NetworkRail

Route Services

Route Services Shared Learning
Environment & Sustainability

Route Services: Carbon Reduction and Assessment Guidance

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Introduction

1. INTRODUCTION

This guidance has been created to provide instructions for Network Rail Route Services and associated teams on how to:

- Drive carbon reduction on individual infrastructure projects; and
- Undertake associated carbon assessments, including how to use the Rail Carbon Tool (RCT).

The structure and detail are designed to ensure it can be used by project teams with comparatively limited technical experience, confidence or resource availability on both these subjects, and to accommodate the current low availability and quality of data for assessments. However, it is also designed to ensure that it will quickly advance the capability of teams, and progress with carbon reduction and assessment.

Central to this guide is ensuring the correct focuses are in place, specifically:

- Carbon reduction is a core element of project development; and
- Assessments are always suitable to the need concerned, focused on being:
    - Simple and fast for decision making, wherever possible; and
    - Consistent and with appropriate detail for reporting purposes.

This guidance is also set up to ensure:

- Assessments have a clear use;
- Project teams are empowered to correctly address carbon reduction and assessments; and
- Development and reuse of carbon reduction knowledge and assessment data occurs from one assessment and/ or one project to the next.

1.1 Structure and Contents

Section 1.2 and 1.3 below set out who this guidance is for, and how to use it. The remainder of this introduction then sets out various key points that need to be understood to enable effective use of this guidance. The main sections of this guidance then introduce and detail carbon reduction and assessment, as follows:

Section 2: Processes for project carbon reduction and assessment across the pre-PACE[1] phase and the PACE framework, covering Engineering Stages 1 to 6 (ES1 – 6).

Section 3: Project carbon assessment methodologies and RCT use, covering how to undertake the various types of carbon assessments that are specified in Section 2, including use of the RCT and case studies.

1.2 Who this Guidance is for

This guidance is for all parties involved in delivery of rail infrastructure projects, and defines roles and processes for:

- Clients/ project sponsors: it enables them to understand how to lead on setting requirements and expectations.
- Project managers and engineering: it enables them to understand and plan what is required, and how they need to provide project and technical leadership; and

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[1] Project Acceleration in a Controlled Environment

- All parties in project teams: It enables them to know how to drive and undertake carbon reduction, and use carbon assessments to support this.

1.3 How to use this Guidance

This guidance contains extensive content, but it is not onerous to use involving only two key steps:

1. Initially all readers should familiarise themselves with the overall structure and contents, and the headlines provided in sections 2.1, 2.2, and 3.1.
2. For project specific applications, users only need to follow the details for the Engineering Stages involved in their project, as set out in section 2.6, and associated assessment details provided section 3.

1.4 ENV015 Carbon Requirements

This guidance is specifically designed to ensure compliance with the energy and carbon requirements of NR/L2/ENV/015 Environmental and Social Minimum Requirements, section 6.4.1 and 6.4.2. It does this by ensuring:

- Delivery of lower carbon solutions through effective identification and progression of carbon reduction opportunities; and
- Use of appropriate assessments to inform carbon reduction development and demonstrate reductions that have been achieved.

1.5 Knowledge and Data Sharing

There is a cross-project requirement that all project-specific carbon reduction and assessments will be undertaken with a structure and format that enables reuse of carbon reduction knowledge and assessment data from one project to the next, as far as possible.

It is also required that knowledge and data transfer is actively undertaken, i.e. there is a clear network of people and active communication in place for this to happen.

The purpose of this knowledge and data sharing is to:

- Ensure project carbon reduction and assessment is coherently and efficiently undertaken on individual and groups of projects; and
- Facilitate low carbon technical advancement as quickly as possible by enabling and inspiring the most effective innovation.

1.5.1 Rail Carbon Tool Data Sharing

Being able to effectively use this guidance requires knowledge of how to share data between projects in the RCT, for viewing and/ or direct reuse. This is a headline point because ensuring access to RCT assessment data between projects is a key issue that has three significant benefits:

- Enabling insights at pre-PACE and early PACE stages through data reuse;
- Enhancing consistency between projects through good data sharing; and
- Reducing resource demands on individual projects by avoiding primary data development.

Instructions for viewing and sharing data between assessments in the RCT is set out in Appendix A. This is a purely administrative task, hence its inclusion in an appendix. However, it should be understood prior to any RCT assessments, to ensure it can be followed and applied as efficiently and effectively as possible.

1.6 Guidance Updates

As carbon reduction and assessments are undertaken according to the instructions in this guidance, capability, knowledge and data will significantly improve. Consequently, how reductions and assessments can and will need to be undertaken will evolve. This guidance should therefore be considered as a first iteration to meet the current needs of Engineering Services and associated teams, and it will be updated as developments take place, including for integration with other existing Network Rail standards and guidance.

1.7 Strategic Rail Infrastructure Carbon Management

It is intended that this project-focused guidance will contribute to and be supported by wider rail infrastructure innovation and carbon reduction planning and assessment, as these evolve across Network Rail infrastructure development and delivery.

This guidance currently excludes any instructions for wider rail infrastructure carbon reduction and assessment. However, all project-specific carbon reduction and assessments work should be undertaken with the view that it will drive, inform and enable wider innovation and carbon reduction, which all projects can then utilise and benefit from. This includes strategic and supply chain carbon reductions outside of individual project possibilities. For example, development and implementation of a rail re-manufacturing circular economy, by reprocessing end-of-life rails in electric arc furnaces

Additionally, until strategic carbon guidance is in place, this project-specific guidance can be utilised for strategic planning, where it is deemed suitable and applicable, e.g. for developing and assessing strategic options.

PROJECT CARBON REDUCTION AND ASSESSMENT PROCESSES

2. PROJECT CARBON REDUCTION AND ASSESSMENT PROCESSES

This section sets out the processes for carbon reduction and assessment across the stages of a project, according to the current levels of technical maturity.

It starts by setting out the technical focus that needs to be taken. It then sets out:

- Carbon reduction and assessment principles;
- An overview of the project carbon reduction and assessment processes;
- Headline responsibilities; and
- Specific carbon reduction and assessment processes for each pre-PACE, and PACE Engineering Stage.

2.1 Technical Focus

To date, carbon assessments have largely been set as the priority for considering carbon on projects. They are important as they provide useful insights, but they do not fully drive carbon reduction.

Going forward, it is crucial that the technical focus is on driving carbon reductions and achieving realistic lower carbon solutions aligned with core project development, covering two phases:

Phase 1:	In early project development[2] the focus should be on:	• Determining the carbon performance of the existing scenario and each project proposal; • Undertaking high-level carbon reduction of each proposal; and • Using both of the above to inform project development, decision making and single option selection.
Phase 2:	After single option selection the focus should be on:	• Driving more detailed carbon reduction of the selected option, as required.

Carbon assessments should only be undertaken to support these two phases of carbon reduction and demonstrate the reductions that are achieved. Specifically, on any given project:

- The project complexity and extent of carbon reduction options and opportunities should define what carbon assessments are required, and when and how they are undertaken, i.e.:
  - Big projects with lots of opportunities will require much more carbon assessment; whereas
  - Small projects with few or no opportunities will require little if any carbon assessment, especially where representative previous project data can be directly reused; and
- Whole project assessments at the end of each Engineering Stage should only be undertaken where there is a purpose for this, e.g.:
  - To provide a baseline for design development, or create a measure of total emissions to inform prioritisation and future strategic carbon reduction planning; but not

[2] Pre-PACE and PACE 1, ES1 - ES3.

- When there is no need to specifically quantify project carbon performance due to other, suitable data to do this, or where it is known that no reductions have been achieved.

For all of the above, it is critical to ensure the level of detail is appropriate. All project level action should contribute to driving appropriate carbon reduction, and this should be aligned with the long-term direction for carbon reduction of rail infrastructure. It should also be recognised that the RCT is only a single tool in the arsenal for driving and informing carbon reduction, rather than being the defining element.

2.2 Carbon Reduction and Assessment Principles

Throughout project carbon reduction and assessment work there are a range of principles that should be considered to ensure that the project-specific action is as effective as possible. These principles are presented below. (There is no priority in the order in which they are set out as this is determined by project requirements and user experience)

1	Do carbon reduction with action Do carbon management with words Do carbon assessment with numbers	To clearly differentiate between carbon reduction and assessment the Programme Director for Engineering Services has highlighted that: • Carbon reduction is about action and words, i.e. using verbal and written technical discussions, action plans, engineering development, progress logs, specifications, etc. to drive carbon reduction, as per any technical development initiative. • Carbon assessment is about numbers. This covers both qualification using expert technical judgement, or direct quantification at all levels of granularity, to determining emissions quantities for decision making and demonstrating performance.
2	Draw out more of what is already being done, and recognise that carbon reduction and engineering efficiency are often the same thing:	Any efficiency that reduces materials use, construction, operational demands etc. is very likely a carbon reduction, and vice versa. This alignment should be recognised in all cases and highlighted as the full story of carbon reduction across a project.
3	There are no hard and fast rules:	For the current level of maturity carbon reduction and options assessment is about using expert technical knowledge and judgement, plus representative data to inform the way forwards.
4	Purpose:	Ensure the end use of every assessment and who will receive it are clearly established by a project team, and use this to define the purpose of an assessment.
5	Plan according to project capacity:	Ensure carbon reduction and assessment objectives are planned according to the technical resource, budget and programme available, focused on driving reduction and producing knowledge and data that has a clear, constructive use, within the capacity available.

6	Plan according to technical capability:	Initially what carbon reductions and assessments can be achieved on any given project may be limited due to the current levels of maturity. However, competency will quickly increase as carbon reduction knowledge and assessment data improves. Consequently, it is important each project's carbon objectives are planned according to what is technically possible, but also capitalises on increasing competency.
7	Plan according to the level of change possible within a project:	For projects with lots of engineering, construction and operational possibility, ensure the carbon reduction and assessment takes advantage of this, identifying and driving reduction opportunities, and using assessment to support this and demonstrate change. However, for projects with very limited opportunities for change, do not specify extensive carbon reduction and assessment requirements, when inherently no project changes can be affected. For example, where the carbon reduction of the project has been effectively determined by the end of ES3, there is no need to carry out detail carbon reduction planning and assessment across ES4 and ES5. Overall, it is essential that the focus of effort is on the elements of an assessment which help to drive meaningful carbon reductions. This might mean that some details are better estimated or even scoped out to keep effort aligned with the long-term direction for carbon reduction of rail infrastructure. z
8	Question the need for any detailed, quantified assessment:	Question and manage the need for any assessment work that does not have a clear and constructive use.
9	Work iteratively:	Be conscious that all stages of carbon reduction and assessment will potentially involve iterations in which carbon reduction knowledge and data evolves and expands; the iterations and improved knowledge and data should be accommodated and utilised for the most effective carbon reduction outcomes.
10	Use fast intellectual reasoning and justification as a priority for carbon options assessments:	Carbon options assessments are about finding the right way forwards, not extensive quantification. Fast intellectual reasoning using expert technical judgement that can be suitably validated (i.e. a proxy assessment) should therefore be prioritised over quantification. Any documented justification and back-up quantification can then be undertaken where needed.
11	Be pragmatic about assessment accuracy – keep it high level as far as possible:	For assessments, ensure that accuracy levels are sufficient for effective decision making, planning and demonstration of reductions, but nothing further. Avoid assessment updates where significant further accuracy gains will not have a material impact on decisions, planning or demonstration of improvements.

12	For projects starting at advanced PACE stages, consider what previous carbon reduction and assessment requirements need consideration at the starting point:	If a project starts at advanced PACE engineering stage, any preceding carbon reduction and assessment needs should be considered from the previous stages and undertaken as required.
13	Ensure knowledge and data reuse:	There is a lot of consistency across rail infrastructure, and therefore carbon reduction opportunities and assessments. Therefore, reuse of previous project knowledge and assessment data should be prioritised for carbon reduction and assessment, to ensure the focus can be on driving reduction, and not wasted on repeating reduction ideas or assessments.
14	Clearly include carbon as a decision metric in options considerations:	Plan to ensure that carbon reduction knowledge and data is generated at the times when decision making will require it, and the priority of carbon over other metrics is understood and utilised correctly.

These principles will be updated as experience and expertise evolve.

2.3 Assessment Types

There are three different types of assessment to use. These are:

A	Proxy Assessments:	These are qualitative assessments using engineering judgement and project data that is representative of equivalent carbon emissions, for fast understanding of carbon emissions for decision making. They often consider whole project, whole life scopes, including user emissions, but at extremely high level, focused on the key emissions and their magnitudes.
B	Headline Assessments:	These are quantitative assessments using engineering judgement to estimate representative data and/or high level, or standard project data that is used for understanding of carbon emissions for decision making. They often consider whole project, whole life scopes, but quantification is only for relevant emissions to be compared, all other sources being either aligned in magnitude with the emissions being quantified or considered equal across options being compared.
C	Detailed Assessments:	These are details assessment to demonstrate performance, covering whole project, life emissions for the emissions stages of relevance.

2.4 Carbon Reduction and Assessment Overview

The processes for project carbon reduction and assessment follow the two-phase structure outlined in section 2.1. Directly below are the specific headlines for each phase (according to the principles set out in section 2.2) to provide a full overview of how they are intended to be applied. Figure 1 and Figure 2 then provide further visual explanation. The overviews are then followed by:

- Definition of the different types of assessment involved to provide clear technical definition throughout this guidance;
- Headline responsibilities (section 2.5); and
- Full process details (section 2.6).

Phase 1: Pre-PACE to PACE 1 - ES3

Reduction

In this phase, the focus is on:

- Definition and iterative development of the existing scenario and project proposals, across pre-PACE to PACE1 - ES3.
- Understanding the scope and magnitude of emissions across the existing scenario and each project proposal, to define the overall project carbon context and inform decision making and subsequent carbon reduction planning.
- Driving high-level carbon reduction thinking using the carbon reduction hierarchy and the project carbon context, to maximise the overall project reductions across the proposals, and for headline choices within proposals.

Assessment

The carbon assessments needed for this phase include a potentially significant range of emissions scopes to determine the necessary context and drive high-level reductions. However, the primary types of assessments are:

- Simple and fast, using indicative data, or very high-level quantities i.e. proxy or fast headline assessments only.

The primary purpose of assessments in this phase is to enable understanding of magnitudes of emissions only, sufficient to inform proposal development and whole project decision-making.

Phase 2: PACE 2 ES4 to PACE3 - ES6

Reduction

In this phase the focus is on:

- Driving carbon reductions within the selected single option according to the carbon reduction hierarchy; and
- Ensuring planned reductions are carried through to construction.

Important to note for this stage is that seemingly small reductions on large projects can outweigh all reductions on small projects, and both should be planned accordingly, i.e. overall resource should be focused on where the greatest reductions can be achieved.

Assessment

The carbon assessments for this phase include:

- Simple and fast, and/ or more detail headline assessments (as required) for options development, i.e. proxy or headline assessments; and
- Detailed assessments to quantify the carbon profile of a project and demonstrate reduction against the design baseline.

The design baseline is taken as the selected single project option at the end of ES3.

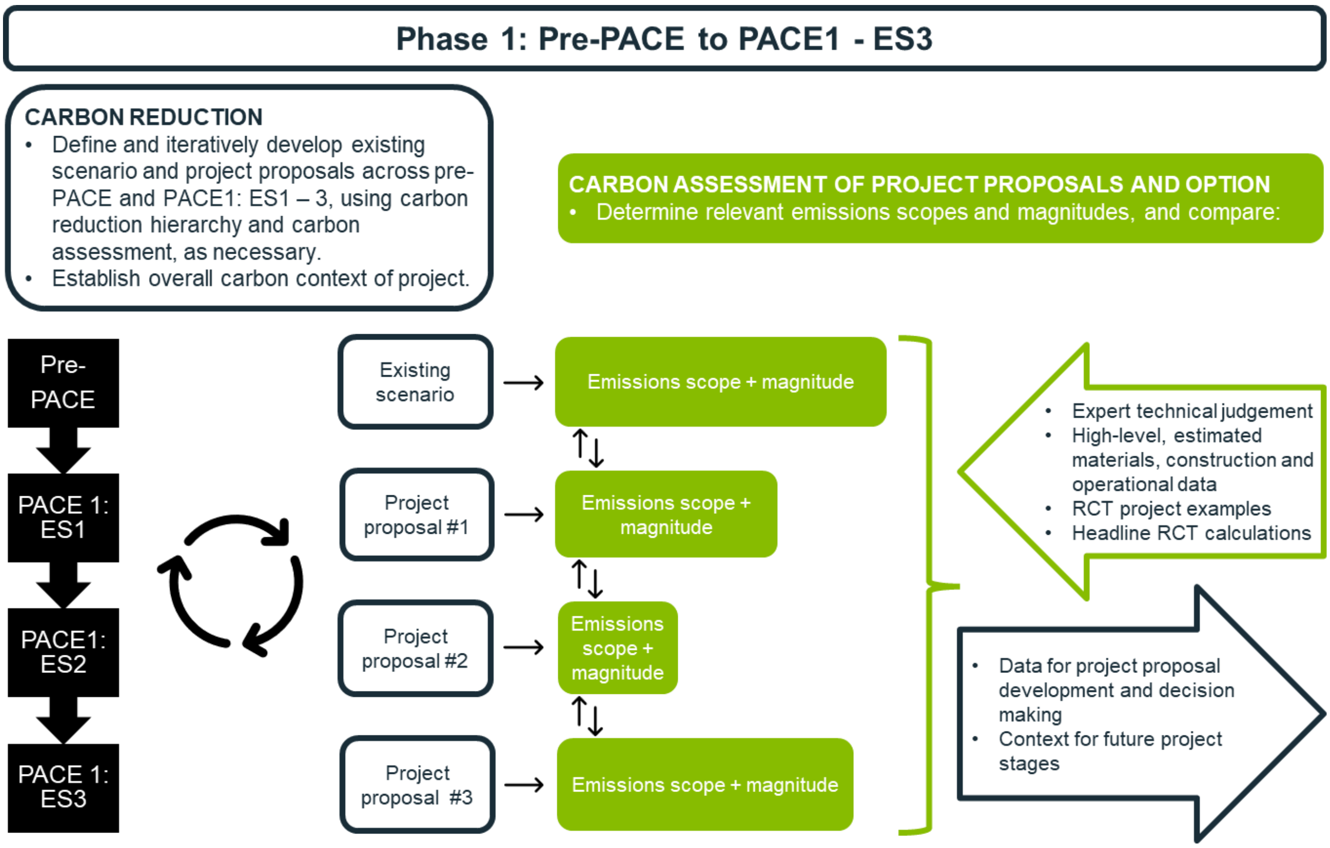


Figure 1: Phase 1 Process Outline

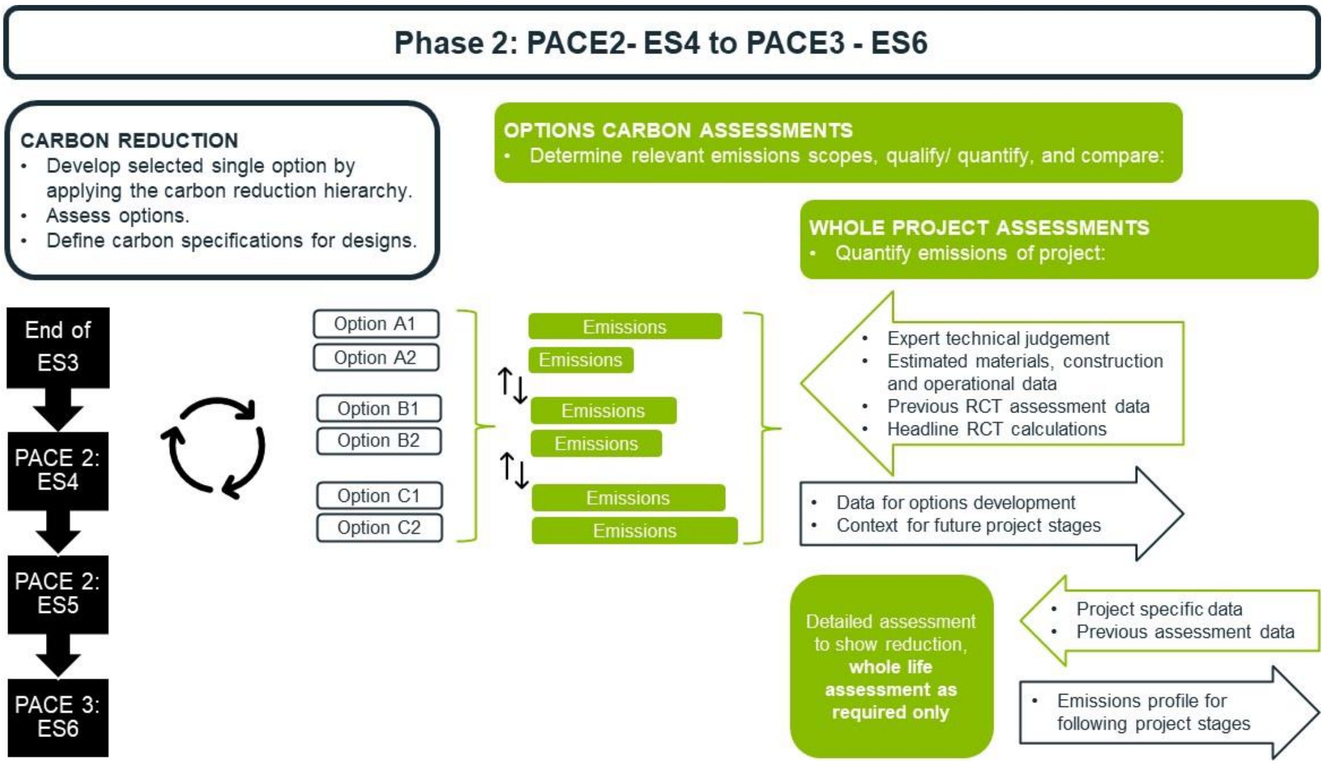
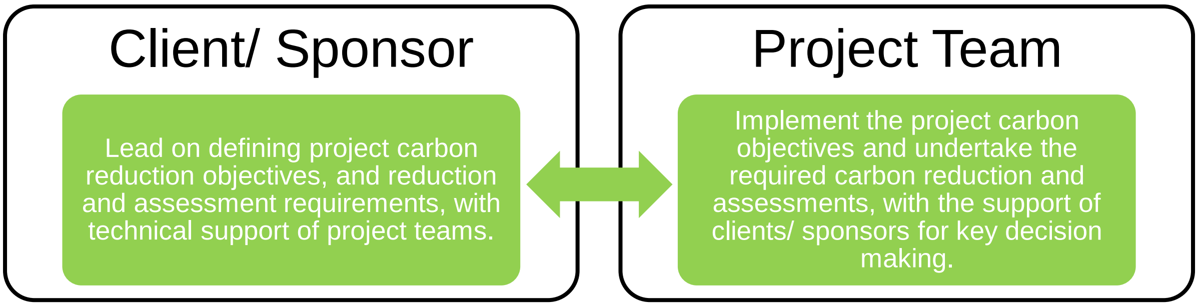


Figure 2: Phase 2 Process Outline

2.5 Headline Responsibilities

There are two key areas of responsibility for driving carbon reduction:



- Project clients/ sponsors have overall responsibility for carbon reduction because they have ultimate control of overall infrastructure development, the technical scope, needs and objectives of a project, and therefore what project carbon reduction and assessments should to be undertaken.
- Project teams have responsibility for implementation due to their direct control of projects.

Beyond these headline responsibilities, the following sub-sections provide further details.

2.5.1 Client/ Sponsor

As part of initiating implementation of this guidance on each project, the client/ sponsor should:

- Engage with Engineering Services to strategically understand the requirements in this guidance; and
- Engage with each project team to determine the project-specific carbon reduction and assessment objectives to be set, which will then be defined in the project Remit.

2.5.2 Client/ Sponsor AND Project Teams

The client/ sponsor and project team should collectively understand what is possible, or needed on each project, taking account of:

- Overall infrastructure carbon reduction possibilities;
- The existing scenario and operational need to be addressed;
- Available engineering options and associated carbon reduction opportunities, and therefore the design, procurement and construction changes to be pursued;
- Previous carbon reduction knowledge and assessment data;
- Programme; and
- Resource

Both the clients/ sponsors and project teams should prompt each other for this engagement to ensure they carry out their responsibilities and define appropriate project carbon objectives, and reduction and assessment requirements.

2.5.3 Project Teams

It is the responsibility of the project manager and the relevant engineering lead (e.g. design manager, discipline CRE, CRM, etc) on each project to determine specific responsibilities for each action within the carbon reduction and assessment processes defined in section 2.6, and the project-specific objectives and requirements. Beyond these headline responsibilities details, specific responsibilities are as follows:

- Principal Engineers should have overall discipline-specific responsibility for reduction, aligned with the project carbon objectives, reduction and assessment requirements

- Senior engineers should lead on direct implementation and communicating lessons learned.
- For multi-disciplinary projects, the Systems Engineer should ensure that increases and decreases in carbon emissions caused by different disciplines are understood and balanced out, as far as possible.
- The project manager, engineering lead and procurement manager should ensure that contractually and administratively any carbon reduction information and carbon assessments will be:
  - Shared from one participating organisation to the next across each engineering stage; and
  - In a format and tool that is in a fully transferable, accessible and editable.

2.5.4 Updates

Beyond the roles in sections 2.5.1 and 2.5.3, there is currently insufficient knowledge of project carbon reduction and assessment (*until this guidance has been put into practice*) to detail the responsibilities for implementing carbon reduction and assessment directly on projects, but also with clients/ sponsors and across other supporting functions, such as Design Research Group (DRG).

Given this, these sections 2.5.1 and 2.5.3 will be updated and expanded once further clarifications are identified.

2.6 Carbon Reduction and Assessment Processes

The specific processes for carbon reduction and assessment across pre-PACE and the PACE Engineering Stages are set out in the following landscape pages. These provide the specific instructions for each stage in accordance with the overview provided in section 2.2.

Pre-PACE

Carbon Reduction:

- As part of project development and as required or where possible, use high-level proxy or headline carbon assessments to establish the key carbon emissions of:
  - The existing scenario (i.e. the project baseline); and
  - Each project proposal, as each is identified.
- Review the emissions profiles of the project baseline and each proposal and determine:
  - The highest to lowest order;
  - An understanding of how they align with other project metrics; and
  - How each metric should be prioritised/ applied during proposals comparisons.
- Use the knowledge gained from the emission profiles and priority of metrics to inform decision making for advancing or deselecting each proposal, or elements of them;
  - Repeat the above steps as required, as each proposal is identified and developed.
- Where development leads to descoping the overall project, document the carbon benefits in the Save report; use additional carbon assessments to inform this, as required.
- For each proposal being developed, apply the carbon reduction hierarchy within development, and as required use proposal-specific options assessments to inform this.
- Log the carbon reduction opportunities and decisions for all proposals in a pre-PACE Design Decision Log, or equivalent.
- Ensure the pre-PACE carbon reduction knowledge and assessment data is fully passed to the next project stage via the outputs, and any separate documents and data sharing, as required.

Carbon Assessment:

Baseline and proposal carbon assessments may not be possible at this stage due to lack of data or definition of the baseline and proposals, which limits decision making. Where this is the case, the implications should be identified, documented, and actions defined to address them in future project stages.

Where baseline and proposal assessments are to be undertaken, they will be carried out as defined in the following bullets, and further detailed in section 3.3 and 3.4. All assessments should be designed to be quick, potentially taking only a matter of seconds or minutes (i.e. proxy or headline assessments), and the headline methodology then documented after they have been completed, for transparency and repeatability.

- Identify the full range of the infrastructure and operational scenarios and associated emissions to be considered. These will potentially include significant and very different emissions sources, but be very high level, e.g. comparison of freight train traction power use based on distance travelled, and infrastructure construction, operation and maintenance based on overall industry knowledge of emissions quantities for new build.
- Identity the knowledge and proxy data, or extremely high-level quantification to be used to determine the comparative or actual magnitude of the emissions concerned. Quantitative assessment can be used, using the RCT where required/ possible, including use of previous project data, if available.
- According to the identified scenarios and associated qualitative and/or quantitative data, determine the comparative magnitude of emissions for the project baseline, each proposal and/or option within a proposal.
- Document the assessment undertaken once complete with the appropriate level of detail, a very short note will suffice.

Where proposal-specific options assessments are required they should be undertaken according to the methodology specified for ES4 options assessments.

Pre-PACE Outputs: For projects that are to be progressed, define the carbon context in the Remit covering:

- Description of the carbon emissions of the project baseline and each proposal, issues and opportunities identified, how they were considered, and decisions made, i.e. a straight-forward explanation of the overall project carbon context according to the carbon intelligence that is developed.
- Design Decision Log, or equivalent details.
- Details of any assessments undertaken, if applicable.
- Next steps for ES1 based on knowledge gained from pre-PACE development and by considering overall requirements for ES1 - ES6, as far as possible.

For projects that are descoped, define the carbon savings achieved in the Save report.

ES1

Carbon Reduction:

- Continue with the carbon reduction initiated in pre-PACE by undertaking further iterations of the pre-PACE Carbon Reduction requirements defined above; OR
- Where there has been no consideration of carbon prior to ES1, simply undertake the first iteration of the pre-PACE carbon reduction requirements.
- Start to define the expectations for carbon reduction and assessment to be undertaken in the subsequent Engineering Stages, according to the knowledge and data gained during pre-PACE and ES1, and the latest wider rail carbon reduction knowledge and assessment data, i.e. start to define the project carbon reduction and assessment objectives.
- Ensure the ES1 carbon reduction knowledge and assessment data is fully passed to the next project stage, via the outputs, and any separate document and data sharing, as required.

Carbon Assessment:

- According to the carbon assessment needs for ES1, further develop any pre-PACE carbon assessments, OR initiate new assessments using the method defined for pre-PACE.
- Where assessments are further developed, according to more detailed needs and better data availability, update the methodology accordingly.

ES1 Outputs: As required, update project carbon context in reference design documents covering:

- Pre-PACE Output details, as above.
- Project carbon reduction and assessment principles.
- Update of next steps for ES2 based on further knowledge and any clarification of requirements for ES2 – ES6.

ES2

Carbon Reduction:

- Undertake feasibility assessments of the proposals, and options within them, with consideration of the:
  - Carbon reduction hierarchy; and
  - Proxy or headline carbon assessments.
- As required, directly use or update any pre-PACE and ES1 assessments, or undertake new assessments for each proposal and relevant project option, to support the feasibility assessments.
- As required, update the highest to lowest order of the proposals according to their carbon emissions, and how they are to be prioritised against the other project metrics.
- Update the recorded carbon reduction opportunities and decisions for all proposals in a Design Decision Log, or equivalent, according to latest developments in ES2.
- Update the project objectives for carbon reduction and assessment according to the outcomes of ES2.
- Ensure the ES2 carbon reduction knowledge and assessment data is fully passed to the next project stage, via the outputs, and any separate documents and data sharing, as required.

Carbon Assessment:

- According to the carbon assessment needs for ES2, initiate new assessments, OR further develop any pre-PACE and ES1 carbon assessments, using the methods defined for pre-PACE.

ES2 Outputs:

- As required, update the project carbon details generated in pre-PACE and ES1 in the Options Assessment/ Feasibility Report and add details of:
  - Feasibility assessment findings, decisions and project carbon priorities.
  - Update the project carbon reduction and assessment objectives.
- Update of next steps for ES3 based on further knowledge and any clarification of requirements for ES3 – ES6.

ES3

Carbon Reduction:

- Develop the project proposals and options within them, as required with consideration of the:
  - Carbon reduction hierarchy; and
  - Proxy or headline carbon options assessments.
- As required, directly use or update any pre-PACE, ES1 or ES2 assessments, or undertake new assessments for each proposal and relevant detailed design options, to support the options assessments.
- Undertake single option selection, with consideration of the carbon performance of each proposal, aligned with the other relevant project metrics and the priority of each.
- Finalise the project objectives for carbon reduction and assessment according to the outcomes of ES3.
- Update the recorded carbon reduction opportunities and decisions for all proposals in a Design Decision Log, or equivalent, according to latest developments in ES3.
- Where is it deemed necessary, produced a detailed whole project assessment of the selected single option, according to the level of data available. If needed, this will then function as the design baseline for measuring improvements during ES4 and ES5.
- Ensure the ES3 carbon reduction knowledge and assessment data is fully passed to the next project stage, via the outputs, and any separate documents and data sharing, as required.

Carbon Assessment:

- According to the carbon options assessment needs for ES3, initiate new assessments, OR further develop any pre-PACE, ES1, or ES2 assessments using the methods defined for pre-PACE. However, it is important to ensure that where options assessments become more complex that the assessment methodologies are updated accordingly, including use of the ES4 options assessment method defined in ES4 below.
- For the detailed design baseline, produce a quantification methodology according to BS EN 17472 and undertake the whole project carbon assessment accordingly, where required.
  - Use methodologies and assessments from previous projects for consistency and efficiency, where at all possible.
  - Where a previous RCT assessment is to be reused, even from a previous project stage, it must be copied and updated, rather than directly editing any previously assessment.

ES3 Outputs:

- ES3 carbon assessment report covering:
  - Summary of carbon background from Pre-PACE to end of ES3.
  - Carbon reduction and assessment details, including project baseline assessment, if carried out.
  - Justification for selecting the single option and specific carbon requirements for ES4.
- Include a carbon summary in Options Selection Report.

ES4

Carbon Reduction:

- Develop the selected single option and as required:
    - Apply the carbon reduction hierarchy; and
    - Undertake proxy or headline options carbon assessments.
- Log carbon reduction opportunities identified from applying the carbon reduction hierarchy and decisions in a Design Decision Log.
- Document design specifications with necessary details to ensure carbon reduction solutions will carry through and continue to be realised in ES5.
- Update the design baseline, where created and as required, where improved detail is possible and will enable more enhanced definition of improvements when compared to the ES4 design; the preference should be to avoid this unless necessary.
- Demonstrate the reductions achieved, by either assessing each carbon reduction and comparing them to the baseline, or carry out an ES4 whole project carbon assessment and comparing this to the project baseline to highlight the savings achieved. This should avoid excessive detail and always only be done to a sufficient level of accuracy.
- Ensure the ES4 carbon reduction knowledge and assessment data is fully passed to the next project stage, via the outputs, and any separate document and data sharing, as required.

Carbon Assessment:

- Options assessments will be carried out similarly to the project proposal assessments defined for the Pre-PACE carbon assessments. The primary objective is that they are quick and only sufficiently accurate and comprehensive to correctly inform decision making. They should be carried out as follows:
    - Determine the representative objects and activities to be considered, and associated emissions, ensuring the balance of comparisons will be equal.
    - Select a calculation method ranging from: using expert technical judgement to determine emissions proportions; using engineering and operational data to directly indicate emissions quantities; to numeric calculations using suitably indicative estimated or actual project data; or combinations of all three methods, i.e. a range of proxy or headline assessments with varying degrees of complexity, but remaining simple.
    - Briefly record the emissions taken into consideration, how they were determined and the decision make, such that they are repeatable for confirming reductions at the end of the engineering stage.
- Where the design baseline update or ES4 whole project assessment are to be undertaken, produce a quantification methodology according to BS EN 17472 and undertake the whole project carbon assessment accordingly, where required.
    - These should use the design baseline methodology and assessment, or methodologies and assessments from previous projects for consistency and efficiency, where at all possible.
    - As stated in the ES3 Carbon Assessment above, any previous RCT assessment to be reused must only ever be copied and updated.

ES4 Outputs:

- Design carbon specifications.
- ES4 Carbon Report covering project carbon background and carbon reduction and assessment details, including project baseline update and ES4 assessment, if carried out.
- Next steps for ES5.

ES5

Carbon Reduction:

- Continue to develop the selected single option, and where opportunities remain:
  - Apply the carbon reduction hierarchy; and
  - Undertake proxy or headline options carbon assessments, as required.
- Update then carbon reduction opportunities and decisions in a Design Decision Log, as required.
- Document design specifications with details and clauses sufficient to ensure lower carbon reduction will be transferred to procurement and realised in construction.
- Update the design baseline, where created and as required, where improved detail is possible or needed for more enhanced definition of improvements when compared to the ES5 design; the preference should be to avoid this unless necessary.
- Demonstrate the reductions achieved (avoiding excessive detail and always only to a sufficient level of accuracy), by either:
  - Assessing each carbon reduction and comparing them to the baseline, or
  - Update the ES4 whole project carbon assessment for ES5, or
  - Carry out a new ES5 whole project carbon assessment.
- Use the outputs from which ever type of assessment is undertaken to highlight the savings achieved across ES5.
- Ensure the ES5 carbon reduction knowledge and assessment data is fully passed to the next project stage, via the outputs, and any separate document and data sharing, as required.

Carbon Assessment:

- Carry out both options assessments, as specified for ES4.
- Where the design baseline update or ES5 whole project assessment are to be undertaken, produce a quantification methodology according to BS EN 17472 and undertake the whole project carbon assessment accordingly, where required.
  - These should use the design baseline or ES4 methodologies and assessments, or methodologies and assessments from previous projects for consistency and efficiency, where at all possible.

ES5 Outputs:

- Design carbon specifications.
- ES5 Carbon Report covering project carbon background and carbon reduction and assessment details, including project baseline update and ES5 assessment, if carried out.
- Next steps for ES6.

ES6

Carbon Reduction:

- Where sufficiently significant changes occur, as required apply the carbon reduction hierarchy to change planning and assess options as necessary.
- Demonstrate the reductions achieved (avoiding excessive detail and always only to a sufficient level of accuracy), by either:
  - Assessing each carbon reduction and comparing them to the baseline, or
  - Update the ES5 whole project carbon assessment for ES6, or
  - Carry out a new ES6 whole project carbon assessment.
- Use the outputs from which ever type of assessment is undertaken to highlight the savings achieved across ES6.
- Ensure the ES6 carbon reduction knowledge and assessment data is fully documented, via the outputs, and any separate document and data sharing, as required, to ensure knowledge and data transfer to future projects.

Carbon Assessment:

- Carry out options assessments, as specified for ES4.
- Review and update ES5 methodology for ES6 (minimal change expected).
- Copy and update ES5 whole project carbon assessment for ES6.

ES6 Outputs:

- Update ES5 Project Carbon Assessment Report to ES6 report, according to the changes.

CARBON ASSESSMENT METHODOLOGIES AND RAIL CARBON TOOL USE

3. CARBON ASSESSMENT METHODOLOGIES AND RAIL CARBON TOOL USE

This section sets out how to undertake carbon assessments and use the RCT, expanding on the carbon assessment instructions provided in section 2.6 for each PACE and Engineering Stage. Specifically, it:

- Provides a clear overview on what a carbon assessment is, the different types of assessment, how they are carried out and the uses for them.
- Defines technical clarifications and requirements to be taken into consideration.
- Provides examples for each type of assessment, covering use of the RCT.
- Set out headline instructions for undertaking an assessment in the RCT, ahead of the details provided in the RCT User Guide.

3.1 Carbon Assessment Overview

The headline points for all carbon assessments are:

- As stated in section 2.3 and referred to in section 2.6, carbon assessments will be one of three types:

A Proxy Assessments

B Headline Assessments

C Detailed Assessments

- They all have a common methodology, as follows:

  - Define assessment purpose, in particular audience and end use.
  - Identify the assets, activities and timeframe to be accounted for.
  - Identify the emissions to be assessed for the included assets, activities and timeframe.
  - Plan how the emissions will be calculated and compared (where required), using either qualification and/ or quantification.
  - Undertake and use the assessment according to how it has been planned.

,

- The differentiating characteristics across the three types of assessment are:
  - Low to high levels of granularity;
  - Low to high levels of accuracy; and
  - Small to large time needs to undertake the assessment.

3.1.1 Assessment Details and Uses

The specific details for each type of assessment, and the primary uses are as set out below. Section 3.3 - 3.5 then provide examples with further instructions for each type of assessment and where applicable how to use the RCT to undertake them.

Further to the details provided here, is important to recognise that for the current level of maturity this guidance cannot answer all relevant questions. Further technical support is still therefore likely required to plan project-specific assessments, but that should now be possible with much greater clarity and ease using this guidance.

A Proxy Assessments

Characteristics:	These are the fastest and least detailed type of assessment, using qualitative information, rather than calculation and very possibly taking only seconds or a couple of minutes.
Approach:	Use expert technical judgement and intellectual reasoning, either with oneself or verbally to others to carry out an assessment.
Emissions Calculation:	Define scope, timeframe and emissions using technical reasoning. Qualify emissions using technical reasoning based on expert technical judgement, or using estimated or actual asset and activity data.
Uses:	Proxy assessments are primarily used for immediate knowledge gain and decision making, where detail is least important. They prioritise fast assessment and knowledge development. They can be undertaken in someone's head in a matter of seconds or minutes, using intellectual reasoning for both high-level decision making such as in pre-PACE planning, all the way through to asset specific options considerations.

B Headline Assessments

Characteristics:	Headline assessments are still fast, high-level assessments, but involve quantification, and take a few minutes to a few hours to carry out.
Approach:	Use expert technical judgement and representative asset and activity data.
Emissions Calculation:	Define scope, timeframe and emissions using technical reasoning. Generate data using estimated or actual asset and activity data. Quantify emissions in any format, from simple written mathematics using mental arithmetic, to Excel calculations, to calculations in the RCT.

Uses:	Headline definition of critical emissions sources, where quantification is required for sufficient clarity. Comparison of differing assets and activities, where comparison of indicative data for the same materials and activities is not possible. Knowledge development to inform understanding and decision making, where accuracy has more importance due to need for greater assurance, or to accommodate comparison of differing or more complex assets.

C Detailed Assessments

Characteristics:	Detailed quantified modelling taking anything from hours, to days, to weeks to carry out.
Approach:	Carry out detailed calculations according to BS EN 17472.
Emissions Calculation:	Produce a written calculation methodology. Fully document calculations in the RCT, including detailed data collection, data preparation datasets, and RCT data entry.
Uses:	Detailed assessments are used to obtain formal, comprehensive understanding of the carbon profiles for assets or projects, to demonstrate and report project carbon emissions and reductions, including: • Against carbon reduction targets; and to • Inform more extensive development planning. They are specific technical exercises using the RCT. A detailed, quantified RCT assessment will require specific data collection, data preparation, RCT data entry and robust referencing, and will take hours, days or even weeks to produce, depending on the project size and level of granularity to be included.

3.2 Technical Clarifications and Requirements

Section 2.2 of this guidance sets out principles for carbon reduction and assessment. Further to those, additional technical clarifications and requirements should be taken into account specifically for carbon assessments, as follows:

1	Ensure purpose includes identification of audience and end use.	This point repeats the same point made in section 2.2 due to its critical importance. It is essential that the audience and end use of every assessment is clearly established and used to inform the assessment purpose. Overall, clients/ sponsors should be owning results, ensuring they have clear access to them and taking them into consideration in their management, at project and strategic levels.
2	Assessment accuracy depends on the following four elements, not just the carbon factor values used: 1. Scope 2. Project data 3. Carbon factor values 4. Calculation correctness All four should be considered when planning an assessment.	There is a common assumption that the accuracy, and therefore comparability of carbon assessments depends only on the carbon factor values used - this is incorrect. The numerical range across a specific set of carbon factor values, e.g. for steel, is often not that large, discounting exceptions. The much greater variables are assessment scope, project data and calculation correctness. It should be ensured that both appropriate and consistent scope and project data are used, as well as the correct carbon values, and that calculations are mathematically correct.
3	Assessments do not need to be detailed.	There is currently fairly significant uncertainty on the level of detail required for an assessment. It only needs to be sufficient to enable a correct decision or demonstration of performance and improvements.
4	Assessment accuracy is important, but suitability, consistency, and transparency are crucial factors, especially for comparability between assessments and reuse of project data.	Assessments do not need to be fully accurate to be effective for supporting both decision making and demonstration of performance and improvements. Often suitability of scope and data, transparency, and consistency are more important. Ensuring assessments are suitably representative through appropriate scope and data, and are comparable and reusable by way of good transparency and consistency are key elements of an effective assessment, compared to outright accuracy. An additional benefit of not pursuing detailed accuracy is that assessments can be undertaken more quickly, used more effectively, and can be more easily reused.

5	Good assessment structure and referencing are essential elements to ensure transparency and potential for data reuse.	Every assessment should be clearly defined by life cycle stage, then discipline, then individual item aligned with the relevant level of granularity. Data sources should also be clearly referenced. These are the primary factors for ensuring transparency and possibility for data reuse. These apply to all assessments, but to a greater degree to detailed quantified assessments over qualitative high level assessments. However, qualitative high level assessments can also require very clear definition, especially when used for major decisions.
6	Assessments are both a science and an art and should be planned accordingly:	As shown by both the principles in section 2.2 and the clarifications and requirements in this section, there are a range of points to be taken into consideration for carrying out an assessment that require a judgement call, as well as specific technical decisions. Undertaking carbon assessments that robustly inform planning and decision making, and enable carbon performance and reductions to be demonstrated is both a science and an art. • The science element involves following standards, consistent use of appropriate data, etc. • The art element involves determining the correct scope, appropriate data, granularity etc according to the purpose and type of assessment to be undertaken, and levels of technical maturity and data availability concerned. Each assessment should be planned with consideration of both these perspectives
7	One assessment can use both qualification and quantification.	Numerical data and qualified technical judgement can be used as part of a carbon assessment, especially those for options and headline assessments, as defined in section **Error! Reference source not found.** below.
8	Carbon factor values must be correctly selected and consistently used	Use the asset or activity definition and the carbon factor name/ details to determine which value to use: • The factor must relate to the emissions you are looking to quantify. • The correct factor to use is best identified by iteratively exploring the asset or activity to be quantified and the available carbon factors. • Practice and growing knowledge of the carbon factors will enable the correct one to be identified much more swiftly, and with comprehensive knowledge of carbon factors the correct value to use will be able to be determined immediately. Where a range of potential carbon factor value options exist, the correct value should be select according to the following: • Use the most applicable, in the following high to low priority order: 1) Product or activity specific; 2) Industry specific; 3) Generic.

		• Use the most recent value where different versions exist, or the version applicable to the timeframe being considered. • Select the middle value of range where there is uncertainty. Agree use of the same values across all comparable calculations. The separate Carbon Factor Viewer should be used to assist this. The Viewer is a downloaded copy of the RCT carbon factor library, in Excel format, that enables much easier review of the carbon factors and values.
9	One carbon package in an RCT Project Tree must only every represent one object or activity	Every carbon package must only ever be used to represent one object or activity, and calculations within a package (either as sub-packages or calculation) must only ever represent a single functional unit of the object or activity.
10	Life cycle stages must be used as shown opposite:	• The life cycle stages referred to by reference number A1 – D, are shown in Figure 3. • The type of works being undertaken determine the lifecycle stages to be used: • New Build: A1-5. • Replacements, or renewals: B4, and the following sub-stages: ▫ B4.1 Manufacturing of materials and components ▫ B4.2 Transportation of materials and components from primary manufacturing to site ▫ B4.3 Construction plant use for carrying out the required works ▫ B4.4 Construction compound operation ▫ B4.5 Waste transportation; and ▫ B4.6 Waste disposal. • A replacement, must not be defined as demolition, covering C1-4, plus new-build A1-5. A replacement (a.k.a a renewal) is effectively demolition and new-build. Using C1-4, and A1-5 over complicates data collection and separation for an assessment.

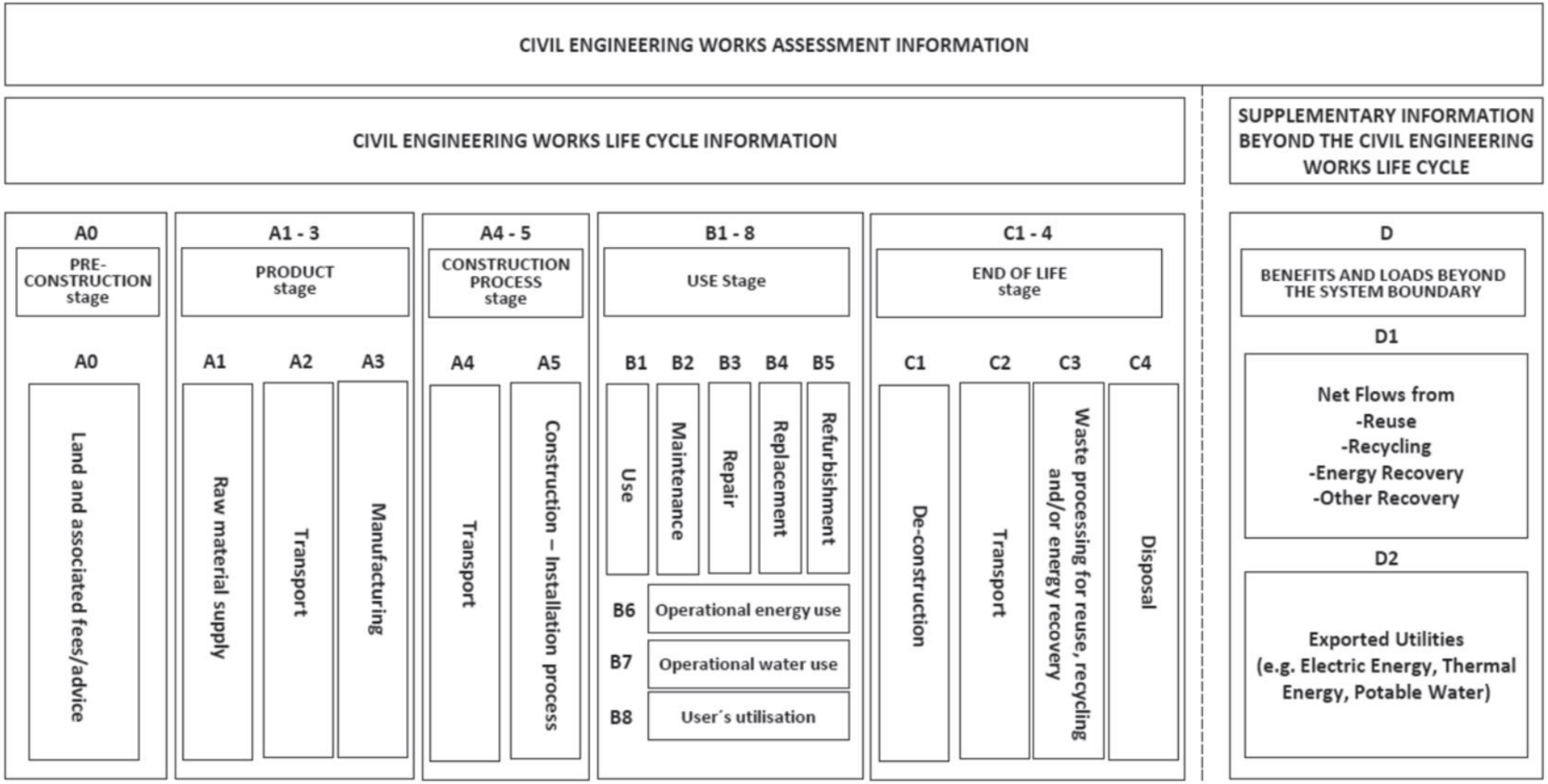


Figure 3: Carbon Emissions Life Cycle Stages[3]

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[3] BS EN 17472: Sustainability of construction works — Sustainability assessment of civil engineering works — Calculation methods

3.3 Proxy Assessment Examples

All of the examples in this section have been obtained via the technical development workshops used to prepare this guidance. They all consist of previous projects led by engineering and other project justifications, where carbon assessments were not undertaken. However, using the project data available, proxy carbon assessments have been used to demonstrate how such assessments are carried out and the carbon reductions achieved. This includes two full examples of proxy assessment as follows:

- Doncaster iPort: A freight capacity improvement project, requiring a carbon assessment for headline decision making at pre-PACE stage.
- Concrete Foundation Comparison: Asset options comparison requiring carbon assessment for detailed design development.

It also includes various other more concise examples and discussion points on level crossing and footbridges.

Doncaster iPort

Project Stage:	Pre-PACE
Scenario:	Infrastructure works had been proposed to provide a new run-round facility in Decoy Up Yard at a cost of circa £4,000,000, to accommodate 650m long trains, divert them away from St James Junction and Hexthorpe, and to provide a route between iPort and the Scunthorpe line that avoided crossing the ECML at Doncaster Station. The Engineering Services Design Delivery (ESDD) engineers proposed an alternative solution that would completely avoid infrastructure changes and enable the additional, longer trains to run within a few weeks: instead of using Up Decoy solution (c. £4,000,000), run the trains into the former Royal Mail Terminal yard, release the loco via Belmont Hump and run-round using the Up Flyover line. This would: • Save about 20 minutes of journey time for each train; • Avoid the need for infrastructure works; • Remove their impact from St James Junction; and • Accommodate 650m long trains.
Assessment Purpose:	The purpose of the assessment is to demonstrate the proposed alternative solution has the lowest carbon emissions.
Assets, Activities and Timeframe:	Project Proposal 1: Decoy Up Yard: • New infrastructure construction, renewals and maintenance over 60 years • Operation of the trains over 60 years. Project Proposal: Use of Royal Mail Terminal Yard. • Operation of the trains over 60 years.

Emissions:	Project Proposal 1: Decoy Up Yard: • Materials, transport and construction works for the new infrastructure (A1-5) • Materials, transport and construction works for maintenance and renewals (B2-4) • Fuel use for operation of the trains (B8) Project Proposal 2: Use of Royal Mail Terminal Yard • Fuel use for operation of the trains (B8)
Emissions Calculation:	The only information and data available is: • A defined need for new track, and • Indication of higher or lower traction power use for each scenario as defined by the operating difference for each proposal. The infrastructure construction, renewals and maintenance emissions do not need quantifying as it can be qualified that proposal 1 will be higher carbon by way of needing new infrastructure, versus proposal 2 not needing any infrastructure. The traction power emissions can be qualified by way of proposal 2 avoiding 20 mins of train operation, minus the loco run-round.
Assessment findings:	Proposal 2 will result in lower emissions by way of avoiding the need for infrastructure and lower traction power usage.
Notes:	If quantification is needed: • Infrastructure emissions could be calculated using generic track construction works calculations, using data generated from standard designs and expert technical judgement. • Traction power emissions could be calculated using actual and estimated fuel usage by either actual fuel consumption (total litres of fuel), or locomotive fuel consumption rates and duration of use. This could be calculated with mental arithmetic, Excel or the RCT. The correct option should be selected according to the need, but the preference should be to use the RCT to maximise possibilities of data sharing and reuse.

Concrete Foundation Comparison

Project Stage:	Engineering Stage 4
Scenario:	Design, for construction of new overhead line electrification foundations.
Assessment Purpose:	Determine which foundation is lower carbon.
Assets, Activities and Timeframe:	Option 1: 1.1 m^3 Concrete Foundation • New infrastructure construction, renewals and maintenance over 60 years Option 2: 0.7 m^3 Concrete Foundation • New infrastructure construction, renewals and maintenance over 60 years
Emissions:	Option 1: 1.1 m^3 Concrete Foundation • Materials, transport and construction works for the new infrastructure (A1-5) • Materials, transport and construction works for maintenance and renewals (B2-4) • Option 1: 0.7 m^3 Concrete Foundation • Materials, transport and construction works for the new infrastructure (A1-5) • Materials, transport and construction works for maintenance and renewals (B2-4) Both options have the same engineering performance.
Emissions Calculation:	The only information and data available different sizes of foundation. None of the emissions need to be calculated as the difference in emissions can be deduced by qualification. Options 2 will require less materials, transport and construction for initial build, and there will be no difference in maintenance and renewals, as none are required for either.
Assessment findings:	Options 2 is lower carbon by way of less construction emissions, as the only element needing consideration.
Quantification:	If quantification is needed, infrastructure emissions could be calculated using either: • Examples from previous calculations in the RCT that are then edited accordingly; • Known sizes of the foundations and estimated concrete type and rebar proportions. Given the simplicity of the calculations, unless RCT examples are known, it can be just as quick to undertaken specific calculations.

3.3.1 Simple Proxy Assessments

Project	Project Situation	Proxy Assessment
Birmingham Station Full OLE Auto-Tensioning Due to Heat Sagging	Route Services demonstrated that only partial auto-tensioning was required, for the wires exposed to heat.	Less auto tensioning installation, is less use of materials, transportation of material and installation works, and is therefore a lower carbon solution.
Earth Works Scheme	Earthworks required for stabilisation.	Ground investigation undertaken to proving that earthworks were not required. Minimal carbon emissions resulting from travel to sites, and investigations. However, carbon emissions avoided from avoided materials use, transportation of material, and construction works, which would be significantly greater than site investigation works
St James Station, Liverpool Upgrade	Installation of two new platforms required. Original proposal was for reboring the tunnel, and installation of parallel platforms. Revised proposals were for staggered platforms, with track realignment.	No change to overall platform sizes. Track works required whether realignment, or bored tunnel solution. Avoidance of tunnel boring is significant reduction of new construction works, and therefore is significantly lower carbon.
Scotland OLE Design Standards	Standards revised for: • Increased span length so fewer structures. • Reduced foundation depth requirements. • Reduced electrical clearances, so fewer route clearances.	All changes are reduction of new construction works and are therefore lower carbon.

3.3.2 Level Crossing and Footbridges

These level crossing and footbridge examples are provided on the basis that they were a focal point of discussion in the workshops, and because they provide a good demonstration of:

- How simple understanding of fairly complex carbon contexts can and needs to be, including comparison to other project metrics; and
- The basis for establishing scope for quantified options and scenario comparison, should quantified understanding be required.

They are provided in a narrative format, aligned with the information available.

- Level Crossing Closures and Public Right of Way (PRoW) and Active Travel Needs
    - Two level crossings that are notoriously dangerous are to be closed for safety reasons. However, they include is a high priority public right of way (PRoW) and the route needs to be compliant with active travel requirements, and will be replaced with a footbridge.
    - Construction of the footbridge will incur carbon emissions. However, this is potentially significantly off set by avoided car travel that would otherwise occur.

    - Moreover, the PRoW and active travel benefits are priority metrics when compared to the likely small carbon emissions from constructing the footbridge and the likely greater reduction of carbon emissions from avoided car use.
- Strategic Context for all Footbridge
    - Every footbridge that off-sets car usage will likely have a positive carbon benefit over its lifetime, due to the small impacts from construction and maintenance in comparison to on-going avoided car usage.
    - Moreover, conversion to a footbridge from a level costing could increase active travel due to the safer route option.
    - The carbon emissions or construction of a footbridge with stairs and ramps compared to a footbridge with stairs only will be lower carbon to produce as less materials and construction are require. However, it could create greater mode-shift through more active travel. Additionally, the social value benefits could supersede any carbon impacts being a deciding factor.
    - All of the above could be determined for one example project, and this standard justification used for all relevant future projects.

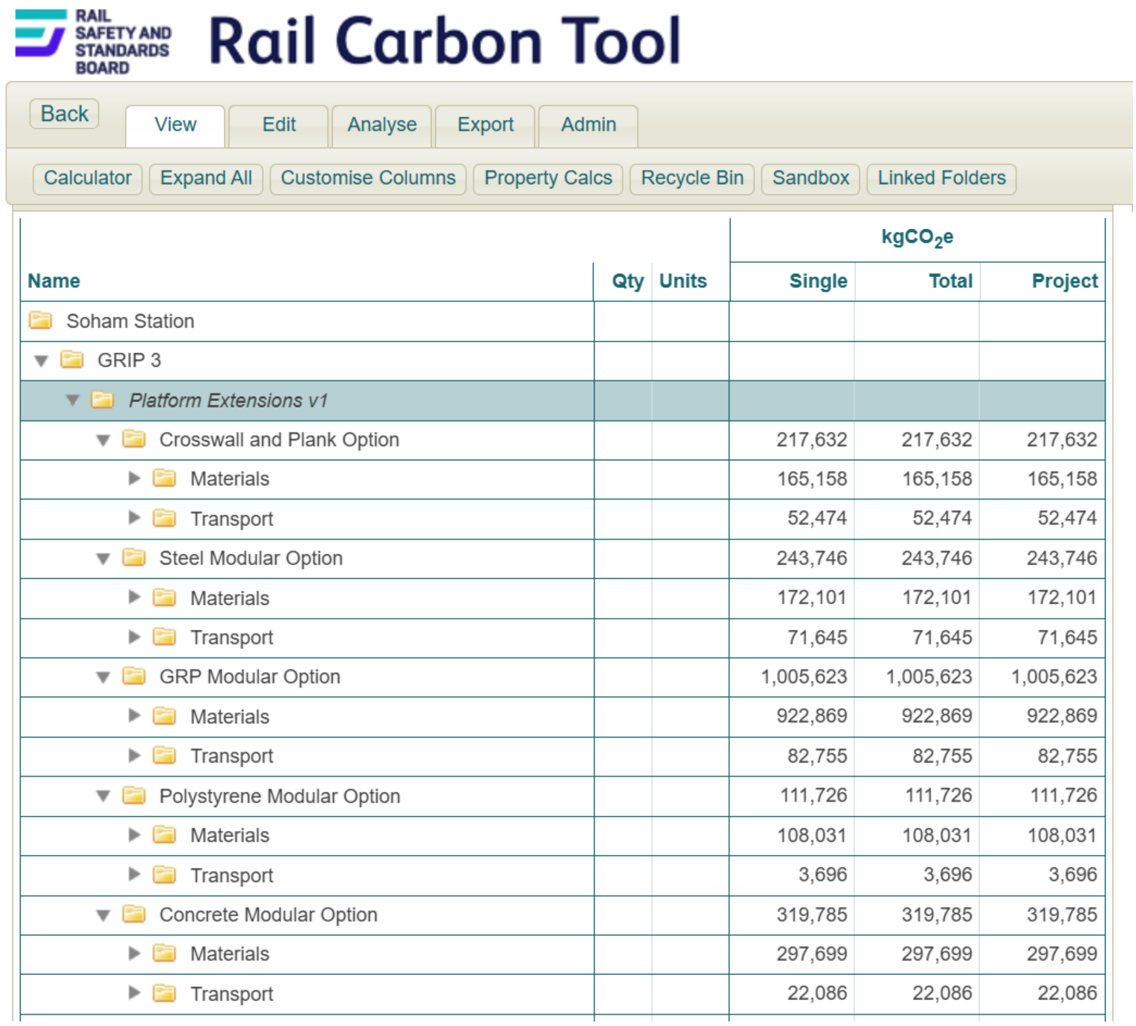
3.4 Headline Assesssment Examples

Two headline assessment examples of are provided here:

- Soham Platform Option Comparison: A station upgrade project requiring a carbon assessment for at ES3 for the five different platform options being considered.
- Concrete and Steel Foundation Comparison: Asset options comparison requiring carbon assessment for detailed design development, where the design varies sufficiently that a proxy assessment is not feasible.

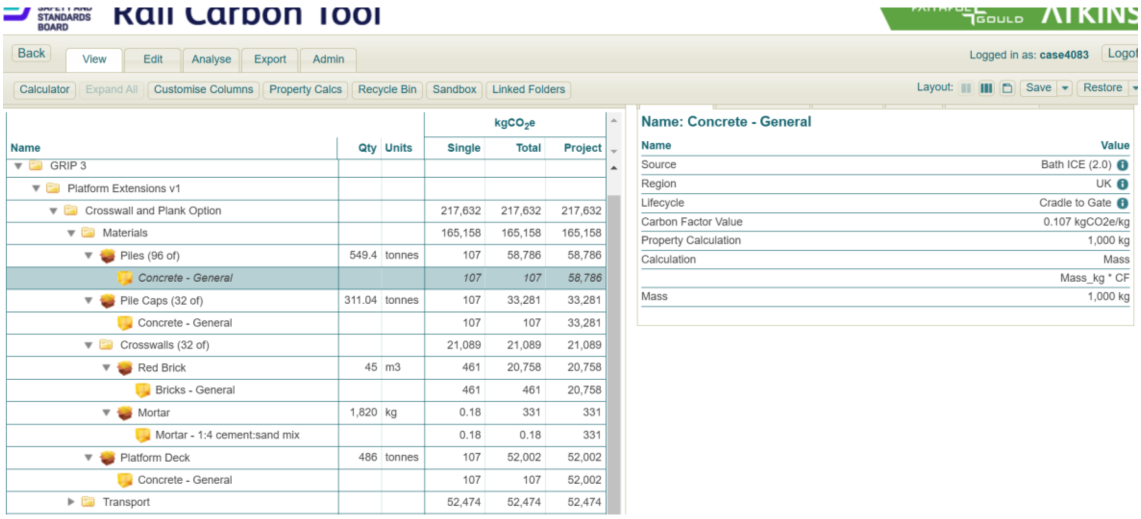
Soham Station Platforms Comparison

Project Stage:	Engineering Stage 3
Scenario:	Soham station is to be reopened and new platforms are required.
Assessment Purpose:	Five platform designs are to be compared to determine their carbon performance to inform options selection alongside other decision-making metrics, e.g. cost.
Assets, Activities and Timeframe:	New infrastructure construction only for the following design options: Option 1: Crosswall and Plank Option 2: Steel Modular Option 3: GRP Modular Option 4: Polystyrene Modular Option 5: Concrete Modular
Emissions:	Materials and materials transport for new construction (A1-4) for all options. A5 was not included due to lack of data at the time.
Emissions Calculation:	Total quantities of materials for each element within each option were estimated using engineering technical judgement, and transportation was quantified using total mass from the materials calculations and assumed transport distance based on standard assumptions. Data for each option was prepared and entered into the RCT as a parallel calculation within a sub-section of a Project Tree. Figure 4 and Figure 5 show the folder and package structures used, and Appendix B shows the full calculation details, as a PDF report from the RCT. The folder, package and calculation structures were produced using the standard RCT functionality for these, as defined in the RCT user guide.
Assessment findings:	The polystyrene modular option was found to be lowest carbon.
Notes:	This assessment uses headline quantities, which are fast and simple to produce, but limits reuse.



Name	Qty	Units	kgCO$_2$e Single	Total	Project
Soham Station					
GRIP 3					
Platform Extensions v1					
Crosswall and Plank Option			217,632	217,632	217,632
Materials			165,158	165,158	165,158
Transport			52,474	52,474	52,474
Steel Modular Option			243,746	243,746	243,746
Materials			172,101	172,101	172,101
Transport			71,645	71,645	71,645
GRP Modular Option			1,005,623	1,005,623	1,005,623
Materials			922,869	922,869	922,869
Transport			82,755	82,755	82,755
Polystyrene Modular Option			111,726	111,726	111,726
Materials			108,031	108,031	108,031
Transport			3,696	3,696	3,696
Concrete Modular Option			319,785	319,785	319,785
Materials			297,699	297,699	297,699
Transport			22,086	22,086	22,086

Figure 4: RCT Structure for Soham Station Platform Options Comparison



Name	Qty	Units	kgCO$_2$e Single	Total	Project
GRIP 3					
Platform Extensions v1					
Crosswall and Plank Option			217,632	217,632	217,632
Materials			165,158	165,158	165,158
Piles (96 of)	549.4	tonnes	107	58,786	58,786
Concrete - General			*107*	*107*	*58,786*
Pile Caps (32 of)	311.04	tonnes	107	33,281	33,281
Concrete - General			107	107	33,281
Crosswalls (32 of)			21,089	21,089	21,089
Red Brick	45	m3	461	20,758	20,758
Bricks - General			461	461	20,758
Mortar	1,820	kg	0.18	331	331
Mortar - 1:4 cement:sand mix			0.18	0.18	331
Platform Deck	486	tonnes	107	52,002	52,002
Concrete - General			107	107	52,002
Transport			52,474	52,474	52,474

Name: Concrete - General

Name	Value
Source	Bath ICE (2.0)
Region	UK
Lifecycle	Cradle to Gate
Carbon Factor Value	0.107 kgCO2e/kg
Property Calculation	1,000 kg
Calculation	Mass
	Mass_kg * CF
Mass	1,000 kg

Figure 5: Crosswall and Plank Materials Calculation Structure Details

Concrete and Steel Foundation Comparison

Project Stage:	Engineering Stage 4
Scenario:	Design, for construction of new overhead line electrification foundations.
Assessment Purpose:	Determine which foundation is lower carbon.
Assets, Activities and Timeframe:	Option 1: 1.1 m^3 Concrete Foundation • New infrastructure construction, renewals and maintenance over 60 years Option 2: 5.5m Circular Hollow Steel Pile • New infrastructure construction, renewals and maintenance over 60 years
Emissions:	Option 1: 1.1 m^3 Concrete Foundation • Materials, transport and construction works for the new infrastructure (A1-5) • Materials, transport and construction works for maintenance and renewals (B2-4) Option 2: 5.5m Circular Hollow Steel Pile • Materials, transport and construction works for the new infrastructure (A1-5) • Materials, transport and construction works for maintenance and renewals (B2-4) Both options have the same engineering performance.
Emissions Calculation:	Dimensions of each pile is available as standard design information and calculation are undertaken in the RCT as a parallel calculations in a very simple Project Tree. Transportation is not calculated as it is assumed to be proportionally equal to the materials calculations. Construction is not considered, as insufficient information is available. Maintenance and renewals are not considered as none is required over the assessment period of 60 years. Figure 6 show the folder and package structures used, and Appendix B shows the full calculation details, as a PDF report from the RCT. The folder, package and calculation structures were produced using the standard RCT functionality for these, as defined in the RCT user guide.
Assessment findings:	The concrete foundation is shown to be significantly lower carbon, and the magnitude of the difference is sufficiently large, such that if construction calculations were included the difference in accounting for these emissions would not effect the result.

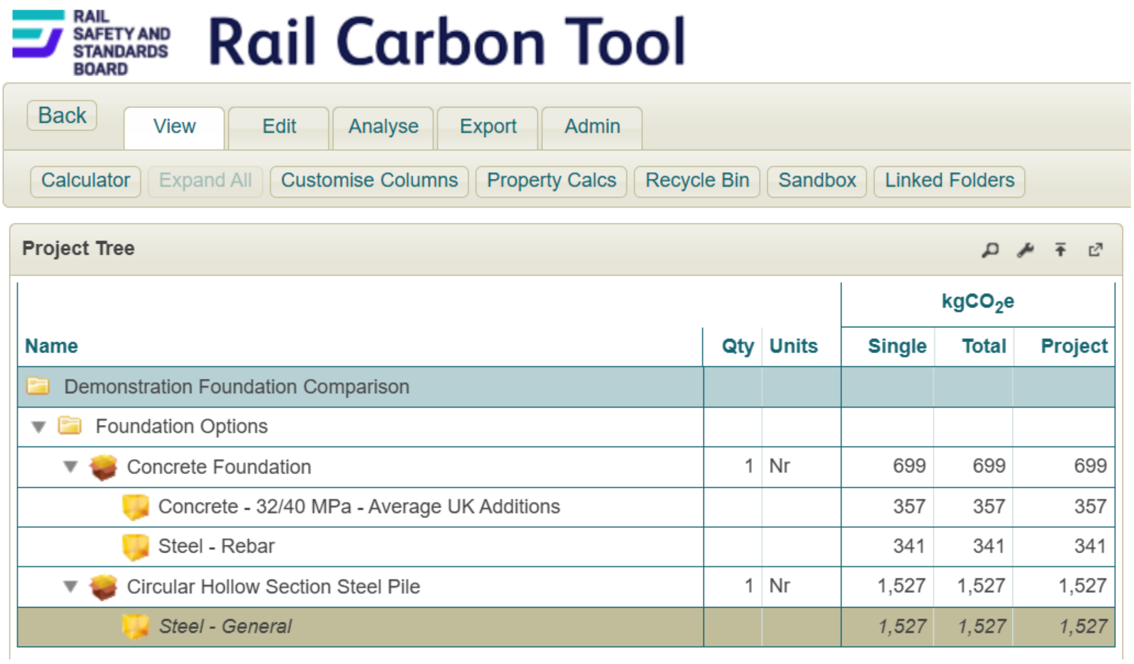


Figure 6: Foundation Comparison Structure Details

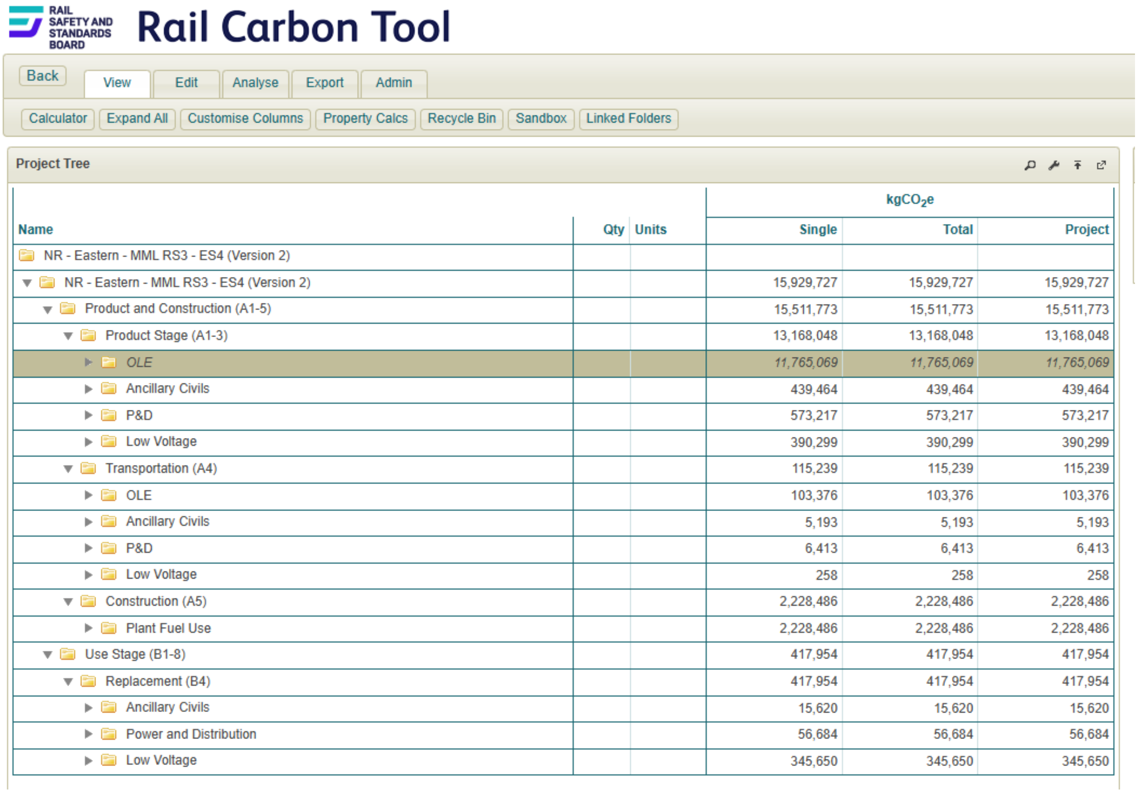
3.5 Detailed Modelling Examples

One detailed assessment example is provided here:

- Midland Mainline Route Section 3, Engineering Stage 4 Whole Life Assessment: This is simply a one-of whole project carbon assessment.

Midland Mainline Route Section 3

Project Stage:	Engineering Stage 4.
Scenario:	Installation of overhead line electrification (OLE) infrastructure.
Assessment Purpose:	Production and reporting of a whole project, whole life carbon assessment to fulfil project carbon requirements.
Assets, Activities and Timeframe:	New build and replacement of OLE infrastructure over a 120 design life covering: • OLE • Ancillary civils • Power and distribution • Low voltage systems
Emissions:	• Materials, transport and construction plant for the new infrastructure (A1-5) • Materials, transport and construction works for replacements (B4)
Emissions Calculation:	Various engineering data was used for materials calculations, including defined engineering sizes, measurements from drawings and estimated gross quantities using expert technical judgement. Quantities of materials transported was obtained directly from the material calculation in the RCT using the View > Property Calcs function, and transport distances were estimated. Construction plant use was estimated per day per item of plant, and the number of weeks and days of operation was also specified. Replacements were estimated using the total carbon emissions data for new build, as calculated for A1-5 above, and application of a percentage reduction for future manufacturing decarbonization. Figure 7 and Figure 8 show the folder and package structures used and example calculation details. Appendix D and Appendix E show further structure and calculation details, as a PDF report from the RCT.
Assessment findings:	The assessment presented the carbon profile of the scheme.
Notes:	The assessment and report follow the current pattern of project carbon reporting for Network Rail projects, whereby the output is generated as what is expected to fulfil the project carbon requirements, but there is no clear end use.



Name	Qty	Units	kgCO$_2$e Single	kgCO$_2$e Total	kgCO$_2$e Project
NR - Eastern - MML RS3 - ES4 (Version 2)					
NR - Eastern - MML RS3 - ES4 (Version 2)			15,929,727	15,929,727	15,929,727
Product and Construction (A1-5)			15,511,773	15,511,773	15,511,773
Product Stage (A1-3)			13,168,048	13,168,048	13,168,048
OLE			*11,765,069*	*11,765,069*	*11,765,069*
Ancillary Civils			439,464	439,464	439,464
P&D			573,217	573,217	573,217
Low Voltage			390,299	390,299	390,299
Transportation (A4)			115,239	115,239	115,239
OLE			103,376	103,376	103,376
Ancillary Civils			5,193	5,193	5,193
P&D			6,413	6,413	6,413
Low Voltage			258	258	258
Construction (A5)			2,228,486	2,228,486	2,228,486
Plant Fuel Use			2,228,486	2,228,486	2,228,486
Use Stage (B1-8)			417,954	417,954	417,954
Replacement (B4)			417,954	417,954	417,954
Ancillary Civils			15,620	15,620	15,620
Power and Distribution			56,684	56,684	56,684
Low Voltage			345,650	345,650	345,650

Figure 7: Midland Mainline Electrification ES4 Whole Assessment Headline Structure

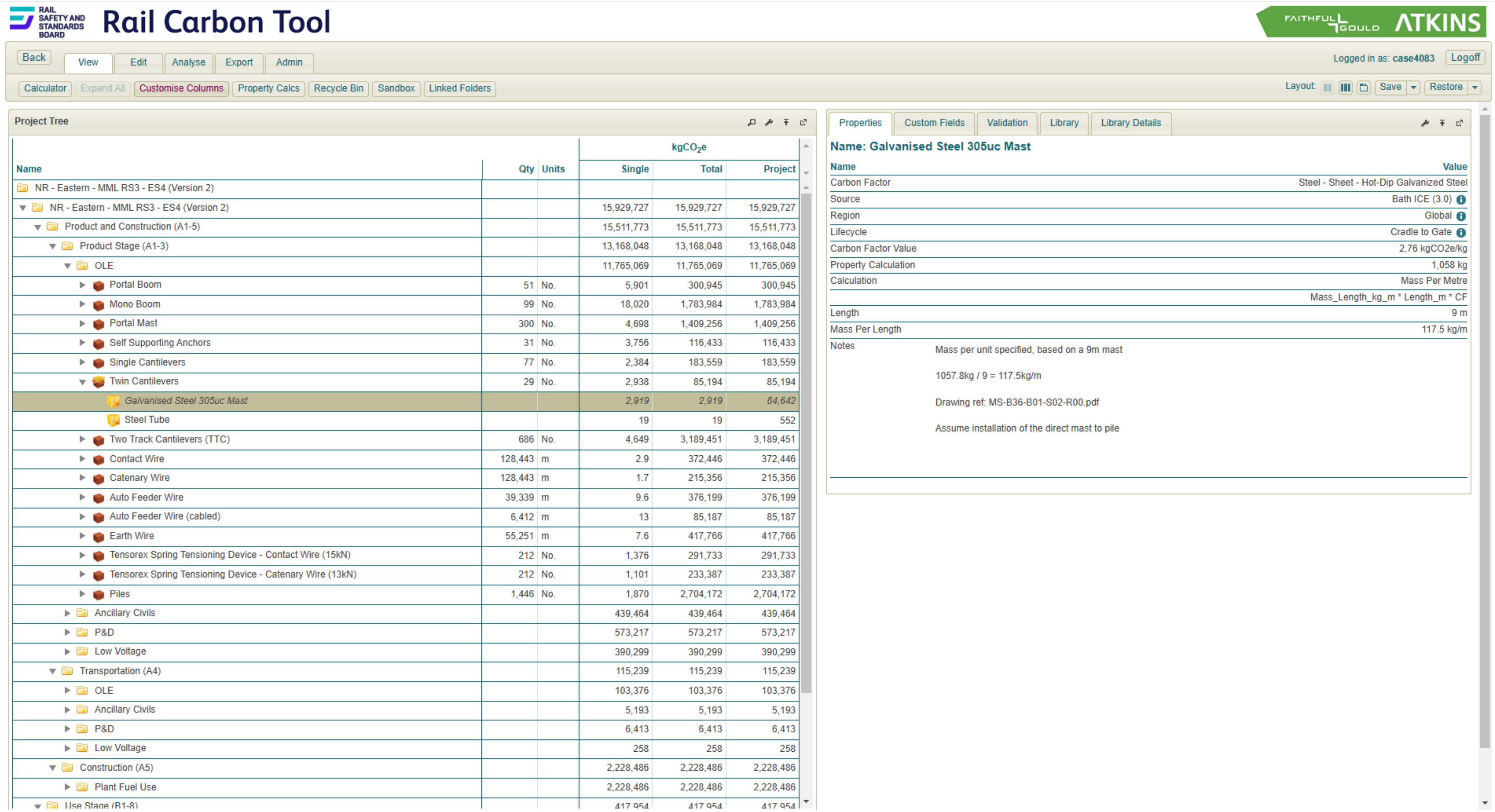


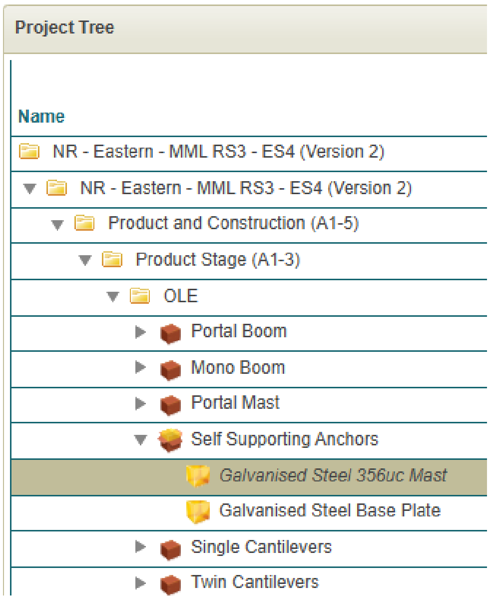
Figure 8: Midland Mainline Electrification Structure and Calculations Details and Referencing

3.6 Rail Carbon Tool Assessment Instructions

Assessments in the RCT must follow common rules, and a core format for either headline assessments, or detailed assessments.

3.6.1 Common Rules

- Create each calculation using the standard folder, package and calculation functionality, as required, and specified in the RCT User Guide.



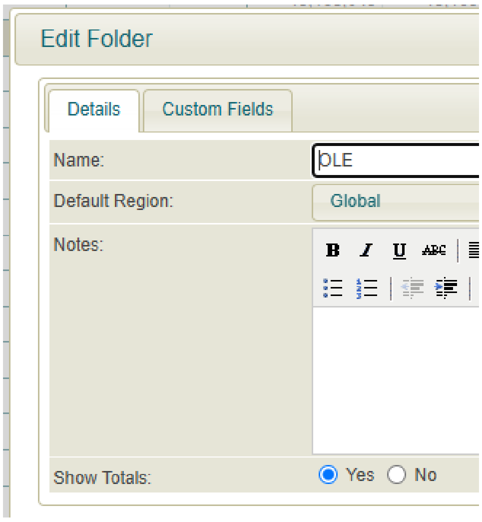
- Every RCT Project Tree must be specific to the programme or project it covers.
- All calculations should include reference details in the calculation notes explaining the source of the data used, as shown below, unless fully self-explanatory:

Properties | Custom Fields | Validation | Library | Library Details

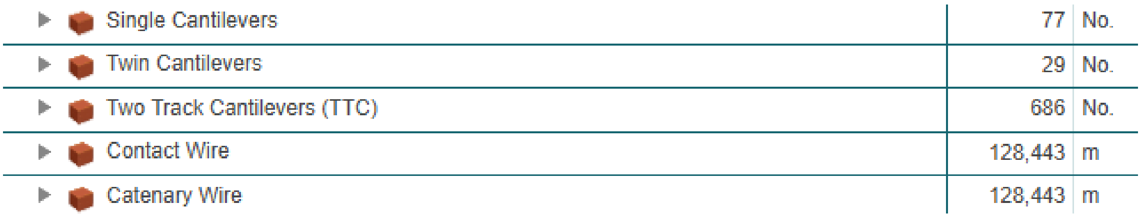
Name: Galvanised Steel 305uc Mast

Name	Value
Carbon Factor	Steel - Sheet - Hot-Dip Galvanized Steel
Source	Bath ICE (3.0)
Region	Global
Lifecycle	Cradle to Gate
Carbon Factor Value	2.76 kgCO2e/kg
Property Calculation	1,058 kg
Calculation	Mass Per Metre
	Mass_Length_kg_m * Length_m * CF
Length	9 m
Mass Per Length	117.5 kg/m
Notes	Mass per unit specified, based on a 9m mast 1057.8kg / 9 = 117.5kg/m Drawing ref: MS-B36-B01-S02-R00.pdf Assume installation of the direct mast to pile

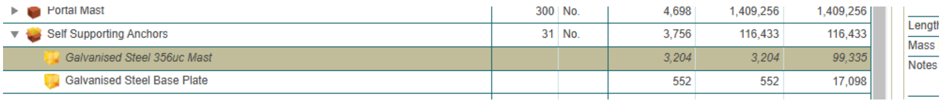
- Ensure folders do and do not Show Totals, as required.

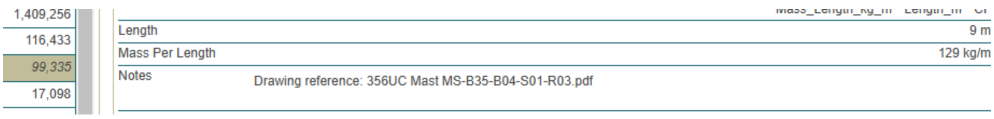


- Ensure a single package only represents a single object or activity.



- Ensure the sub-packages and calculations in a parent package only account for a single functional unit, according to the units set for the parent package. For example, as per the images below, one mast is 9 metres long, and 129 kg/m, and there are a total of 31 masts in the calculation





- Ensure the mathematics of each calculation and package structure, e.g. as above, scale up correctly.
- Ensure the Security specifications are correctly set, and are updated to share assessments, as required.
- Share data from one project to another by copying a whole project, or using the Sandbox functionality in a Project Tree to transfer content; instruction for both of these are set out in the Rail Carbon Tool User Guide.

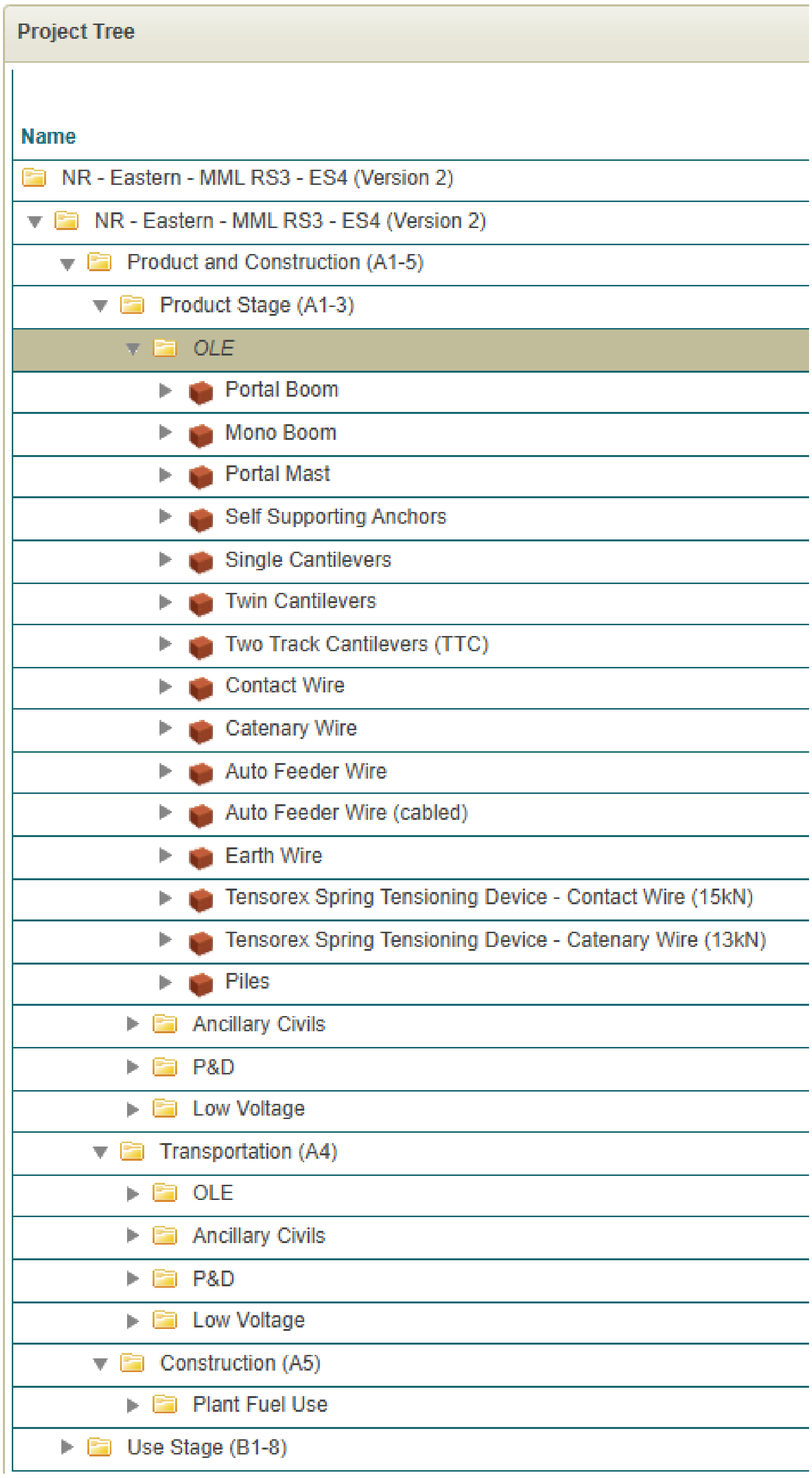
3.6.2 Headline Assessments

- These are often comparatively small, and there can be multiple assessments per project. These can be carried out as parallel assessments within a Project Tree.
- The folder structure can be bespoke to the assessment concerned, but must include life cycle stages, disciplines, then objects and items, as packages, as required.

3.6.3 Detailed Assessments

- Only one assessment should be documented in one project tree. The reasons for this are clarity, but also lack of stability of Projects Trees with significant amounts of content.
- The structure must follow the primary format of:
    - Life cycle stages, then disciplines as folders

- Objects and items, as packages.



- There should be consistency of naming of disciplines, and objects across projects.
- There should be consistency of calculations structures across projects.
- Both of the above consistency points require co-ordination, and complete consistency can not be expected with the current format of the RCT. However, technical communication and data sharing should be used as far as possible to ensure this.
- If updating or using an assessment for a future project stage, always:
  - Leave the original in place;
  - Create a copy and set the required Security;

- Carry out the updates in the copied version.

Appendices

Appendix A. Viewing and Sharing Data

A.1 What this Appendix covers

This part sets out how to provide visibility of project data in the RCT, and directly share data from on project to another project, for reuse.

This section also covers publishing calculations to the Templates Library, but for the reasons set out in section 0 of this part, this is currently not fully detailed.

A.2 How to Provide Visibility of Project Data

Visibility of project data in the RCT is enabled by the Security function.

Every project has a Security function, as shown in Figure 9 for a new Project, but it is also present on all existing projects. This function is automatically provided for all project managers and allows them to set who can view data in their projects.

(The Security function also allows project manager to set who can edit and copy data, which is discussed in section A.3 of this part.)

•

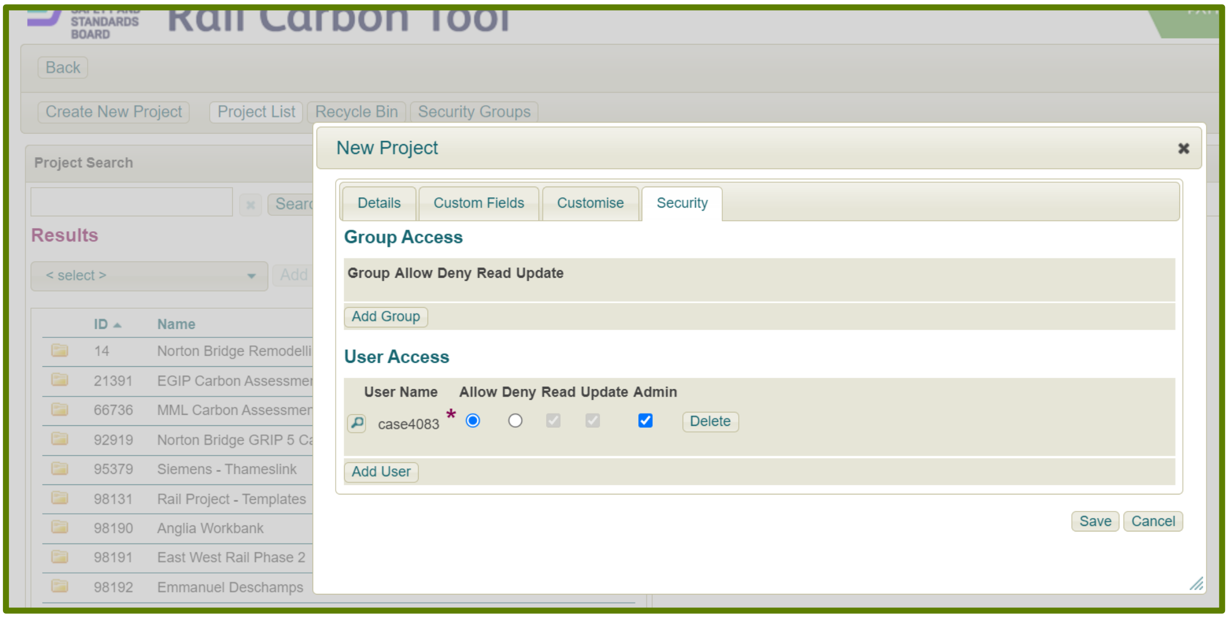
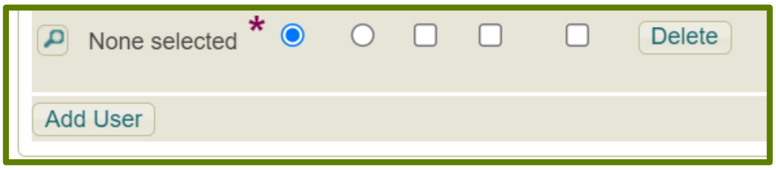


Figure 9: Project Security Function

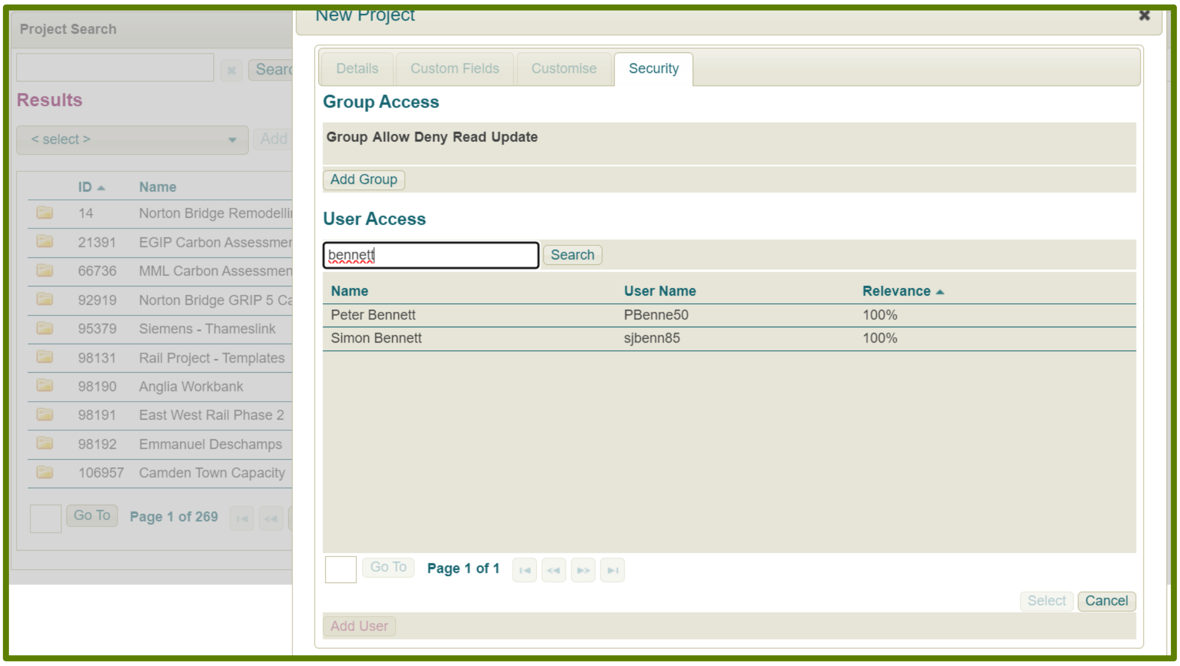
To enable others to see your project data, they need to be added to your project either individually, or as a group and given 'Read' access using the following steps.

How to add individual users:

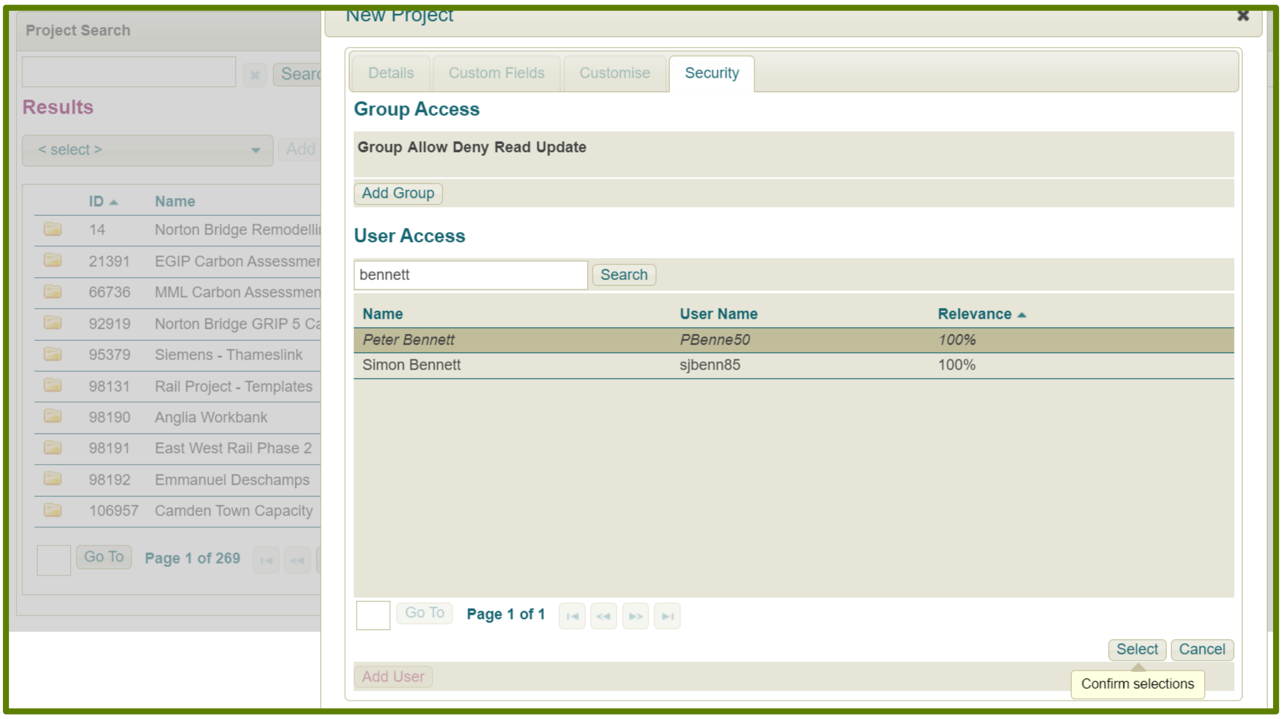
- Step 1: On the Security tab, click the Add User button then the magnifying glass icon next to the new 'None selected' entry that pops up.



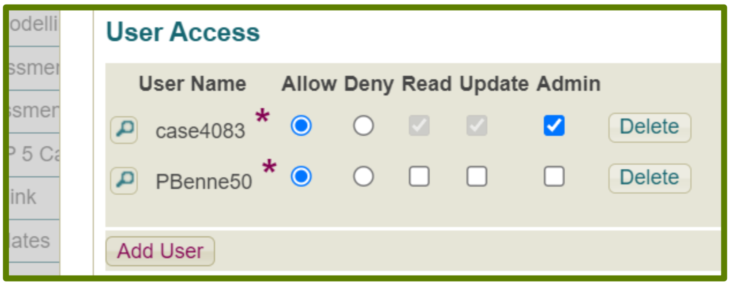
- Step 2: Search for the user by adding their name to the search box that appears following step 1, and click the 'Search' button.



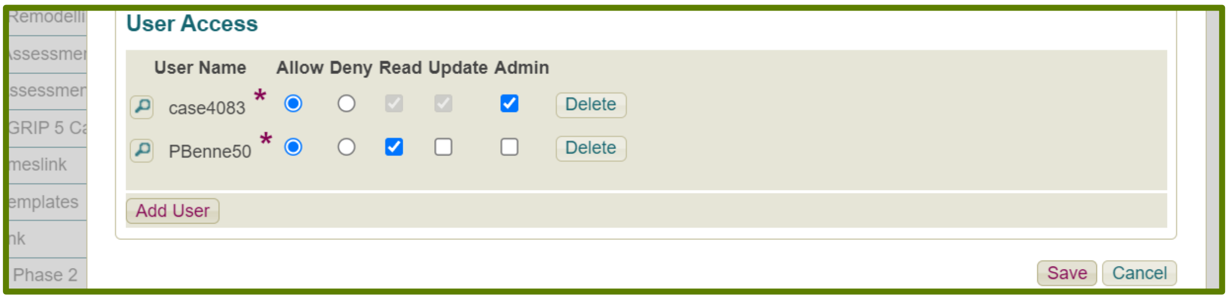
- Step 3: Click on the relevant user and then the Select button.



- Step 4: The selected user is added to the User Access list with no security settings.



- Step 5: Tick the Read radio button and click Save to give the user access to view the project. The project will now show up in their Project Library and they can open it and view its contents.

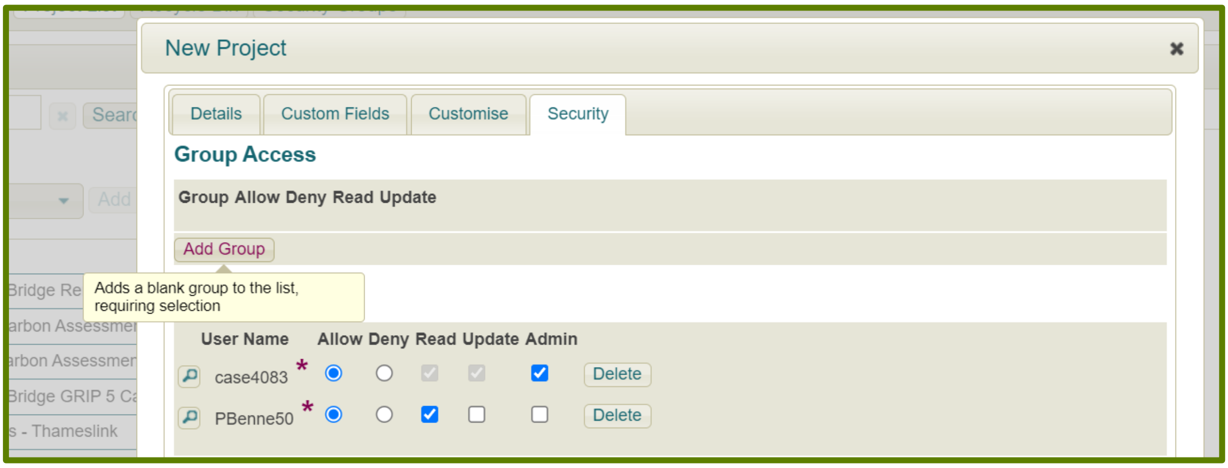


How to add a group of users:

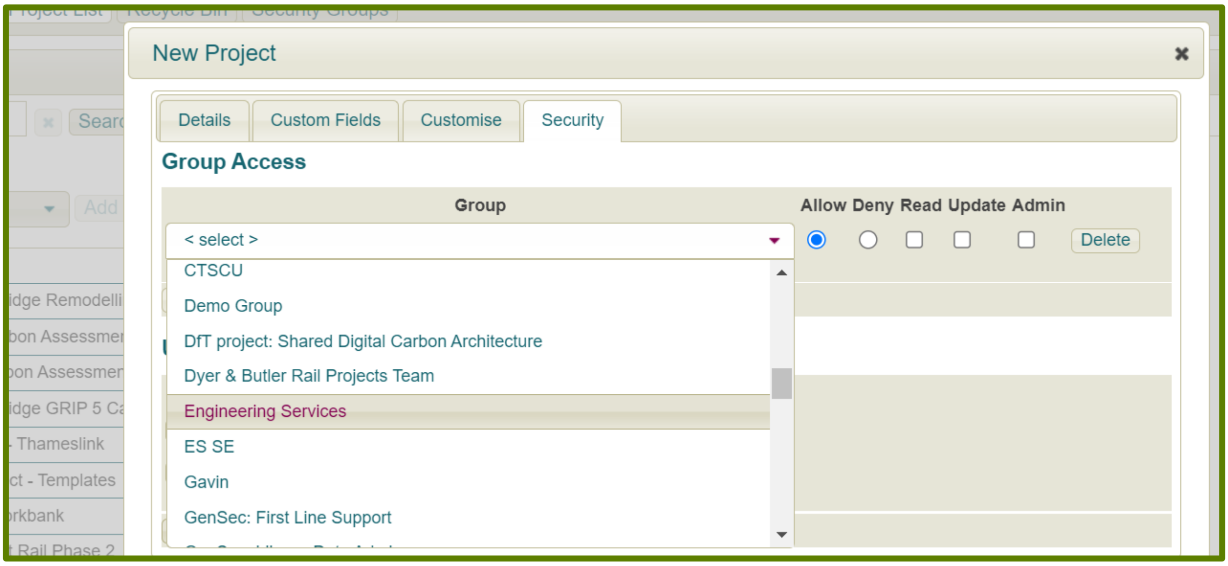
The RCT includes a Security Group functionality that allows groups of users to be given access to projects, avoiding the need to individual add every relevant user to every relevant project.

An Engineering Services group has been set up to enable immediate sharing of data across the whole Engineering Services community. To add this group use the following steps:

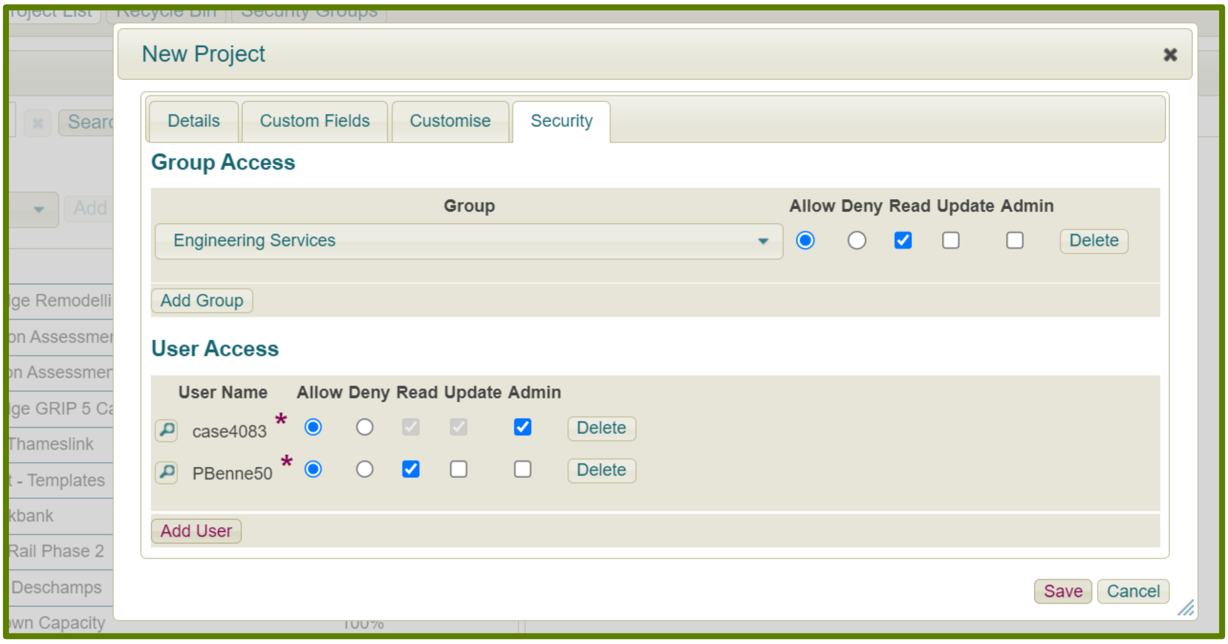
- Step 1: On the Security tab, click the Add Group button.



- Step 2: Select the Engineering Services group from the drop-down list.



- Step 3: Tick the Read radio button and then Save. The project will now show up in the Project Library of everyone in the Engineering Services group and they can open it and view its contents.



Note: The above steps can be repeated for any other security group to give different sets of users access. The Engineering Services group has been show as this is the primary group to use.

How to get included in the Engineering Security Group:

You must be included in the Engineering Services security group to see the projects it has been added to. To be added to the group request access from the Route Services Carbon Team.

A.3 How to Share Data Between Projects

Sharing data between projects is provided by two methods which are:

- Copying partial content from one project to another; or
- Directly copying a whole project.

These two methods are set out in the following sub-sections.

A.3.1 Copying Partial Content

Copying partial content from one project to another is undertaken using a combination of the Security controls and use of the Sandbox panel in a project. The two primary actions are:

1. Users who want to reuse data from one project in another need to be given Update access in the Security controls for both projects.
2. Users then copy the data from the first project into their Sandbox, and then from their Sandbox into the second project.

The specific steps for these actions are set out below.

It is recommended that only individuals are given Update access as this level of security also enables editing capability, therefore enabling editing of the project they are copying data from. If a whole Security Group is given update access the risk of unplanned edits is increased.

How to provide individual users with Update access:

- Step 1: Add the user(s) in the Security tab on both projects, where not already done, following the steps for this, as set out in section A.2 above.
- Step 2: On the Security tab against each user, tick the Update radio button and then Save. The project will now show up in the Project Library of the individual, and they will have edit access.

How to provide Groups with Update access:

Where it is decided that data will be shared with an entire group, this is done by adding the group to the Security for the project from which data is to be copied, as set out in section A.2 above, and by ticking the Update radio button for the group, and saving the settings.

The caution about excessive data sharing provided above is reiterated here. It is recommended that Groups are not given Update access as this level of security also enables editing capability, therefore increasing the risk of unplanned edits.

How to copy data from a project to the Users Sandbox:

- Step 1: Open the project that data is to be copied from.
- Step 2: On the Edit menu click the Sandbox button to open the Sandbox panel.
- Step 3: Select the content to be copied from the Project Tree.
- Step 4: In the Sandbox panel, select the location where the content is to be copied to.
- Step 5: Click the Copy from Project button.

As with building a Project Tree, is should be noted that folders can only be added to other folders, packages can only be added to other packages or folders, and calculations can only be added to packages.

How to copy data from a Sandbox into a project:

- Step 1: Open the project that data is to be copied to.
- Step 2: On the Edit menu click the Sandbox button to open the Sandbox panel.
- Step 3: In the Sandbox panel, select the content to be copied from the Sandbox.
- Step 4: Select the location in the project where the content is to be copied to.
- Step 5: Click the Copy from Sandbox button.

A.3.2 Copying Whole Projects

The function to copy a whole project is provided by the Copy functionality in the Project Library.

- Step 1: Select the project to be copied in the Project Library.
- Step 2: Click the copy button.
- Step 3: Revised the Project Name: as required.
- Step 4: Set the User and Group Security settings as required, the same as set out above.
- Step 5: Click Save.

It should be noted that very large projects will potentially cause the RCT to stall and show an error message. Where this is the case, the copy will very possibly continue in the background and can be viewed in the Project Library after a few minutes. Where this is not the case repeated copying attempts must not be done. As an alternative solution a large project can be copied in sections using the Sandbox copying process outlined above.

Appendix B. RCT Example: Soham Station Crosswall and Plank Calculation Details

Rail Carbon Tool

Project Name: Soham Station

Section: Crosswall and Plank Option

Name	Quantity	Single ($kgCO_2e$)	Total ($kgCO_2e$)	Project ($kgCO_2e$)
Crosswall and Plank Option		217,632	217,632	217,632
Materials		165,158	165,158	165,158
Piles (96 of)	549.4 tonnes	107	58,786	58,786
Concrete - General Carbon Factor Value: 0.107 kgCO2e/kg Lifecycle: Cradle to Gate Calculation: Mass (Mass_kg * CF) Property Calculation: 1,000 kg Source: Bath ICE (2.0) Region: UK Mass: 1,000 kg		107	107	58,786
Pile Caps (32 of)	311.04 tonnes	107	33,281	33,281
Concrete - General Carbon Factor Value: 0.107 kgCO2e/kg Lifecycle: Cradle to Gate Calculation: Mass (Mass_kg * CF) Property Calculation: 1,000 kg Source: Bath ICE (2.0) Region: UK Mass: 1,000 kg		107	107	33,281
Crosswalls (32 of)		21,089	21,089	21,089
Red Brick	45 m3	461	20,758	20,758
Bricks - General Carbon Factor Value: 0.24 kgCO2e/kg Lifecycle: Cradle to Gate Calculation: Volume (Volume_cu_m * Density_kg_cu_m * CF) Property Calculation: 1,922 kg Source: Bath ICE (2.0) Region: UK Density: Brick - Common Red - 1,922 kg/m3 Volume: 1 m3		461	461	20,758
Mortar	1,820 kg	0.18	331	331
Mortar - 1:4 cement:sand mix Carbon Factor: Mortar - 1:4 Cement:Sand Mix - UK Average Value: 0.182 kgCO2e/kg Lifecycle: Cradle to Gate Calculation: Mass (Mass_kg * CF) Property Calculation: 1 kg Source: Bath ICE (2.0) Region: UK Mass: 1 kg		0.18	0.18	331
Platform Deck	486 tonnes	107	52,002	52,002
Concrete - General Carbon Factor Value: 0.107 kgCO2e/kg Lifecycle: Cradle to Gate Calculation: Mass (Mass_kg * CF) Property Calculation: 1,000 kg Source: Bath ICE (2.0) Region: UK Mass: 1,000 kg		107	107	52,002

Name	Quantity	kgCO2e Single	Total	Project
Transport		52,474	52,474	52,474
Piles (Concrete)	250 km	83	20,730	20,730
Road Freight: Rigid HGV. 7.5 - 17t. 100% Load Carbon Factor Value: 0.15093 kgCO2e/tkm Lifecycle: Partial process Calculation: Freight - Tonne Kilometre (Weight_tonne * Distance_km * CF) Property Calculation: 549.4 tkm Source: Defra: HGV. Scope 1 or 3. (2017) Region: UK Distance: 1 km Weight: 549.4 tonne		83	83	20,730
Pile Caps (Concrete)	250 km	47	11,736	11,736
Road Freight: Rigid HGV. 7.5 - 17t. 100% Load Carbon Factor Value: 0.15093 kgCO2e/tkm Lifecycle: Partial process Calculation: Freight - Tonne Kilometre (Weight_tonne * Distance_km * CF) Property Calculation: 311.04 tkm Source: Defra: HGV. Scope 1 or 3. (2017) Region: UK Distance: 1 km Weight: 311.04 tonne		47	47	11,736
Crosswalls (Masonary)	250 km	6.7	1,670	1,670
Road Freight: Articulated HGV. 3.5 - 33t. 100% Load Carbon Factor Value: 0.07722 kgCO2e/tkm Lifecycle: Partial process Calculation: Freight - Tonne Kilometre (Weight_tonne * Distance_km * CF) Property Calculation: 86.49 tkm Source: Defra: HGV. Scope 1 or 3. (2017) Region: UK Distance: 1 km Weight: 86.49 tonne		6.7	6.7	1,670
Platform Deck (Concrete)	250 km	73	18,338	18,338
Road Freight: Rigid HGV. 7.5 - 17t. 100% Load Carbon Factor Value: 0.15093 kgCO2e/tkm Lifecycle: Partial process Calculation: Freight - Tonne Kilometre (Weight_tonne * Distance_km * CF) Property Calculation: 486 tkm Source: Defra: HGV. Scope 1 or 3. (2017) Region: UK Distance: 1 km Weight: 486 tonne		73	73	18,338

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Appendix C. RCT Example: Foundation Comparison

Rail Carbon Tool

Project Name: Demonstration Foundation Comparison

Name	Quantity	kgCO$_2$e Single	kgCO$_2$e Total	kgCO$_2$e Project
Demonstration Foundation Comparison				
Foundation Options				
Concrete Foundation	1 Nr	699	699	699
Concrete - 32/40 MPa - Average UK Additions Carbon Factor Value: 0.138 kgCO2e/kg Lifecycle: Cradle to Gate Calculation: Volume with percentage composition (Volume_cu_m * (Percentage_Composition / 100) * Density_kg_cu_m * CF) Property Calculation: 2,587.2 kg Source: Bath ICE (3.0) Region: UK % Composition: 98 % Density: Concrete - General - 2,400 kg/m3 Volume: 1.1 m3		357	357	357
Steel - Rebar Carbon Factor Value: 1.99 kgCO2e/kg Lifecycle: Cradle to Gate Calculation: Volume with percentage composition (Volume_cu_m * (Percentage_Composition / 100) * Density_kg_cu_m * CF) Property Calculation: 171.6 kg Source: Bath ICE (3.0) Region: Global % Composition: 2 % Density: Steel - General - 7,800 kg/m3 Volume: 1.1 m3		341	341	341
Circular Hollow Section Steel Pile	1 Nr	1,527	1,527	1,527
Steel - General Carbon Factor Value: 1.46 kgCO2e/kg Lifecycle: Cradle to Gate Calculation: Pipe: circular (Length_m * PI * (Power((External_Diameter_m/2),2) - Power((Internal_Diameter_m/2),2)) * Density_kg_cu_m * CF) Property Calculation: 1,045.98265157 kg Source: Bath ICE (2.0) Region: UK Density: Steel - General - 7,800 kg/m3 External Diameter: 0.61 m Internal Diameter: 0.584 m Length: 5.5 m		1,527	1,527	1,527

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Appendix D. RCT Example: Midland Mainline Electrification Assessment Headline Structure

Project Name: NR - Eastern - MML RS3 - ES4 (Version 2)

Name	Quantity		kgCO2e Single	kgCO2e Total	kgCO2e Project
NR - Eastern - MML RS3 - ES4 (Version 2)					
NR - Eastern - MML RS3 - ES4 (Version 2)			15,929,727	15,929,727	15,929,727
Product and Construction (A1-5)			15,511,773	15,511,773	15,511,773
Product Stage (A1-3)			13,168,048	13,168,048	13,168,048
OLE			11,765,069	11,765,069	11,765,069
Portal Boom	51	No.	5,901	300,945	300,945
Mono Boom	99	No.	18,020	1,783,984	1,783,984
Portal Mast	300	No.	4,698	1,409,256	1,409,256
Self Supporting Anchors	31	No.	3,756	116,433	116,433
Single Cantilevers	77	No.	2,384	183,559	183,559
Twin Cantilevers	29	No.	2,938	85,194	85,194
Two Track Cantilevers (TTC)	686	No.	4,649	3,189,451	3,189,451
Contact Wire	128,443	m	2.9	372,446	372,446
Catenary Wire	128,443	m	1.7	215,356	215,356
Auto Feeder Wire	39,339	m	9.6	376,199	376,199
Auto Feeder Wire (cabled)	6,412	m	13	85,187	85,187
Earth Wire	55,251	m	7.6	417,766	417,766
Tensorex Spring Tensioning Device - Contact Wire (15kN)	212	No.	1,376	291,733	291,733
Tensorex Spring Tensioning Device - Catenary Wire (13kN)	212	No.	1,101	233,387	233,387
Piles	1,446	No.	1,870	2,704,172	2,704,172
Ancillary Civils			439,464	439,464	439,464
Loughborough TP			64,511	64,511	64,511

Name	Quantity	kgCO_2e Single	Total	Project
Site foundations	1 No.	18,339	18,339	18,339
DNO base	1 No.	318	318	318
Palisade Fence: 3.0m high	1 No.	23,614	23,614	23,614
Palisade Fence: 1.8m high	1 No.	7,422	7,422	7,422
Access road	1 No.	12,333	12,333	12,333
Hardstanding areas	1 No.	2,484	2,484	2,484
Syston TP		81,211	81,211	81,211
East Midlands Parkway TP		248,430	248,430	248,430
Syston TSS		10,977	10,977	10,977
Sileby TSS		3,470	3,470	3,470
Mountsorrel TSS		9,716	9,716	9,716
Loughborough TSS		6,845	6,845	6,845
East Midlands Parkway TSS		12,386	12,386	12,386
Trent Triangle TSS		1,917	1,917	1,917
P&D		573,217	573,217	573,217
Syston SATS		85,062	85,062	85,062
Auto transformer	2 No.	35,028	70,056	70,056
25kV cable	570 m	19	10,552	10,552
25kV cable indoor sealing end	16 m	14	228	228
25kV Pfisterer indoor/outdoor sealing ends	6 m	14	81	81
25kV cable outdoor sealing end	12 m	14	171	171
19.422 Traction return cable	50 m	13	643	643
HV cable troughing	85 m	26	2,203	2,203

Name	Quantity	kgCO2e Single	kgCO2e Total	kgCO2e Project
HV cable ducting	280 m	4.0	1,128	1,128
Siemens HV Substation 1		71,919	71,919	71,919
Loughborough ATS		96,930	96,930	96,930
Siemens HV Substation 2		38,508	38,508	38,508
East Midlands Parkway ATFS		209,569	209,569	209,569
Siemens HV Substation 3		71,229	71,229	71,229
Low Voltage		390,299	390,299	390,299
DNO cubicles	5 No.	138	691	691
Cables	14 Sections	27,704	387,849	387,849
Busbar chamber	5 No.	22	111	111
Cable cut out	5 No.	48	238	238
Fuse switches	17 No.	14	231	231
Galvanised trunking	5 No.	228	1,139	1,139
Copper earth bars	5 No.	2.1	10	10
Distribution board	5 No.	5.8	29	29
Transportation (A4)		115,239	115,239	115,239
OLE		103,376	103,376	103,376
Portal Boom	50 km	9.3	465	465
Mono Boom	67 km	55	3,692	3,692
Portal Mast	67 km	44	2,916	2,916
Self Supporting Anchors	67 km	3.6	241	241
Single Cantilevers	67 km	5.7	383	383
Twin Cantilevers	67 km	2.6	177	177

Name	Quantity	kgCO2e Single	Total	Project
Two Track Cantilevers (TTC)	67 km	116	7,778	7,778
Contact Wire	1,995 km	12	23,374	23,374
Catenary Wire	1,995 km	6.5	13,019	13,019
Auto Feeder Wire	120 km	2.4	294	294
Auto Feeder Wire (Cabled)	120 km	0.63	76	76
Earth Wire	120 km	3.0	358	358
Tensorex Spring Tensioning Device - Contact Wire (15kN)	1,995 km	4.1	8,113	8,113
Tensorex Spring Tensioning Device - Catenary Wire (13kN)	1,995 km	3.3	6,490	6,490
Piles	228 km	158	36,001	36,001
Ancillary Civils		5,193	5,193	5,193
Loughborough TP		1,658	1,658	1,658
Syston TP		1,581	1,581	1,581
East Midlands Parkway TP		1,596	1,596	1,596
Syston TSS		90	90	90
Sileby TSS		33	33	33
Mountsorrel TSS		36	36	36
Loughborough TSS		121	121	121
EMP TSS		52	52	52
Trent Triangle TSS		24	24	24
P&D		6,413	6,413	6,413
Syston SATS		553	553	553
Siemens HV Substation 1		1,013	1,013	1,013
Loughborough ATS		692	692	692

Name	Quantity	kgCO2e Single	Total	Project
Siemens HV Substation 2		527	527	527
East Midlands Parkway ATFS		2,593	2,593	2,593
Siemens HV Substation 3		1,035	1,035	1,035
Low Voltage		258	258	258
DNO Cubicles	21 km	0.01	0.14	0.14
Cables	21 km	12	256	256
Busbar Chamber	21 km	0.01	0.14	0.14
Cable Cut Out	21 km	< 0.01	0.01	0.01
Fuse Switches	21 km	0.01	0.26	0.26
Galvanised Trunking	21 km	0.04	0.74	0.74
Copper Earth Bars	21 km	< 0.01	0.01	0.01
Distribution Board	21 km	< 0.01	0.09	0.09
Construction (A5)		2,228,486	2,228,486	2,228,486
Plant Fuel Use		2,228,486	2,228,486	2,228,486
Basket SEL 14 AJX RR	95 Weeks	1,233	117,159	117,159
Basket EVO II	95 Weeks	925	87,869	87,869
Nifty Lift RM 14	95 Weeks	925	87,869	87,869
Lowloader	95 Weeks	2,110	200,403	200,403
20 ton Hiab Truck	95 Weeks	2,337	221,985	221,985
24 Ton Tele Handler	95 Weeks	2,337	221,985	221,985
5 Ton Tele Handler	95 Weeks	1,636	155,390	155,390
Colmar 10000	95 Weeks	3,349	318,179	318,179
Colmar 12000	95 Weeks	3,505	332,978	332,978

Name	Quantity	kgCO2e Single	Total	Project
Long Reach Doosan Excavator	95 Weeks	1,266	120,242	120,242
Doosan Crane	95 Weeks	2,337	221,985	221,985
AC 45 Crane	95 Weeks	1,499	142,441	142,441
Use Stage (B1-8)		417,954	417,954	417,954
Replacement (B4)		417,954	417,954	417,954
Ancillary Civils		15,620	15,620	15,620
Cable Ducts 2049 Replacement	1 Replacement	378	378	378
Cable Trough 2049 Replacement	1 Replacement	15,242	15,242	15,242
Power and Distribution		56,684	56,684	56,684
Cable Trough 2049 Replacement	1 Replacement	45,543	45,543	45,543
Cable Ducts 2049 Replacement	1 Replacement	10,095	10,095	10,095
12v Batteries 2034 Replacement	1 Replacement	526	526	526
12v Batteries 2044 Replacement	1 Replacement	520	520	520
Low Voltage		345,650	345,650	345,650
Cables 2049 Replacement	1 Replacement	344,090	344,090	344,090
Busbar Chamber 2049 Replacement	1 Replacement	99	99	99
Cable Cut Out 2049 Replacement	1 Replacement	211	211	211
Fuse Switches 2049 Replacement	1 Replacement	205	205	205
Galvanised Trunking 2049 Replacement	1 Replacement	1,010	1,010	1,010
Copper Earth Bars 2049 Replacement	1 Replacement	8.9	8.9	8.9
Distribution Board 2049 Replacement	1 Replacement	26	26	26

Appendix E. RCT Example: Midland Mainline Electrification Assessment Example Calculation Details

Project Name: NR - Eastern - MML RS3 - ES4 (Version 2)

Section: Portal Boom

Name	Quantity	Single ($kgCO_2e$)	Total ($kgCO_2e$)	Project ($kgCO_2e$)
Portal Boom	51 No.	5,901	300,945	300,945
Steel - Sheet - Hot-Dip Galvanized Steel Carbon Factor Value: 2.76 kgCO2e/kg Lifecycle: Cradle to Gate Calculation: Mass (Mass_kg * CF) Property Calculation: 2,138 kg Source: Bath ICE (3.0) Region: Global Mass: 2,138 kg		5,901	5,901	300,945

Section: Twin Cantilevers

Name	Quantity	Single ($kgCO_2e$)	Total ($kgCO_2e$)	Project ($kgCO_2e$)
Twin Cantilevers	29 No.	2,938	85,194	85,194
Galvanised Steel 305uc Mast Carbon Factor: Steel - Sheet - Hot-Dip Galvanized Steel Value: 2.76 kgCO2e/kg Lifecycle: Cradle to Gate Calculation: Mass Per Metre (Mass_Length_kg_m * Length_m * CF) Property Calculation: 1,057.5 kg Source: Bath ICE (3.0) Region: Global Length: 9 m Mass Per Length: 117.5 kg/m		2,919	2,919	84,642
Steel Tube Carbon Factor: Steel - General Value: 1.46 kgCO2e/kg Lifecycle: Cradle to Gate Calculation: Pipe: circular (Length_m * PI * (Power((External_Diameter_m/2),2) - Power((Internal_Diameter_m/2),2)) * Density_kg_cu_m * CF) Property Calculation: 13.0265401 kg Source: Bath ICE (2.0) Region: UK Density: Steel - General - 7,800 kg/m3 External Diameter: 0.0483 m Internal Diameter: 0.0403 m Length: 3 m		19	19	552

Section: Contact Wire

Name	Quantity	Single ($kgCO_2e$)	Total ($kgCO_2e$)	Project ($kgCO_2e$)
Contact Wire	128,443 m	2.9	372,446	372,446
Copper - EU Tube & Sheet Carbon Factor Value: 2.71 kgCO2e/kg Lifecycle: Partial process Calculation: Mass Per Metre (Mass_Length_kg_m * Length_m * CF) Property Calculation: 1.07 kg Source: Bath ICE (2.0) Region: Europe Length: 1 m Mass Per Length: 1.07 kg/m		2.9	2.9	372,446

Section: DNO base

Name	Quantity	kgCO₂e Single	Total	Project
DNO base	1 No.	318	318	318
Concrete - General Carbon Factor Value: 0.103 kgCO2e/kg Lifecycle: Cradle to Gate Calculation: Cuboid: L* W * D (Length_m * Width_m * Depth_m * Density_kg_cu_m * CF) Property Calculation: 3,091.2 kg Source: Bath ICE (3.0) Region: UK Density: Concrete - General - 2,400 kg/m3 Depth: 0.7 m Length: 1.6 m Width: 1.15 m		318	318	318

Section: Portal Boom

Name	Quantity	kgCO₂e Single	Total	Project
Portal Boom	50 km	9.3	465	465
Road Freight: Articulated HGV. Unknown size. Average Load Carbon Factor Value: 0.08525 kgCO2e/tkm Lifecycle: Partial process Calculation: Freight - Tonne Kilometre (Weight_tonne * Distance_km * CF) Property Calculation: 109.038 tkm Source: Defra: HGV. Scope 1 or 3. (2018) Region: UK Distance: 1 km Weight: 109.038 tonne		9.3	9.3	465

Section: Basket SEL 14 AJX RR

Name	Quantity	kgCO₂e Single	Total	Project
Basket SEL 14 AJX RR	95 Weeks	1,233	117,159	117,159
Days per week	5 Days	247	1,233	117,159
Diesel (biofuel blend) Carbon Factor Value: 3.2454 kgCO2e/litre Lifecycle: Cradle to Gate Calculation: Fuel Burnt - Litres (Fuel_litre * CF) Property Calculation: 76 litre Source: Defra: Fuels. Vol. All Scope. (2018) Region: UK Fuel: 76 Litres		247	247	117,159

Section: Colmar 10000

Name	Quantity	kgCO₂e Single	Total	Project
Colmar 10000	95 Weeks	3,349	318,179	318,179

Name	Quantity	kgCO2e Single	kgCO2e Total	kgCO2e Project
Days per week	6 Days	558	3,349	318,179
Diesel (biofuel blend) Carbon Factor Value: 3.2454 kgCO2e/litre Lifecycle: Cradle to Gate Calculation: Fuel Burnt - Litres (Fuel_litre * CF) Property Calculation: 172 litre Source: Defra: Fuels. Vol. All Scope. (2018) Region: UK Fuel: 172 Litres		558	558	318,179

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