rolling stock investments.

Operators will have limited control over the source of traction electricity and so will be unable to directly affect carbon intensity for this category. However, they can improve efficiency and reduce consumption of traction electricity.

Operators will also have more ability to address the magnitude and intensity of Scope 2 emissions related to station and depot heating and lighting.

While not resulting in as large reductions in carbon emissions as electrification and replacement of diesel rolling stock, installation of solar panels on station or depot buildings can be an early, effective, and reasonably easy decarbonisation measure to implement. This is a measure that is likely to be relevant for most staffed stations in the future. The majority of station and depot buildings are owned by Network Rail and leased to TOCs. The terms and responsibilities in the leases can make installation of solar panels challenging as Network Rail are usually responsible for the roof including maintenance. However, implementation of such initiatives may become easier under GBR.

7 Supporting decarbonisation investment decisions

This section clarifies how to develop an effective business case for funding decarbonisation actions in a manner that is consistent and coherent across the industry. This will allow effective interaction and interfacing with other rail industry organisations and particularly with the government. The section is primarily aimed at TOCs, FOCs, and ROSCOs. It will have less relevance to Network Rail who have extensive experience in developing electrification business cases and who have a more defined planning and investment process that is subject to ORR review.

7.1 Funding mechanisms

Most carbon reduction investments will be funded or approved by DfT or other government bodies. Applications for such funding will need to be prepared in a standard way, generally following the DfT's TAG or a variant of that process. Understanding the application and review process for this funding, and the pitfalls that can occur when making applications for funding, is critical.

There are a range of funding channels for investment funding including rail decarbonisation measures:

- **The High-Level Output Specification (HLOS)** and **Statement of Funds Available (SoFA)** are key components of the UK government's planning and funding framework for Network Rail during its Control Periods.
- **Annual funding streams for TOCs in England**; some are multi-year streams but there is not a 5-year approach that would allow for more certainty in investment planning.
- Funding from the Scottish and Welsh Governments provided to **ScotRail** and **TfW** for both OpEx and CapEx. This funding ultimately primarily comes from Central Government (subject to the Barnett Formula contribution) although some taxation powers are available to the Devolved Administrations.
- **Merseyrail** and **Nexus** (Tyne and Wear) have direct government funding from DfT (unlike Scotland and Wales).
- **TfL** where decarbonisation targets are largely self-set and self-funded. (TfL receive a comparatively small amount of direct central government funding that is usually assigned for specific projects or purposes.)
- For Open Access passenger operators and freight operators decarbonisation measures will generally be self-funded unless they can benefit from an electrification scheme.

With these different routes to funding source there will also be different information requirements and differences in how investment cases should best be presented. Nevertheless, most, if not all, major investment cases will be dependent on government funding. Applications for such funding need to be prepared in a standard way, generally following the DfT's TAG or a variant of that process.

7.2 Components of a decarbonisation investment case

Many rail decarbonisation measures may not have a high carbon reduction benefit compared to potential government investments across other sectors in the short to medium term. Consequently, the business cases for decarbonisation action will need to show other benefits in relation to their costs and, ideally, savings.

The benefit-cost ratio (BCR) is a key metric used in evaluating government-funded decarbonisation investment cases. The economic efficiency of a decarbonisation measure is assessed by comparing the total expected benefits to the total expected costs over the measure's lifetime.

Often potential decarbonisation actions are not single individual measures but a package of measures where the overall GHG impact of the measures in combination is lower than the sum of their individual savings because some measures may overlap. This requires careful calculation and the use of appropriate hierarchies to prevent double (over) counting of GHG reductions and to allow accurate comparative assessment of different packages of measures and the relative value of each potential investment.

Example: Potentially replacing existing DMUs at end of life on a partially electrified route with BEMUs that could charge from overhead line equipment (OHLE): New BEMUs would have lower whole-life costs than replacement DMU or Bi-modes. The lower whole-life cost derives from multiple factors including typically lower capital costs (and hence lower financing costs), lower operating costs due to lower energy costs, less distance travelled to refuelling locations, lower maintenance requirements (both in terms of materials and staff and hence lower costs), and less maintenance downtime resulting in a requirement for few units to provide the same level of service.

7.2.1 Costs

Costs represent the monetary outlay for a particular scheme, both capital investment and operational costs. Not all costs will be negative: some may be positive, representing savings (typically of fuel, energy or maintenance costs) or increased revenue from greater passenger usage and/or rolling stock utilisation. The BCR calculation will be based on net costs over multiple years, accounting for initial implementation costs but also savings over the lifetime of the scheme.

7.2.2 Decarbonisation benefits

Decarbonisation benefits are monetised by the carbon values provided by the UK Government (known as the traded and non-traded carbon prices)²⁰. These monetary values of the avoided emissions are based on the cost of meeting the UK's legally binding national carbon budgets and net zero targets. They are expressed in £ per tonne of CO₂e and increase over time to reflect the growing urgency and cost of decarbonisation.

²⁰ <https://www.gov.uk/government/collections/carbon-valuation--2>

7.2.3 Co-benefits

The Sustainable Rail Blueprint identifies reduction of emissions of NO_x and PM from diesel trains (particularly in enclosed stations and depots) and the mitigation of key sources of rail-related noise and vibration as strategic aims. Many decarbonisation actions will also address these aims.

Furthermore, decarbonisation benefits alone are unlikely to be strong enough to justify a business case. It will therefore be necessary to look at other areas for savings and co-benefits to improve the BCR of a business case. These areas include:

- air quality damage costs
- noise
- fuel (energy) savings (in addition to the benefits of avoided carbon emissions)
- maintenance savings. If relevant initiatives are carried out early then they will accrue the most savings in maintenance costs. Some initiatives, such as LED lighting, will save on both energy usage and maintenance costs.
- journey time, rolling stock utilisation and capacity benefits
- congestion and accident reduction (resulting from mode shift and increase in capacity on the rail network)
- social and economic benefits to communities.

Fuel and maintenance savings will have a direct monetary impact, as will improved rolling stock utilisation. Other benefits are based on environmental and social impacts and these can be monetised using TAG²¹ or the RSSB Rail Social Value Tool.²² These tools are discussed further in Section 7.3.

Air quality damage costs are the estimated monetary value of the harm caused by air pollution to human health, the environment and the economy. They are expected to decline over time due to a combination of policy, technology, and behavioural changes, including:

- stricter emission standards for vehicles, industrial sources, and domestic heating systems
- electrification of transport
- more use of renewables for power generation
- policies promoting modal shift
- a decrease in the health burden.

In appraisal frameworks such as TAG this will result in lower marginal damage costs per tonne of air quality pollutant and reduced monetised environmental benefits for future transport schemes. This is a reason to

²¹ <https://www.gov.uk/guidance/transport-analysis-guidance-tag>

²² <https://www.rssb.co.uk/sustainability/maximising-social-value/the-rail-social-value-tool>

carry out actions sooner in order to be able to derive the maximum benefit of air quality improvements in the business case.

TAG provides the Marginal Economic Costs (MEC) for other relevant impacts, including noise. The MEC in TAG for congestion and accidents reflects the direct and indirect impacts on the public and wider economy and can be used to monetise the benefits of any increase in passengers shifting to rail for a particular investment.

7.3 Key tools and guidance

This sub-section provides advice on how to assess low carbon investment options, including an overview of the relevant government approaches and how these should be used.

7.3.1 HMT Green Book

The HMT Green Book is official guidance from HM Treasury (HMT) on how to appraise and evaluate public policies, projects and programmes in the UK. It helps government departments and public bodies make decisions on available options that deliver value for money, support economic, social, and environmental goals, and are based on evidence and analysis. The Green Book sets out how to:

- identify and compare options
- assess costs and benefits (including environmental and social impacts)
- use tools like cost-benefit analysis and discounting.

The Green Book uses a structured approach, including the Five Case Model, to evaluate different options. Key aspects of option selection in the Green Book are:

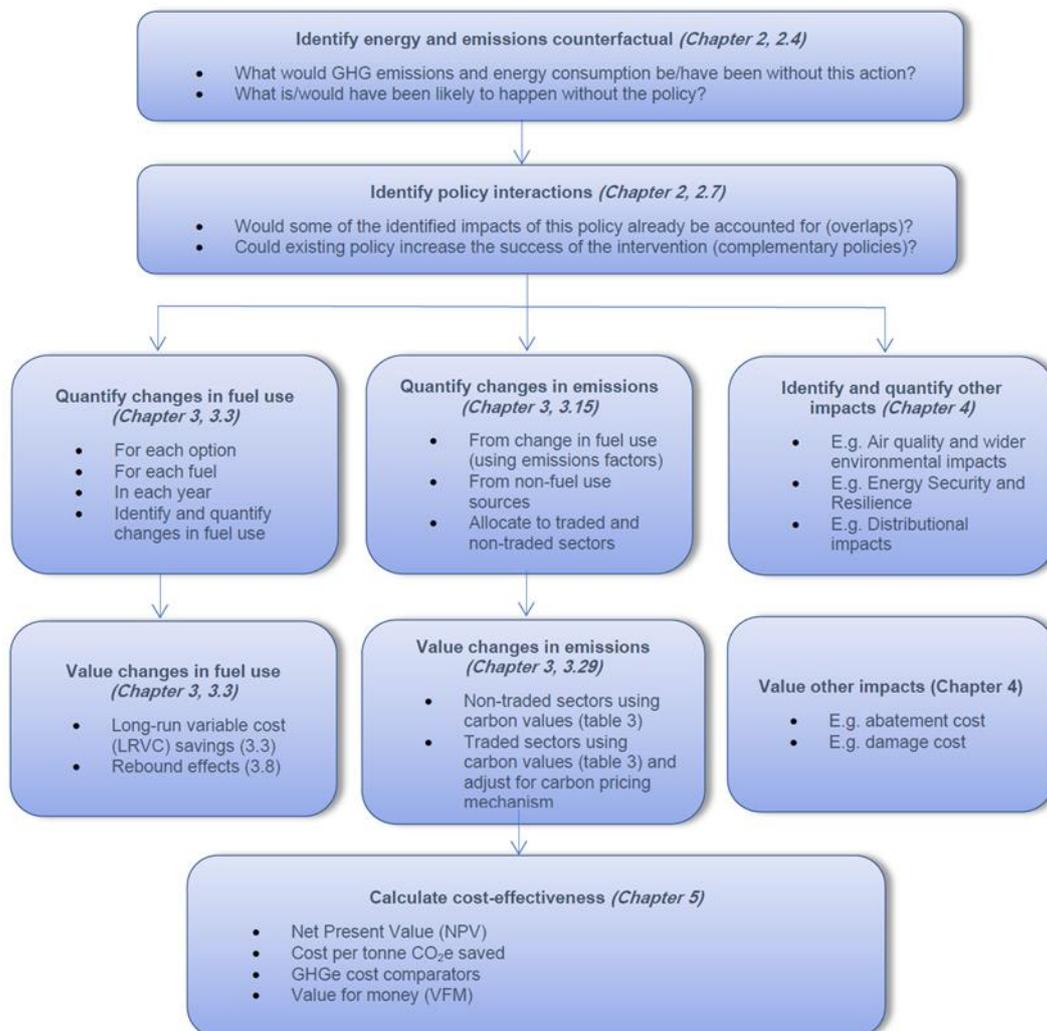
- Long-listing: The process begins with identifying a wide range of potential options.
- Short-listing: Long-listed options are then assessed and narrowed down based on criteria such as strategic fit, potential value for money, affordability, and achievability.
- The Green Book emphasizes the importance of understanding the ‘business as usual’ scenario (which should include future committed changes) to properly assess the impact of an intervention as a base for Counterfactual Analysis. The five-case model (Strategic, Economic, Commercial, Financial, and Management) is used to assess the viability of each option. There is detailed sensitivity analysis involving testing the sensitivity of the results to changes in key parameters to identify potential risks and uncertainties. The Green Book emphasizes that options should be assessed holistically for overall Value for Money (VfM), considering all costs and benefits, not just financial ones.

The *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal*²³ and its associated tool kits will be of the most use when developing decarbonisation investment cases. The flow chart in Figure 5 shows the key steps and relevant parts of this guidance to refer to. Note that

²³ <https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal>

total costs, not just carbon costs, should be considered. A key point made in the Green Book supplementary guidance is to reduce energy usage first before reducing carbon intensity.

Figure 5 Green Book process for value energy and GHG emissions reductions



7.3.2 HMT Magenta book

The HMT Magenta Book²⁴ is the UK Government’s official guidance on evaluation of public policies, programmes and projects. While the Green Book is about appraisal before implementation, the Magenta Book focuses on policy evaluation during and after implementation. However, its relevance is that many potential decarbonisation measures will be first-of-a-kind (FOAK) examples that will likely be subject to deeper scrutiny. A key requirement of the Magenta Book is having to provide a range of options (which enables optioneering), and then to show how the final option was selected. Key relevant themes are:

²⁴ <https://www.gov.uk/government/publications/the-magenta-book>

- the timing both in terms of the starting point and duration of making a change (for example when a new rolling stock fleet starts to be introduced and how long it takes to complete fleet introduction)
- the effects of non-linearity and sensitivity in assumptions (such as how the cost of a new technology has been evolving and is expected to evolve in the future).

7.3.3 TAG

While the Green Book summarises what to consider when appraising a public investment, DfT's TAG and its Scottish and Welsh equivalents (STAG and WelTAG, respectively) advise on how to do so for transport projects supported by government funding, using specific tools, data and assumptions. TAG is the default tool for looking at transport economics where there is a significant government interaction as well as wider societal impacts. It is widely understood and accepted by a broad range of stakeholders, including policymakers, and is based on an extensive historical base of analysis and validated assumptions. As such, TAG presents a useful transparent approach to quantify the various economic, environmental and social benefits of transport, including rail, investments.

TAG represents a conservative approach in that economic benefits and other impacts are monetised only where a robust evidence base is available. Consequently, the capture of wider economic impacts, such as social welfare impacts and domestic job creation that are elements contained within gross value added (GVA), is sometimes limited in TAG.

TAG is based on four categories of economic impact, economy, public accounts, environment and social, as shown in Table 4. In TAG analysis usually only items in the second column in Table 4, 'impacts that are typically monetised', are included in cost-benefit assessments of investment cases. This category includes costs and benefits for which the evidence on monetary values is considered most robust. Other significant costs and benefits, such as reliability impacts or wider economic impacts, which cannot be presented in monetised form or where the evidence on monetisation is less robust (and so may need to be approved by DfT for use in a particular business case), are presented in the third and fourth columns.

Table 4 TAG economic impact appraisal categories

Category of impact	Impacts that are typically monetised	Impacts that can be monetised but are not typically included in TAG cost-benefit assessment	Impacts that are not currently feasible to practical to monetise
Economy	Business users and private sector providers (including revenues)	Reliability impact on business users Wider economic impacts	
Public accounts	Cost to broad transport budget Indirect tax revenues		
Environment	Greenhouse gases Air quality Noise	Landscape	Townscape Historic environment Biodiversity Water environment
Social	Commuting and other users Accidents Physical activity Journey quality	Reliability impact on commuting and other users Option and non-use values	Security Access to services Affordability Severance

7.3.3.1 Asset lifecycle considerations in TAG

In TAG asset lifecycle considerations are essential for understanding the long-term costs and benefits of transport infrastructure and services. These considerations ensure that appraisals reflect the true economic impact of a project over its entire life.

The typical asset life for rail passenger vehicles is 30-40 years which is significantly different from the HGV asset lifecycle (even when accounting for primary, secondary and tertiary users). The TAG appraisal period is 60 years, unless the lifetime of the asset is shorter.

The asset lifecycle stages that should be considered in TAG are:

- capital investment (CapEx)
- operation and maintenance (OpEx)
- renewals and replacements (such as periodic major maintenance or component replacement)
- residual value (at the end of the appraisal period)
- decommissioning and disposal (for example end of life costs).

The business case needs to compare alternative options across the full asset lifecycles.

7.3.4 Rail Social Value Tool

The Rail Social Value Tool (RSVT) is an online tool developed specifically for the GB rail industry by RSSB and co-funded by Network Rail. It can be used to forecast, monitor and evaluate the social value of projects and day-to-day operations. The RSVT contains over 500 social indicators, around half of which have monetised values associated with them that have been calculated using Organisation for Economic Co-operation and Development (OECD) and Green Book principles.

The RSVT is designed to complement TAG-compliant appraisals, not replace them. It allows rail organisations to include social value projections alongside traditional economic appraisals in business cases. This provides a more holistic view of the potential value of rail investments.

Note that the RSVT includes a small number of monetised values that are from TAG. To avoid double counting, do not use these TAG indicators in any project forecast where a TAG-compliant appraisal is also being produced.

7.4 Challenges and barriers

The rail sector's mix of traded and non-traded GHG emissions (see Section 7.4.2) makes financial accounting and business case evaluation quite complex. Furthermore, the complex rail industry structure and ownership, split between public and private sector, with costs and benefits of potential measures split between both sectors, as well as potentially users, is challenging. This is recognised by DESNZ and HMT as a gap in current methodology that can only be solved by specific detailed analysis and comparative assessment of the value of spending for government (as opposed to private companies and users)²⁵.

Rolling stock asset ownership presents challenges to quantifying benefits and the costs that accrue (both overall and to individual parties) and how these evolve overtime. For example, a ROSCO could fund retrofits of an existing fleet that would give an operator immediate operational benefits (for example fuel usage, maintenance requirements and intervals), and it could increase the leasing costs to cover this investment. However, the minimum pay-back period for the ROSCO may not correlate with the remaining term of the TOC's contract. Funding from government and/or users indirectly covers increased leasing costs, however the rolling stock is often on shorter term leases resulting in lack of certainty in its remaining working lifespan, and hence the length of the assessment period.

Similarly for stations, Network Rail is usually the freeholder whereas TOCs are 'shop-type' leaseholders with limited rights and responsibilities for the building. In all cases, tools and guidance to assist the rail industry in investment decisions need to be able to reflect the ownership structure and responsibilities of multiple industry parties so that costs and benefits are allocated to the correct organisations.

²⁵ <https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal>

7.4.1 Data sources may not be in alignment

There is no one single authoritative data set that should be used for all types of carbon accounting and assessment of decarbonisation actions. Emission intensity values (for example for electricity generation) published by the Department for Energy Security and Net Zero (DESNZ) and HMT in the Green Book can occasionally be out of sync. This can occur for several reasons.

Different purposes:

- DESNZ focuses on energy policy and forecasting, so its emission intensities reflect real-world, operational data and future energy mix projections.
- HMT Green Book values are used for economic appraisal, so they are designed to be consistent, conservative, and stable for long-term decision-making.

Update cycles:

- DESNZ updates its data more frequently (for example annually or quarterly) to reflect the latest energy trends.
- Green Book values are updated less often to maintain consistency across government appraisals.

Scenario assumptions:

- DESNZ may use dynamic scenarios based on evolving energy policy (for example Net Zero Strategy, electricity decarbonisation).
- HMT uses standardised assumptions to ensure comparability across sectors and projects.

Use cases:

- DESNZ values are used in carbon accounting, energy modelling, and policy impact assessments.
- Green Book values are used in cost-benefit analysis and business case development.

When appraising a transport project using TAG, the Green Book-compliant values should be used (even if DESNZ has newer figures), unless explicitly advised otherwise. However, changes in the Green Book may take time to propagate down to other government departments, resulting in a time lag for updates to TAG and values that need to be used in business cases.

The inputs for cost calculations can change because:

- The general economic outlook changes and GDP deflators (representing the inflation rate) get updated.
- Carbon intensities are updated – both actuals and forecasts (recent years are preliminary and can often be subsequently revised). This can be due to:
 - Estimates of the amount of solar generation being refined (older installations did not have effective export metering).
 - The carbon intensity for imported electricity imported through interconnectors from overseas being revised.

A key consequence of these changes is that values, for the carbon baseline year and/or the future state, may be higher or lower than originally forecast. This in turn will affect the magnitude of the expected carbon reduction, which may then need to be recalculated. Furthermore, calculations of the value of carbon reductions can vary between the time an application is submitted and when the application is reviewed by DfT. Values in the Green Book, DESNZ emission factors, and values in TAG can all potentially be updated—and at different times—during this (potentially prolonged) interregnum period, and you may be asked to update your calculations. Not being able to do so quickly may cause further delays.

Given that there are a wide range of reasons why data sources and carbon intensity estimates can change, it is vital to have the flexibility to quickly update data sets and easily refresh your calculations.

7.4.2 Traded versus non-traded carbon

Traded carbon emissions are covered by the UK Emissions Trading Scheme (UK ETS; previously the EU ETS) and include emissions from power stations. The value of traded carbon is based on the market price of carbon allowances within the UK ETS.

Non-traded carbon emissions are not covered by the UK ETS and include emissions from transport, buildings, agriculture and smaller industrial sources. They are valued using a non-traded carbon price, which is a shadow price set by the government that reflects the estimated cost of reducing emissions in these sectors to meet national carbon budgets and net zero targets.

In the context of the UK Government's Green Book and related guidance on policy appraisal, traded and non-traded carbon are valued differently for economic and policy analysis.

In the GB rail sector, gas used for heating depots is an example of traded carbon, whereas traction energy is non-traded carbon. Although traded carbon makes up only a small percentage of rail-sector carbon emissions, the greater current impact of traded carbon on an organisation's finances in the near term may incentivise earlier reduction in traded carbon. In particular, it provides a good incentive to address the small number of very large gas heating systems in the rail sector.

The evolution of the value of these two types of carbon emissions will be different over time. The correct price for current and future years needs to be based on correctly assigning the emissions to the Traded or Non-Traded categories. These values can be found in TAG. In the longer term (beyond 2040), traded and non-traded economic values are expected to converge.

7.4.3 Differences in base years

Carbon reductions in future years will be tied to a particular recent year for which an accurate baseline for annual carbon emissions is available. Cost and benefit financial calculations for a business case for a decarbonisation measure can often need to be tied to a different price and discount base year. For instance, for comparable-year accounting, DfT has preferred to use 2010 or, more recently, 2023 as both the price and discount base year, only recently updating this to 2023. Other government departments may change the designated price and discount base year more frequently, to a year that is more recent.

Differences in base years causes complexity when carrying out calculations and it is imperative that values are tracked, well documented, and easily refreshable.

7.4.4 Modelling monetary values in future years

In TAG deflators are used to convert future or past monetary values into the price base year (currently 2023) to ensure that all costs and benefits are expressed in real terms (constant prices) rather than nominal terms. This removes the effects of inflation and ensuring consistency in cost-benefit analysis across years and that different projects are compared fairly and consistently.

There are different ways of discounting the value of different changes in future years.

- Standard deflator which is used for most items such as for fuel savings.
- TAG-specified environmental cost deflator for reduced air quality damage costs in future years, reflecting the benefit of the long-term decline of AQ pollution as abatement measures are applied to multiple sources of air quality pollutants across multiple sectors (such as power generation, industry, and domestic heating as well as transport).
- Carbon pricing in TAG will vary for different years, reflecting the increasing cost of carbon as the UK moves toward net zero. The TAG Data Book includes a carbon price table with year-by-year values up to 2100.

Given these variations in deflators for future years it is crucial that deflators are applied separately to the different relevant parts of cost-benefit analysis and accounted for separately for each different calendar year.

If there is a delay in review and authorisation process then calculations will have to be refreshed, so organisations need to be prepared to be able to quickly do this.

7.4.5 Optimum timing for implementation

The ideal time for implementation will vary for a number of reasons. Where a measure will result in OpEx savings (such as of fuel costs, maintenance costs) it would be best to implement the measure as early as possible in order to accrue the most savings over the lifetime of the relevant asset.

Technology maturity will affect timing. Heating boilers, which are used in many other sectors, have undergone substantial efficiency advances in recent years, while solar panels are well understood with widescale deployments having already taken place outside the rail sector. These are examples of mature decarbonisation technologies. Other rail-specific decarbonisation technologies have not matured as quickly, though battery appears to have moved further forward than hydrogen as a power source for services on rural branch lines. Indeed, since BEMU costs have come down substantially recently, the optimum time to introduce such trains may be now.

As discussed in Section 7.4.4, monetary values assigned to different types of benefit will evolve at different rates in future years. Higher air quality damage cost values in earlier years may prompt earlier action while higher carbon prices in later years may justify later action.

It is important to be aware that a business case will not necessarily produce the same answer if it is implemented at different times. Thus optimising the timing for implementation for different measures will require careful consideration.

8 Further resources

8.1 Illustrative examples of decarbonisation measures

The examples in this sub-section build upon and illustrate the points discussed in the sections above. While generalised, they are based upon specific situations encountered across the GB rail industry.

8.1.1 Reduce onboard energy consumption

Fluorescent bulbs have a typical lifetime of 4-5 years, but when stockpiles run out a decision to replace with LEDs is forced. As well as energy savings, LEDs have longer lifetimes that enable maintenance savings since, essentially, they are 'fit and forget' for the remaining lifetime of the rolling stock. These maintenance savings need to be included in the business case for this decarbonisation action to improve its BCR.

LEDs require a multi-year payback period. Thus it is not possible to time implementation and derive savings within the duration of a one-year TOC management contract. Therefore the business case has to be made across multiple years.

8.1.2 Reduce station and depot energy consumption for heating

A simple decarbonisation action is to reduce energy demand for heating. This fits into the government's core approach across all sectors which is to reduce energy usage before addressing the carbon intensity of the energy used. Compliance with the Offices, Shops, and Railway Premises Act (1963) and later by the Workplace (Health, Safety and Welfare) Regulations 1992, which set a minimum 16°C heating requirement in workrooms, must be ensured.

Roof insulation is an effective measure. with a typical payback period of 4-5 years. It can be carried out in association with installing new heat pumps, or it can be its own intermediate step before replacement with a heat pump of an existing gas boiler is life expired that would enable immediate energy savings.

Under many TOC station 'shop type' leases, Network Rail will be responsible for maintenance and improvements outside of the 'lease line' (the boundary that defines the tenant's leased space). So, their cooperation to approve or fund measures affecting the building roof will be needed.

8.1.3 Address station and depot energy sources

The reduction of energy consumption on the demand side can be mirrored on the supply side through moving away from gas towards electricity as the energy source and towards cleaner electricity.

Current heating sources will be predominantly gas, and the overall national decarbonisation strategy is to move towards electric heat pumps. Most current small and medium gas boilers have a lifetime of around 15 years so replacing this equipment at end of its operational life will make the best business case.

Larger gas boilers at depots, which typically have a longer operation lifespan, may be under Network Rail ownership, an artefact of privatisation arrangements in the 1990s. The timing and nature of the replacement

of such equipment may not be a priority for Network Rail so constructive engagement and cooperation will be needed. Coordination of such initiatives should improve under GBR.

Installation of solar panels on station or depot roofs is an option with a degree of technical maturity and tractability, and which could be implemented as an early and ongoing measure. This will likely be a more immediate option than addressing the carbon intensity of traction electricity.

Self-generation reduces consumption of energy from external sources. While electricity may be exported to the grid during certain times of the day, grid supplies will still be needed at night. These differences in power source at different times of day should be factored in to assess the benefit of self-generation on net annual basis. However, the net effect of self-generation should be lower annual emissions for the station or depot operator.

Depending on the scale of the solar panel installation at particular site this will likely leading to near-zero annual emissions overall for equipment powered by this source. If the installation were sufficiently large then there might be value in the net export of electricity, however the payback period for larger installations is likely to make this challenging currently.

Earlier station/depot solar installations done under passenger franchising regime allowed operators more freedom to invest in improvements than the current management contracts. For example, before 2020, some TOCs fully funded solar panels installation at stations and depots and have full use and control of the energy generated. More recent station and depot installations have typically been achieved with power sharing partnerships with a third party that funds the installation so the TOC may only get the use and control of half the power generated by the panels. This has typically led to larger solar panel installations to maximise export opportunities and value for third parties, but results in lower overall benefit for the TOC.

As with dealing with roof insulation, there may be limitations on what an operator can immediately carry out under the terms of their lease. An operator may not have responsibility for the building roof under the terms of their building lease (typically from Network Rail). So, a multi-organisation effort with Network Rail's cooperation will be necessary to install solar panels. The work would need to align with regular roof maintenance or replacement to avoid Network Rail incurring costs while the operator receives the benefit. More centralised planning under GBR (instead of decentralised among operators) could enable more integrated and strategic decarbonisation across infrastructure and operations.

8.1.4 Modification of traction energy sources for existing rolling stock

The viability of investment cases for mid-life modifications will depend on the particular circumstances. An example predominantly electric operator has a small fleet of DMUs rapidly approaching end of life that operate partially on a non-electrified section of route and partially on the operators core mainline electrified route. The timing is important: some kind of action will need to be taken but potential decarbonisation impacts will vary.

There is an opportunity to replace the diesel stock with available mid-life EMUs (already used by that operator) converted to BEMUs. These particular EMUs have sufficient space and capability for transformers

and batteries to be easily and quickly fitted. However, the business case depends on the total cost including new infrastructure (electrification islands for battery charging), as well as whether the cost of the rolling stock modifications can be recouped within the remaining lifetime of the modified rolling stock.

Net cost savings, including energy usage and fuel costs, the maintenance savings and efficiencies of moving to a more common fleet, and slightly higher infrastructure maintenance costs will all need to be factored into a full comparison against procuring new rolling stock which might have smaller decarbonisation benefits. For example, new diesel-electric bi-modes would not require additional route electrification but would require continued running on diesel on the non-electrified parts of the route.

The business case will be complex, involving the TOC, ROSCO and OEM, as well as Network Rail cooperation on infrastructure improvements; coordination across these organisations should improve under GBR. DfT approval will focus most heavily on the overall business case, not just the decarbonisation benefits, so all other savings and benefits should be included.

8.1.5 Rolling stock replacement

The timing of rolling stock replacement has a significant impact on the strength of decarbonisation investment cases. When rolling stock is life-expired then 'do nothing' cannot be an investment option; some kind of new rolling stock will have to be procured or cascaded from elsewhere. This significantly affects the viability of business cases for decarbonisation options, making certain options more viable since they can be included at marginally lower additional cost. And in some cases, depending on the available opportunities for charging (the degree of existing route electrification) new BEMUs may be cheaper than new DMUs in terms of CapEx and OpEx, as well as avoiding challenges with the industry aspiration 'no diesel-only' trains by 2040. Coordinated joint BEMU procurements across multiple passenger operators, potentially facilitated by GBR, will offer scale benefits.

Another factor that may affect the strength of a business case is fleet consolidation to reduce maintenance and operational complexities and associated costs. Savings from reducing the number and variations of train classes and train manufacturers in an operator's fleet may contribute to a business case. This option may be available for an operator that already has at least some current EMUs approaching life-expired status.

For instance, running and maintaining a BEMU micro-fleet that serves one or a few lines with high per unit costs could be avoided through a larger (well-timed) procurement that ensures a high degree of commonality with a larger EMU fleet (the same electrical architecture and equipment). This option would not be available to operators that primarily have new EMUs, or to operators with mid-life rolling stock.

An example is where a diesel-only operator whose route network is almost completely unelectrified. Its current fleet of DMUs dates from the 1990s and early 2000s. The former types are coming to the end of their operational life and in this case no other suitable existing rolling stock is available. This presents a much larger challenge than the example described in Section 8.1.4. Some type of new rolling stock is needed but for any kind of decarbonisation action at least some amount of route electrification is needed. Investment in new trains and likely associated infrastructure will need to come from government. Therefore in this case the

timing of significant decarbonisation will be dependent on DfT priorities, and this may not occur for a long time before sufficiently extensive locations are electrified to permit realistic battery operations.

Another example of rolling stock replacement is a freight operator that needs to replace early-build Class 66s, around 2035. A new, primarily electric locomotive with modern traction systems will have significantly increased tractive effort across the speed range and be able to meet shorter sectional running times with higher loadings when running on electrified routes. Some level of capability to run on battery on lines away from the electrified network will be needed, but freight running on battery is much more of a challenge than for deploying passenger BEMUs given the much higher sustained energy requirements.

A new freight locomotive represents a significant investment for a private freight operator, yet its viability will also be dependent upon government investment. For instance, servicing intermodal traffic north from Southampton to the Birmingham area and beyond will require substantial electrification of parts of the Didcot to Leamington corridor to make battery operation along non-electrified sections viable, even assuming the new locomotive has the capability to use the third rail from Southampton to Basingstoke. Coordination will be needed with the rolling stock and infrastructure plans for passenger operators using this corridor (Chiltern, CrossCountry, EWR and GWR), for whom there will be beneficial synergies for their own decarbonisation investment cases. This level of interdependency means careful coordination across the rail industry will be needed. It also means individual organisations will need to be realistic about the scope, timing and viability of their planned decarbonisation actions.



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