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Managing whole life carbon in infrastructure

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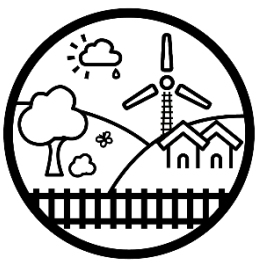

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Managing whole life carbon in infrastructure

This guidance note provides information on how to manage whole life carbon emissions during the planning, option selection, design, construction and long-term management of rail infrastructure. The guidance also supports standard NR/L2/ENV/015 Environment & Social Minimum Requirements – Design & Construction.

This guidance note supersedes and replaces ESD07 Issue 1 – Capital Carbon.

It is likely that NR/L2/ENV/015 will need to be revised in due course to translate certain aspects of this guidance into formal requirements.

1. Background

Carbon dioxide (CO_2) is the most abundant greenhouse gas (GHG) emitted from both natural and man-made activities, but it is not the only one. A greenhouse gas (GHG) is any gas in the atmosphere, both natural and man-made, that absorbs and emits radiation at wavelengths within the infrared radiation spectrum emitted by the Earth's surface, the atmosphere, and clouds, and in so doing causes warming of the atmosphere. There are seven main recognised greenhouse gases including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), nitrogen trifluoride (NF_3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Because carbon dioxide is the most abundant greenhouse gas emitted from man-made activities by volume it is normal practice to relate all GHG contributions to the global warming effect of an equivalent quantity of CO_2, and the term carbon dioxide equivalent (CO_2e) has become the standard unit for quantifying GHG emissions.

Throughout this document the term 'carbon' is used as shorthand for CO_2e and therefore includes direct man-made emissions of carbon dioxide plus any other GHGs that have a material contribution.

Network Rail has committed to achieving net zero carbon emissions by 2050 (2045 in Scotland), consistent to UK Government and devolved nation targets, and has set a range of intermediate science-based targets as the pathway to this ambition. Network Rail's science-based targets for Scope 1 and 2 emissions are set to staying within a 1.5˚C rise above pre-industrialisation levels, and this aligns with UK Government commitments. Our Scope 3 science-based target is aligned to staying well below a 2˚C rise.

Targets are considered 'science-based' if they provide a plan, independently verified and endorsed by the science-based targets initiative (SBTi), that will keep the business's proportion of GHG emissions within the limits of well-below 2˚C and pursuing efforts to limit warming to 1.5˚C.

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2. Business benefits of carbon management

Carbon efficiency is a good general indicator of resource efficiency, so looking at ways to reduce GHGs will often reveal opportunities for other beneficial changes and improvements. Accounting for GHGs in the planning, design and construction of rail infrastructure can bring a range of benefits including:

- Efficient use of materials and other valuable resources
- Improved value management and cost / time efficiency;
- Contribution to national carbon reduction goals;
- Recognition and enhanced reputation for achievements in sustainable development;
- Increased Government and regulator confidence;
- Increased investor confidence for infrastructure developments with proven social value and sustainability credentials.

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3. Measuring carbon emissions at an organisational level – the GHG Protocol

The Greenhouse Gas (GHG) Protocol has established the most widely used international accounting standard for organisations to measure their CO_2e emissions. These emissions are grouped into three scope definitions as follows:

Scope 1	Direct carbon emissions from burning of fossil fuels in operations owned and managed by Network Rail e.g. burning of fuels in boilers for heating premises, consumption of fuels in Network Rail cars and vans.
Scope 2	Indirect carbon emissions from the purchase of electricity, steam, heat or cooling for Network Rail owned and managed premises and operations. While rates of consumption are under Network Rail's operational control the carbon emissions occur with other generation parties.
Scope 3	All other indirect CO_2e emissions that occur within Network Rail's value chain for activities associated with running and growing the business, including building, managing, servicing, maintaining, and disposing of Network Rail infrastructure and property. This also includes the use of traction fuel (mainly electricity and diesel) by train operators operating on our rail network.

Baseline Network Rail carbon emissions calculations conducted in 2017/18 estimated that direct operational fuel use and electricity consumption (Scope 1 and 2 combined) account for around 3 % of the Network Rail carbon footprint, with 97 % occurring across the Scope 3 activities.

The three largest contributors to Network Rail's Scope 3 footprint are:

- Capital goods and services – carbon emissions associated with capitalised spend on the construction, repair, refurbishment and renewal, decommissioning and end of life treatment of rail infrastructure and assets;
- Purchased goods and services – carbon emissions associated with operational spend running the business and for asset upkeep;
- Diesel locomotive traction.

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4. Measuring whole life carbon emissions for assets / infrastructure projects – PAS 2080

Section 3 summarised the role of the Greenhouse Gas Protocol scope 1, 2 and 3 emissions categories for quantifying carbon emissions at an **organisational level**. This section introduces Publicly Available Specification (PAS) 2080:2016, *Managing carbon in infrastructure*, as the preferred approach for describing and quantifying carbon emissions for **assets and infrastructure** and promotes the principle of whole life carbon, or whole life-cycle carbon emissions.

Whole life carbon is the cumulative total carbon emissions that arise from all stages in the life cycle of an asset or infrastructure. This includes carbon emissions associated with:

- the creation of materials, products and components (often referred to as embodied carbon);
- construction transportation and site activities e.g. transport of materials, plant and equipment operations, transport of plant and equipment, site-based utilities consumption, and removal / treatment of wastes;
- fuel, electricity and water consumption throughout the operating life of the asset;
- maintenance, repair, replacement and refurbishment activities to sustain the operational condition of the asset;
- servicing the asset with operational consumables and removal / treatment of waste;
- end of life decommissioning, deconstruction and treatment.

PAS 2080 represents the whole life cycle emissions of infrastructure as a series of numbered modules as illustrated at **Figure 1**.

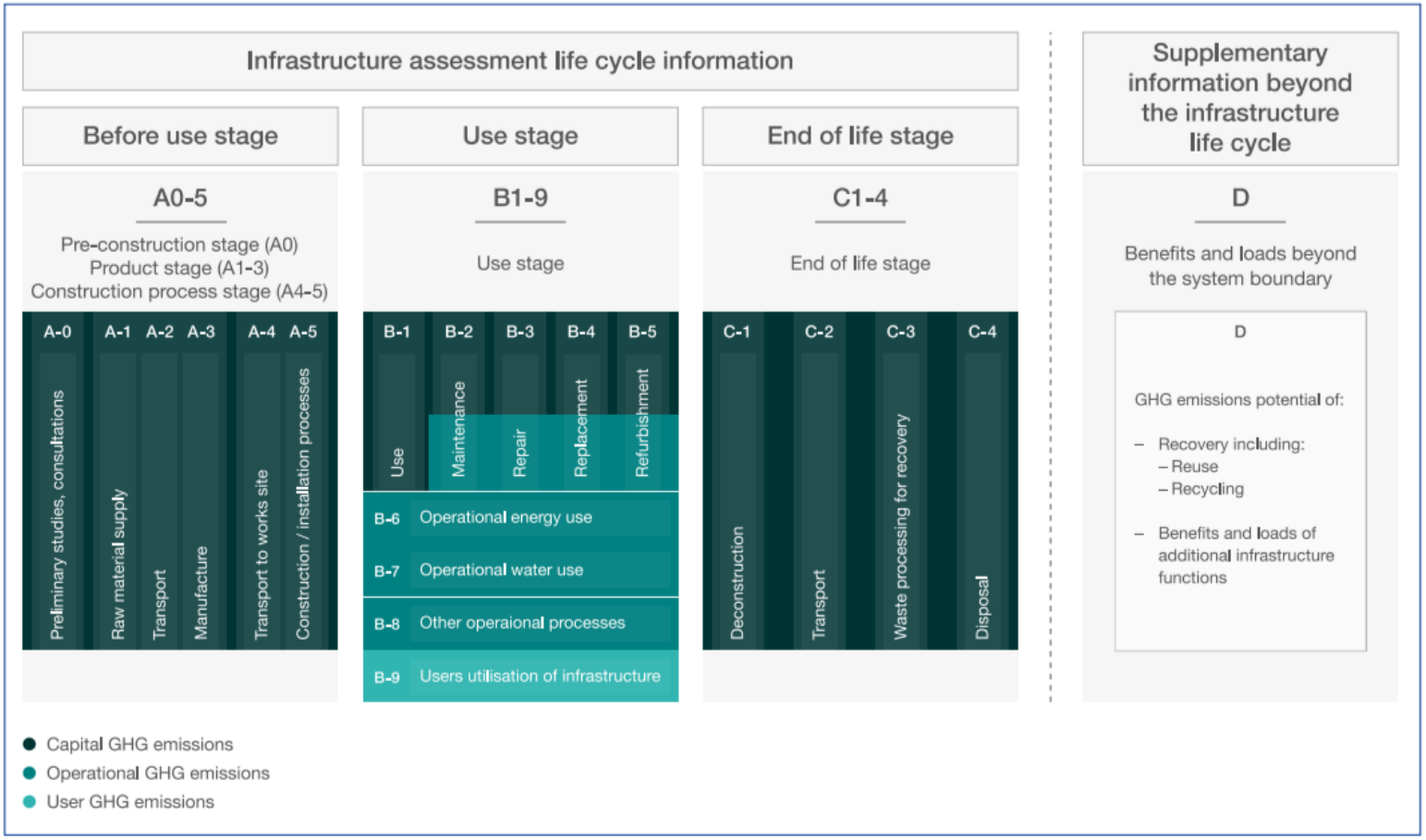

Figure 1: Life cycle stages and individual modules for quantification of infrastructure whole life carbon emissions (reproduced from PAS 2080:2016, Figure 7)

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Network Rail has embraced the principles of PAS 2080 and the modular approach to life cycle carbon accounting. We have arranged the modules slightly differently to make it easier to build data sets, see **Figure 2**.

Expanded guidance on the scope of individual PAS 2080 modules is provided at **Appendix A**

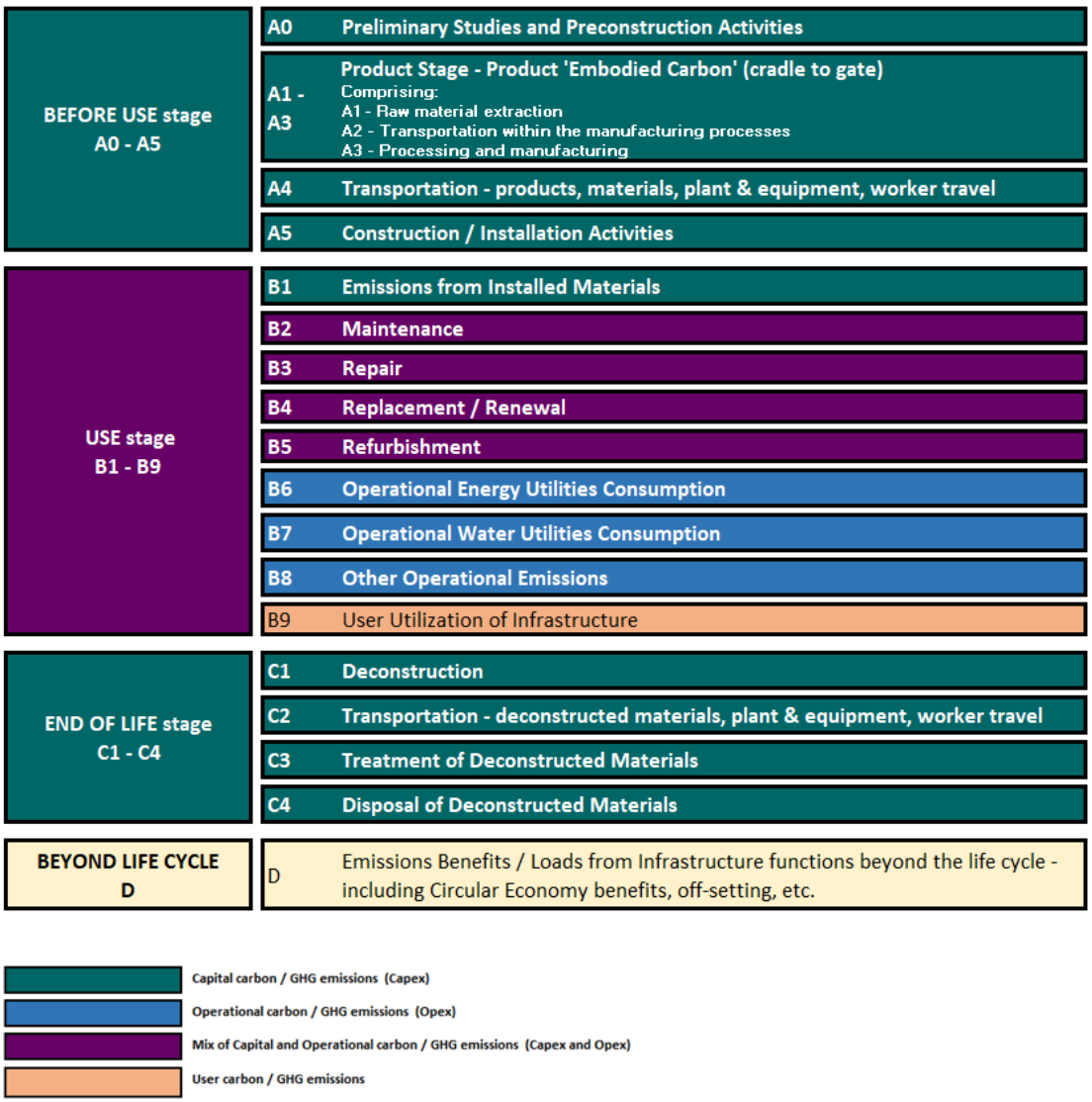

Figure 2: Alternative Network Rail representation of PAS 2080 life cycle modules arranged to support data reporting (derived from PAS 2080:2016, Figure 7).

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5. Defining system boundaries for carbon assessments

It is important when quantifying and reporting carbon emissions to clearly specify and declare the system boundaries of the assessment. This supports open and transparent interpretation of the carbon emission data. System boundaries should have three critical dimensions:

a) PAS 2080 MODULAR SCOPE – The declaration of which PAS 2080 asset life cycle modules will be quantified as part of the assessment. This may be referred to as the 'life cycle' boundary.

Note 1: Network Rail has proposed time-bound criteria to specify which PAS 2080 modules will be required or optional for new build / enhancement projects and asset replacement / renewal works overtime. See section 6.1 – Figures 3.1, 3.2 and 4.

b) SYSTEM COMPONENTS AND FACTORS – The definition of which physical assets, elements and components (hardware), activities and other influential factors will be included in the assessment. This may be referred to as the 'spatial' boundary.

The spatial boundary will need to be defined and agreed for each applicable PAS 2080 module so that the scope of the assessment is understood by all parties.

The decision on which elements/components/activities to include in the spatial boundary for a given PAS 2080 module should be based on the item's relative contribution to the module total to ensure that all significant whole life carbon contributions are included.

Note 2: It is useful to include within the spatial system boundary those elements and factors that are directly part of the core system and those that can strongly influence or be influenced by the system. However, selecting the spatial system boundary can be challenging as interdependent relationships with neighbouring systems can be difficult to isolate. It is important to agree the spatial boundaries and ownership carefully so that significant asset elements/components are neither double counted or overlooked at the system interfaces.

Note 3: PAS 2080:2016 (7.1.3.3) requires that eliminated elements/components/activities must be recorded, with an explanation for exclusion. Total excluded emissions should be no more than 5 % of the final sum of the Module.

c) REFERENCE STUDY PERIOD (RSP) – The time period over which carbon emissions will be assessed. For whole life carbon assessments this should ideally correspond to the expected functional life of the asset system. This may be referred to as the 'temporal' aspect. For rail infrastructure it is common practice to apply reference study periods of either 60 years or 120 years.

Within the reference study period of an asset system, many components will require maintenance, repair and replacement at shorter planned intervals. The carbon emissions from these repeat cycles of maintenance, repair and replacement will be accounted for in the B2 (Maintenance), B3 (Repair) and B4 (Replacement) modules of PAS 2080 respectively (see section 8).

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6. Criteria for specifying the system boundaries of project whole life carbon assessments

In accordance with standard NR/L2/ENV/015 '*Environment & Social Minimum Requirements – Design & Construction*' (currently at Issue 9) - for any works over £1 million comprising civil, mechanical or electrical engineering activities, the Designer/Contractor shall use the Rail Carbon Tool to identify and record opportunities for reduction of whole life carbon emissions.

This guidance document extends those principles to align with wording from the January 2022 Department for Transport (DfT) requirements stating that transport sector arms-length bodies shall "*develop the capacity to assess, report and reduce the carbon impacts of all infrastructure projects*" and that "*all contracting authorities should adopt the use of whole life carbon assessments to understand and minimise the carbon footprint of projects*."

This guidance note therefore promotes the concept that all Network Rail projects valued at more than £1m should conduct carbon assessment to quantify whole life carbon emissions and demonstrate measurable carbon reduction. It is foreseeable that NR/L2/ENV/015 will need to be revised in due course to translate certain aspects of this guidance into formal requirements.

As we have seen in section 5 above it is important to establish and agree well defined system boundaries for carbon assessments so:

a) all project participants and stakeholders are clear about the scope;
b) the resulting carbon data can be interpreted and reported transparently.

6.1 Which PAS 2080 modules to assess? (life cycle boundaries)

Adoption of the infrastructure life cycle carbon emission modules from PAS 2080 is relatively new to Network Rail so it will take a little time to build the experience and resource capability for this type of whole life carbon assessment. To support the maturity process we have been developing time-bound criteria to specify which PAS 2080 life cycle modules are mandatory or optional for different projects.

The proposed Network Rail criteria for deciding which PAS 2080 modules should apply to project carbon assessments are as follows:

- a minimum baseline suite of PAS 2080 modules for all existing projects >£1m that have not yet reached PACE (project acceleration in a controlled environment) milestone ES6 (Construction complete);
- a PAS 2080 escalator to increase the range of PAS 2080 modules assessed by projects based on:
  - the date of the PACE milestone ES1 (Client requirements defined and baselined), and

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- the project level of control (LoC) assessment or project complexity assessment (PCA) rating.

In parallel the Department for Transport (DfT) have also issued requirements for DfT arms-length bodies to start assessing, reporting and reducing whole life carbon emissions for infrastructure projects. The DfT criteria for when projects should start whole life carbon reporting are based on:

- where the project sits in the DfT financial threshold tier system
  Tier 1 >£500m
  Tier 2 £50m to £500m
  Tier 3 <£50m
- the date when projects reach each of the three principal business case stages:
  strategic outline business case (SOBC)
  outline business case (OBC)
  full business case (FBC).

The following sub-sections, Table and Figures illustrate the application of these dual DfT and Network Rail criteria to expand the range of PAS 2080 life cycle modules to be assessed by projects. New build/enhancement projects are treated differently to asset renewal/replacement works.

Table 1: Summarised interpretation of reporting requirements for DfT funded projects and those outside the DfT funding process:

DfT Tier 1 >£500m	February 2022 Onwards	• Commence assessing and reporting forecast carbon emissions across the required PAS 2080 modules (**Figure 3.1**) if the project reaches either SOBC, OBC or FBC after 1st February 2022. • Continue carbon assessment and reporting requirements through remaining business cases - but retrospective reporting for business case phases passed before 1st February2022 is not required. • Continue carbon assessment and reporting through design and construction until project completion and demobilisation, replacing forecast data with actual data where available.

DfT Tier 2 £50-£500m	July 2022 Onwards	• Commence assessing and reporting forecast carbon emissions across the required PAS 2080 modules (**Figure 3.1**) if the project reaches either SOBC, OBC or FBC after 1st July 2022. • Continue carbon assessment and reporting requirements through remaining business cases - but retrospective reporting for business case phases passed before 1st July 2022 is not required. • Continue carbon assessment and reporting through design and construction until project completion and demobilisation, replacing forecast data with actual data where available.
DfT Tier 3 <£50m	January 2023 Onwards	• Commence assessing and reporting forecast carbon emissions across the required PAS 2080 modules (**Figure 3.2**) if the project reaches either SOBC, OBC or FBC after 1st January 2023. • Continue carbon assessment and reporting requirements through remaining business cases - but retrospective reporting for business case phases passed before 1st January 2023 is not required. • Continue carbon assessment and reporting through design and construction until project completion and demobilisation, replacing forecast data with actual data where available.
Non-Tiered Network Rail new build / enhancement Projects	February 2022 Onwards	• Network Rail **new build or enhancement projects** that fall outside the DfT's tiered funding model shall apply the Network Rail progression of PAS 2080 modules (**Figures 3.1 & 3.2**), based on: 1) Minimum baseline requirements; 2) Date of PACE ES1 milestone; 3) Project LoC or PCA rating. • Continue carbon assessment and reporting through design and construction until project completion and demobilisation, replacing forecast data with actual data where available.
Non-Tiered Network Rail asset renewal / replacement works	February 2022 Onwards	• Network Rail **asset renewal works** that fall outside the DfT's tiered funding model shall apply the Network Rail progression of PAS 2080 modules (**Figure 4**), based on: 1) Minimum baseline requirements; 2) Date of PACE ES1 milestone; 3) Project LoC or PCA rating. • Continue carbon assessment and reporting through design and construction until project completion and demobilisation, replacing forecast data with actual data where available.

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New Build / Enhancement Projects

Figures 3.1 and 3.2 describe the proposed expansion of PAS 2080 modules to be assessed by new build / enhancement projects based on criteria outlined above.

Asset Renewal / Replacement Works

For practical reasons the range of PAS 2080 modules applicable to asset renewal works is lower than for new build / enhancement works. This is because asset renewal interventions are focused on replacing only specified elements / components to extend the operational life of a larger asset engineering system.

Figure 4 illustrates the proposed application of PAS 2080 carbon emission modules to be assessed for asset renewal / replacement works that are not DfT funded.

Interpretation of Figures 3.1, 3.2 and 4

Interpretation of Figures 3.1, 3.2 and 4 is guided by the following principles:

Required	Assessment and reporting of carbon emissions in this PAS 2080 module will be expected unless the module is shown to be irrelevant and not applicable to the scope and deliverables of a given project.
Optional	Assessment and reporting of carbon emissions in this PAS 2080 module is not required but progressive project teams may choose to do so – only where the module has relevance to the scope and deliverables of a given project.
Not Required	Assessment and reporting of carbon emissions in this module is not required.

New Build / Enhancement Projects - proposed expansion of PAS 2080 life cycle modules for carbon assessment

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Network Rail representation of PAS 2080 life cycle stage modules for quantification of infrastructure whole life carbon emissions (derived from PAS 2080:2016, Figure 7).

BEFORE USE stage A0 - A5	A0	Preliminary Studies and Preconstruction Activities
	A1 - A3	Product Stage - Product 'Embodied Carbon' (cradle to gate) Comprising: A1 - Raw material extraction A2 - Transportation within the manufacturing processes A3 - Processing and manufacturing
	A4	Transportation - products, materials, plant & equipment, worker travel
	A5	Construction / Installation Activities
USE stage B1 - B9	B1	Emissions from Installed Materials
	B2	Maintenance
	B3	Repair
	B4	Replacement / Renewal
	B5	Refurbishment
	B6	Operational Energy Utilities Consumption
	B7	Operational Water Utilities Consumption
	B8	Other Operational Emissions
	B9	User Utilization of Infrastructure
END OF LIFE stage C1 - C4	C1	Deconstruction
	C2	Transportation - deconstructed materials, plant & equipment, worker travel
	C3	Treatment of Deconstructed Materials
	C4	Disposal of Deconstructed Materials
BEYOND LIFE CYCLE D	D	Emissions Benefits / Loads from Infrastructure functions beyond the life cycle - including Circular Economy benefits, off-setting, etc.

Maturing scope of whole life carbon assessment based on DfT Tiers OR Level of Control (LoC) score or project complexity assessment (PCA) and date of PACE ES1 readiness review

	February - June 2022					July - December 2022				
	DfT Tier 1 Projects	Non-Tier 1 Projects >£1m Minimum Requirements for all projects pre-PACE ES6				DfT Tier 1 & 2 Projects	Non-Tier 1 or 2 Projects >£1m with PACE ES1 milestone in Jul - Dec 2022 (NB. All other >£1m projects post ES1 apply Feb - June 2022 minimum requirements)			
		LoC 1 / PCA 1	LoC 2 / PCA 2	LoC 3 / PCA 3	LoC 4 / PCA 4		LoC 1 / PCA 1	LoC 2 / PCA 2	LoC 3 / PCA 3	LoC 4 / PCA 4
A0	Optional	Optional	Not Required	Not Required	Not Required	Optional	Optional	Optional	Not Required	Not Required
A1 - A3	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required
A4	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required
A5	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required
B1	Optional	Optional	Not Required	Not Required	Not Required	Optional	Optional	Optional	Not Required	Not Required
B2	Required	Optional	Optional	Not Required	Not Required	Required	Required	Optional	Not Required	Not Required
B3	Required	Optional	Optional	Not Required	Not Required	Required	Optional	Optional	Not Required	Not Required
B4	Required	Optional	Optional	Not Required	Not Required	Required	Required	Optional	Optional	Not Required
B5	Required	Optional	Optional	Not Required	Not Required	Required	Required	Optional	Optional	Not Required
B6	Required	Required	Required	Not Required	Not Required	Required	Required	Required	Optional	Optional
B7	Required	Optional	Optional	Not Required	Not Required	Required	Required	Required	Optional	Not Required
B8	Required	Optional	Optional	Not Required	Not Required	Required	Required	Optional	Optional	Not Required
B9	Required	Optional	Not Required	Not Required	Not Required	Required	Required	Optional	Not Required	Not Required
C1	Required	Optional	Optional	Not Required	Not Required	Required	Required	Optional	Optional	Not Required
C2	Required	Optional	Optional	Not Required	Not Required	Required	Required	Optional	Optional	Not Required
C3	Required	Optional	Optional	Not Required	Not Required	Required	Required	Optional	Optional	Not Required
C4	Required	Optional	Optional	Not Required	Not Required	Required	Required	Optional	Optional	Not Required
D	Optional	Optional	Optional	Not Required	Not Required	Optional	Optional	Optional	Optional	Not Required

Figure 3.1: Expansion of PAS 2080 modules for Network Rail new build / enhancement projects – February to December 2022

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New Build / Enhancement Projects - proposed expansion of PAS 2080 life cycle modules for carbon assessment

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Network Rail representation of PAS 2080 life cycle stage modules for quantification of infrastructure whole life carbon emissions (derived from PAS 2080:2016, Figure 7).

Maturing scope of whole life carbon assessment based on DfT Tiers OR Level of Control (LoC) score or project complexity assessment (PCA) and date of PACE ES1 readiness review

			January - December 2023					January 2024 onwards			
			DfT Tier 1, 2 & 3 Projects	Non-Tier 1, 2 or 3 Projects >£1m with PACE ES1 milestone in 2023 (calendar)				Non-Tier 1, 2 or 3 Projects >£1m with PACE ES1 milestone in 2024 (calendar)			
				LoC 1 / PCA 1	LoC 2 / PCA 2	LoC 3 / PCA 3	LoC 4 / PCA 4	LoC 1 / PCA 1	LoC 2 / PCA 2	LoC 3 / PCA 3	LoC 4 / PCA 4
BEFORE USE stage A0 - A5	A0	Preliminary Studies and Preconstruction Activities	Optional	Optional	Optional	Not Required	Not Required	Required	Optional	Not Required	Not Required
	A1 - A3	Product Stage - Product 'Embodied Carbon' (cradle to gate) Comprising: A1 - Raw material extraction A2 - Transportation within the manufacturing processes A3 - Processing and manufacturing	Required	Required	Required	Required	Required	Required	Required	Required	Required
	A4	Transportation - products, materials, plant & equipment, worker travel	Required	Required	Required	Required	Required	Required	Required	Required	Required
	A5	Construction / Installation Activities	Required	Required	Required	Required	Required	Required	Required	Required	Required
USE stage B1 - B9	B1	Emissions from Installed Materials	Required	Optional	Optional	Not Required	Not Required	Required	Required	Optional	Not Required
	B2	Maintenance	Required	Required	Required	Optional	Not Required	Required	Required	Optional	Optional
	B3	Repair	Required	Required	Optional	Optional	Not Required	Required	Required	Optional	Optional
	B4	Replacement / Renewal	Required	Required	Required	Optional	Not Required	Required	Required	Optional	Optional
	B5	Refurbishment	Required	Required	Optional	Optional	Not Required	Required	Required	Optional	Optional
	B6	Operational Energy Utilities Consumption	Required	Required	Required	Optional	Optional	Required	Required	Required	Required
	B7	Operational Water Utilities Consumption	Required	Required	Required	Optional	Not Required	Required	Required	Optional	Optional
	B8	Other Operational Emissions	Required	Required	Optional	Optional	Not Required	Required	Required	Optional	Optional
	B9	User Utilization of Infrastructure	Required	Required	Optional	Optional	Not Required	Required	Required	Optional	Optional
END OF LIFE stage C1 - C4	C1	Deconstruction	Required	Required	Required	Optional	Not Required	Required	Required	Optional	Optional
	C2	Transportation - deconstructed materials, plant & equipment, worker travel	Required	Required	Required	Optional	Not Required	Required	Required	Optional	Optional
	C3	Treatment of Deconstructed Materials	Required	Required	Required	Optional	Not Required	Required	Required	Optional	Optional
	C4	Disposal of Deconstructed Materials	Required	Required	Required	Optional	Not Required	Required	Required	Optional	Optional
BEYOND LIFE CYCLE D	D	Emissions Benefits / Loads from Infrastructure functions beyond the life cycle - including Circular Economy benefits, off-setting, etc.	Optional	Optional	Optional	Optional	Not Required	Required	Required	Optional	Not Required

Figure 3.2: Expansion of PAS 2080 modules for Network Rail new build / enhancement projects – January 2023 onwards

Asset Renewal / Replacement Works (non-DfT funded) - proposed expansion of PAS 2080 life cycle modules for carbon assessment

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Life cycle stage modules for quantification of infrastructure whole life carbon emissions (derived from PAS 2080:2016, Figure 7).

Maturing scope of whole life carbon assessment based on Level of Control (LoC) score [or project complexity assessment (PCA)] and date of PACE ES1 readiness review

			February to December 2022				January to December 2023				January 2024 to March 2025			
			Minimum Requirements for all works >£1m pre-PACE ES6				Projects >£1m with PACE ES1 milestone in 2023				Projects >£1m with PACE ES1 milestone from January 2024 to end of 2024/25			
			LoC 1 / PCA 1	LoC 2 / PCA 2	LoC 3 / PCA 3	LoC 4 / PCA 4	LoC 1 / PCA 1	LoC 2 / PCA 2	LoC 3 / PCA 3	LoC 4 / PCA 4	LoC 1 / PCA 1	LoC 2 / PCA 2	LoC 3 / PCA 3	LoC 4 / PCA 4
BEFORE USE stage A0 - A5	A0	Preliminary Studies and Preconstruction Activities	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
	A1 - A3	Product Stage - Product 'Embodied Carbon' (cradle to gate) Comprising: A1 - Raw material extraction A2 - Transportation within the manufacturing processes A3 - Processing and manufacturing	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required
	A4	Transportation - products, materials, plant & equipment, worker travel	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required
	A5	Construction / Installation Activities	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required
USE stage B1 - B9	B1	Emissions from Installed Materials	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Optional	Optional	Not Required	Not Required
	B2	Maintenance	Optional	Not Required	Not Required	Not Required	Required	Optional	Not Required	Not Required	Required	Optional	Not Required	Not Required
	B3	Repair	Not Required	Not Required	Not Required	Not Required	Optional	Not Required	Not Required	Not Required	Optional	Not Required	Not Required	Not Required
	B4	Replacement / Renewal	Optional	Not Required	Not Required	Not Required	Required	Optional	Not Required	Not Required	Required	Required	Optional	Not Required
	B5	Refurbishment	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
	B6	Operational Energy Utilities Consumption	Required	Optional	Not Required	Not Required	Required	Required	Optional	Not Required	Required	Required	Required	Required
	B7	Operational Water Utilities Consumption	Optional	Not Required	Not Required	Not Required	Required	Optional	Not Required	Not Required	Required	Required	Optional	Optional
	B8	Other Operational Emissions	Not Required	Not Required	Not Required	Not Required	Optional	Optional	Not Required	Not Required	Required	Required	Optional	Not Required
	B9	User Utilization of Infrastructure	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
END OF LIFE stage C1 - C4	C1	Deconstruction	Optional	Optional	Not Required	Not Required	Required	Optional	Not Required	Not Required	Required	Required	Optional	Not Required
	C2	Transportation - deconstructed materials, plant & equipment, worker travel	Optional	Optional	Not Required	Not Required	Required	Optional	Not Required	Not Required	Required	Required	Optional	Not Required
	C3	Treatment of Deconstructed Materials	Optional	Optional	Not Required	Not Required	Required	Optional	Not Required	Not Required	Required	Required	Optional	Not Required
	C4	Disposal of Deconstructed Materials	Optional	Optional	Not Required	Not Required	Required	Optional	Not Required	Not Required	Required	Required	Optional	Not Required
BEYOND LIFE CYCLE D	D	Emissions Benefits / Loads from Infrastructure functions beyond the life cycle - including Circular Economy benefits, off-setting, etc.	Optional	Not Required	Not Required	Not Required	Optional	Optional	Not Required	Not Required	Required	Required	Optional	Not Required

Figure 4: Expansion of PAS 2080 modules to be covered by non-DfT funded asset renewal / replacement work

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6.2 Which products, materials, components and activities to assess? (spatial boundaries)

As well as being clear which PAS 2080 life cycle modules are included in the assessment of carbon emissions it is equally important to clearly state which physical assets, elements and components (hardware), activities and other influential factors will be included in the assessment. This may be referred to as the 'spatial' boundary.

The spatial boundary will need to be defined and agreed for each applicable PAS 2080 module so that the scope of each modular assessment is understood by all parties. This also enables the resulting carbon data to be interpreted and reported transparently, with declared gaps and caveats.

The decision on which elements/components/activities to include in the spatial boundary for a given PAS 2080 module should be based on the item's relative contribution to the module. The aim should be to ensure that all significant whole life carbon contributions are included.

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7. RSSB Rail Carbon Tool - Network Rail approved carbon assessment tool and carbon assessments templates

7.1 Access to the RSSB Rail Carbon Tool

Network Rail currently specifies use of the RSSB Rail Carbon Tool (RCT) to undertake carbon assessments on Network Rail projects.

The RSSB Rail Carbon Tool can only be accessed by authorised persons so those required to undertake, update or view project carbon assessments will need to register for an RCT user account via:

https://www.railindustrycarbon.com

Each project should nominate at least one competent person to act as RCT Account Manager. RCT Account Manager(s) will hold the authority for setting up Network Rail projects in the RSSB Rail Carbon Tool, and for defining delegated authority, read-write access control, etc. to other persons.

Network Rail has created a set of standard 'security groups' that should be added to historic projects and routinely to new projects. Each security group will contain an agreed list of contacts with legitimate interest in the project carbon data. Security groups have been set up for each of the five devolved Network Rail regions, plus an additional security group for relevant centralised (corporate) contacts. The security groups are named as follows:

- NR Corp01
- NR Eastern01
- NR NW&C01
- NR Scotland01
- NR Southern01
- NR W&W01

Individual projects must add the relevant regional security group(s) and the centralised (corporate) security group to their security access.

7.2 Standardised project templates for whole life carbon assessments in the RSSB Rail Carbon Tool

Undertaking whole life carbon assessments in accordance with the life cycle modules of PAS 2080 is still a new concept for Network Rail projects. To help construct whole life carbon assessments in a consistent way we are developing standard project templates within the Rail Carbon Tool.

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Single option PAS 2080 Template

Network Rail project template ID 775529 is intended to provide a model folders structure and naming convention for carbon assessment across the life cycle modules of PAS 2080. It contains no carbon calculation packages as these would be added at a project level.

Project template ID 775529 covers all PAS 2080 modules. However, those modules that have been agreed as falling outside the life-cycle boundaries for a given project may be left blank. Section 6.1 above describes the Network Rail criteria to specify which PAS 2080 modules will be required or optional for projects.

The ID 775529 template is freely available to all Rail Carbon Tool users and can be copied as the basis for creating a new project but PLEASE DO NOT OVER-WRITE THE ORIGINAL TEMPLATE.

Multi-option PAS 2080 template aligned to PACE phases

A further recommended development is to arrange the PAS 2080 templates into key PACE phases so that the whole life carbon assessment at each PACE phase can be reviewed and compared as separate folder layers.

A template that implements this structure has been developed in Scotland and converted into a new generic template ID 810153.

Again the project template ID 810153 provides a model folders structure and naming convention for carbon assessment across the life cycle modules of PAS 2080 but contains no carbon calculation packages as these would be added at a project level.

Project template ID 810153 covers all PAS 2080 modules but modules that fall outside the required life-cycle boundaries for a given project may be left blank.

The ID 810153 template can be copied as the basis for creating a new project but PLEASE DO NOT OVER-WRITE THE ORIGINAL TEMPLATE.

For feedback on templates or enquiries about the scope and boundaries of NR carbon assessments please contact: clive.jones@networkrail.co.uk

7.3 Project naming convention in the RSSB Rail Carbon Tool

Historically the naming of projects in the Rail Carbon Tool has been inconsistent, making it difficult to search for projects that may involve similar types of carbon assessment and could offer useful sources of comparative data.

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The purpose of a naming convention is to introduce order and consistency to a data set that would otherwise be highly variable and random. This in turn supports activities such as grouping and interpreting data sets that address similar themes.

While it is not practical to define a fully prescriptive naming convention for all projects those setting up projects should apply the naming principles below. This will help the business to collate, interpret and learn from allied carbon data sets.

NB. The RSSB Rail Carbon Tool has a restriction of 100 characters including spaces for project titles.

Naming for general enhancement / new build projects

Default enhancement project naming convention should have **two** parts as follows:

'Region – Project Name'

Examples:

"NR Eastern – insert free text project name"

"NR NW&C - insert free text project name"

"NR Scotland - insert free text project name"

"NR Southern - insert free text project name"

"NR W&W - insert free text project name"

If the regions wish to introduce differentiation across their route projects a **three**-part naming convention should be used as below:

"NR Southern – Wessex – insert free text project name"

Naming for asset projects

Where project engineering works are restricted to interventions within a specific rail asset category, notably for asset renewal / replacement works or new build of specific rail asset types, the project naming convention should make this clear by including the major asset group in the project name.

Network Rail major asset groups are as follows:

- Buildings - which includes stations, light maintenance depots (LMDs), maintenance delivery units (MDUs), lineside buildings, route services depots
- Drainage
- Earthworks
- Electrification & Fixed Plant
- Level Crossings
- Lineside
- Mobile Plant & Equipment

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- Signalling
- Structures - which includes coastal & estuarine defences, bridges, culverts, non-station footbridges, major structures, retaining walls
- Track - which includes various track types and switches & crossings (S&C)
- Tunnels

Minimum asset project naming should have **three** parts as follows:

'Region - Major Asset Group - Project Name'

Examples:

"NR Southern - Track - insert free text project name"

"NR W&W - Structures - insert free text project name"

"NR Eastern - Earthworks - insert free text project name"

If additional asset differentiation is possible because the project will be focussed on a particular asset sub-group a **four**-part naming convention is recommended as below:

"NR Scotland – Electrification – OLE – insert free text project name"

"NR NW&C – Structures – Bridges - insert free text project name"

"NR Eastern – Track – S&C - insert free text project name"

"NR W&W – Buildings – Station - insert free text project name"

If asset carbon assessment projects are undertaken but not linked to a particular regional location the hierarchical asset naming convention above should be applied but without the regional prefix.

Examples:

"Buildings – Station - Platforms – insert free text project name"

"Electrification – OLE – insert free text project name"

"Structures – Bridges - insert free text project name"

"Track – Plain-line Track - insert free text project name"

Miscellaneous Project Names

Where Rail Carbon Tool project folders are created for other purposes a naming convention should be applied that allows general RCT administrators, such as authorised RSSB staff, to gain reasonable insight to the project type. This helps enormously when categorising projects in the platform. Miscellaneous examples could include:

"Personal Training – insert free text project name"

"Backup Copy – insert free text project name"

"Test Project – insert free text project name"

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7.4 Training and skills development for using the RSSB Rail Carbon Tool

The RSSB host learning tools and training options to support users of the Rail Carbon Tool. These range from short video tutorials on performing specific tasks within the tool to classroom or virtual classroom training sessions. A fee is payable for attendance to the classroom training options.

This link provides access to the Rail Carbon Tool resource hub: Rail Carbon Tool (rssb.co.uk)

From here you can either register for a Hub account or log in if you're already registered. This takes you to the main RSSB Rail Carbon Tool resource hub with links to:

- All the short Rail Carbon Tool 'How to' videos
- Access to open/download the Rail Carbon Tool 'User Guide'
- A link to the training page to see forthcoming dates and other information about booking classroom/virtual training events, including bespoke events for project teams.
- A link to the Rail Carbon Tool (RCT) itself. For RCT access there is a second registration process to be issued with an RCT user account.

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8. Practical considerations for carbon assessment of key PAS 2080 life cycle modules

As described in section 4 (Figures 1 and 2), PAS 2080 represents the whole life cycle carbon emissions of infrastructure through a series of numbered modules. A summary of the scope of individual PAS 2080 modules is provided at **Appendix A.**

The tables in this section explore some practical considerations for planning carbon assessments within key PAS 2080 modules:

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PAS 2080 Module Ref:	**A1-A3 – Before Use – Product / Material Embodied Carbon**
Maturity:	Readily quantifiable and empirical.
Applicable aspects:	All construction materials and manufactured products / components used in construction / fit-out.
Activity / data requirements:	• Bill of quantities data. • Product composition. • Product dimensions. • Access to standard industry carbon conversion factors • Access to environmental product declarations (EPDs) with climate declarations.
Practical considerations:	Requires clear agreement and declaration of which products / components / materials will be included in the assessment and which will be excluded (i.e. the spatial boundaries). We should aim to build an increasingly comprehensive portfolio of embodied carbon calculations for standard rail products / components / materials as 'templates' for projects to drag into their carbon assessments. Waste Materials from this module should be treated through process in Modules C2-C4.
Assumptions / caveats	Dependent on provisional bill of quantities estimates during early project phases, becoming increasingly accurate by construction-ready design.
Uncertainties / problem statements	Relatively easy for civil engineering materials and products. Much more difficult for complex products made from intricate electrical, electronic or mechanical components or single use consumable products. For complex products Environmental Product Declarations (EPDs) conforming to ISO 14025 and EN15804 will become an important source of product information, particularly where they include a climate declaration. Manufacturers and suppliers of products should be encouraged to provide EPDs and climate declarations for their products.
Opportunities:	Embodied carbon of products and materials can be reduced when manufacturers: • source their materials ethically. • use recycled materials in their products. • use low carbon raw materials. • design with products that are highly recoverable / recyclable and satisfy circular economy principles. • implement energy efficiency programmes throughout the manufacturing and other business functions. • commit to renewable or nuclear energy providers. • source raw materials locally. • use low carbon electric, hybrid or hydrogen vehicles to transport their products within their manufacturing processes. • Infrastructure that could use GHGs for various functions (example high voltage switchgear that contains SF6 gas as an insulator) should prioritise alternative technologies and products.
Outputs	Carbon emissions shall be quantified as $kgCO_2e$ from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**A4 – Before Use – Construction transportation**
Maturity:	Readily quantifiable and empirical.
Applicable aspects:	• Transport of construction products and materials from manufacturer's factory gate to any Network Rail site, either directly or via a warehouse, logistics centre, or other intermediate location • Transport of construction plant, equipment and temporary accommodation transport to / from site. • Transport of waste from site. • Worker travel to / from site.
Activity / data requirements:	• Bill of quantities for items requiring transport. • Transport / travel modes and emissions data. • Transport / travel distances. • Number of transport cycles.
Practical considerations:	Requires clear agreement and declaration of which transportation activities will be included in the assessment and which will be excluded (i.e. the spatial boundaries).
Assumptions / caveats	Dependent on provisional estimates during early project phases, becoming increasingly accurate by construction-ready design.
Uncertainties / problem statements	
Carbon Reduction Opportunities:	To reduce carbon emissions of travelling to and from site, opt to use public transport, walk, or cycle to work see more information on cycle to work scheme. Alternatively, arrange to car share with colleagues, where travelling by car is unavoidable.
Outputs	Carbon emissions shall be quantified as kgCO_2e from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**A5 – Before Use – Construction site activities**
Maturity:	Readily quantifiable and empirical.
Applicable aspects:	• Fuel use by mobile plant / equipment / vehicle operations on site. • Fuel use by fixed plant / equipment for site operations and welfare. • Grid electricity use by fixed plant / equipment for site operations and welfare. • Water utilities consumption for site operations and welfare.
Activity / data requirements:	• Bill of quantities for mobile site plant / equipment. • Bill of quantities for fixed site plant / equipment. • Fuel types. • Fuel consumption data. • Grid electricity consumption data. • Mains/potable water consumption data. • Recycled water consumption data.
Practical considerations:	Requires clear agreement and declaration of which site activities will be included in the assessment and which will be excluded (i.e. the spatial boundaries).
Assumptions / caveats	Dependent on provisional estimates during early project phases, becoming increasingly accurate by construction-ready design.
Uncertainties / problem statements	
Carbon Reduction Opportunities:	Fuel use for mobile plant and equipment, and site-based vehicles, should have the following restrictions: Prioritise hybrid/fully electric vehicles over red-diesel or other hydrocarbon-based fuels; Where fuel is necessary, opt for low carbon sources such as biofuel; Unnecessary vehicle movements and journeys are to be avoided; Tyre pressure is to be set at the appropriate level to obtain maximum efficiency; Ensure that generators are specified to optimum efficiency loadings (75 to 80 %); Operate plant/vehicles in an efficient manner by minimising idling time and using the appropriate power only. Where mains connections are not possible consideration should be given to hybrid / renewable alternatives. Staff behaviours often play a big part in energy efficiency, so there should be training and communication strategies focused on encouraging and promoting awareness and conservation of our lighting, water and heating usage.
Outputs	Carbon emissions shall be quantified as $kgCO_2e$ from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**B2 – In Use – Maintenance**
Maturity:	Reasonably predictable and quantifiable from planned maintenance schedules.
Applicable aspects:	• Materials and manufactured products / components used in maintenance cycles. • Transportation of products / materials / plant & equipment / workers for maintenance activities. • Fuel use and utilities consumption for maintenance activities.
Activity / data requirements:	• Infrastructure / asset design life. • Maintenance intervals. • Maintenance schedules and scope. • Repeating cycles of A1-A3 data for materials and products required for planned maintenance schedules. See A1-A3 above for guidance. • Repeating cycles of A4 data for transport of materials and staff for planned maintenance schedules. See A4 above for guidance. • Repeating cycles of A5 data for worksite activities for planned maintenance schedules. See A5 above for guidance.
Practical considerations:	Requires clear agreement and declaration of which maintenance operations will be included in the assessment and which will be excluded (i.e. the spatial boundaries).
Assumptions / caveats	·
Uncertainties / problem statements	Relatively predictable for planned maintenance schedules with known intervention scope.
Carbon Reduction Opportunities:	Where mains connections are not possible consideration should be given to portable hybrid / renewable alternatives. Priorities should be given to electrically run appliances over gas and other fuels, unless reduced emissions over the assets lifecycle can be assured. Staff behaviours often play a big part in energy efficiency, so there should be training and communication strategies focusing on encouraging and promoting awareness and conservation of our lighting, water and heating usage.
Outputs	Carbon emissions shall be quantified as $kgCO_2e$ from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**B3 – In Use – Repair**
Maturity:	Highly speculative and unpredictable.
Applicable aspects:	• Materials and manufactured products / components used in repair cycles. • Transportation of products / materials / plant & equipment / workers for repair activities. • Fuel use and utilities consumption for repair activities.
Activity / data requirements:	• Infrastructure / asset design life. • Repair intervals (if known). • Repair schedules and scope. • Repeating cycles of A1-A3 data for repair activities. • Repeating cycles of A4 data for repair activities. • Repeating cycles of A5 data for repair activities.
Practical considerations:	Requires clear agreement and declaration of which repair operations will be included in the assessment and which will be excluded (i.e. the spatial boundaries).
Assumptions / caveats	.
Uncertainties / problem statements	Unpredictable and speculative - repairs are more specific to the location and asset condition than other modules.
Carbon Reduction Opportunities:	See Opportunities available to A1-A3, A4 and A5.
Outputs	Carbon emissions shall be quantified as $kgCO_2e$ from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**B4 – In Use – Replacement**
Maturity:	Reasonably predictable and quantifiable from planned replacement schedules.
Applicable aspects:	• Materials and manufactured products / components used in replacement cycles. • Transportation of products / materials / plant & equipment / workers for replacement activities. • Fuel use and utilities consumption for replacement activities. • Transportation of decommissioned products / materials. • Treatment for re-use, recovery or recycling of decommissioned products / materials. • Disposal of unrecoverable decommissioned products / materials.
Activity / data requirements:	• Infrastructure / asset design life. • Replacement intervals. • Replacement schedules and scope. • Repeating cycles of A1-A3 data for replacement schedules. • Repeating cycles of A4 data for replacement schedules. • Repeating cycles of A5 data for replacement schedules. • Repeating cycles of C2 for decommissioned products / materials. • Repeating cycles of C3 for decommissioned products / materials. • Repeating cycles of C4 for decommissioned products / materials.
Practical considerations:	Requires clear agreement and declaration of which replacement operations will be included in the assessment and which will be excluded (i.e. the spatial boundaries). We should aim to build an increasingly comprehensive portfolio of embodied carbon calculations for standard rail products / components / materials as 'templates' for projects to drag into their carbon assessments.
Assumptions / caveats	Could be modelled as a proportion (%) of construction phase activity. However, replacement activities follow predictable planned schedules with defined intervention scope, so we should aim to build an increasingly comprehensive portfolio of standard 'templates' for: Replacement product / materials embodied carbon emissions (A1-A3). Replacement transportation A4 emissions. Replacement site activity A5 emissions. Also needs a proportional allowance for: Transportation of decommissioned products / materials C2. Treatment of decommissioned products / materials C3. Disposal of decommissioned products / materials C4.
Uncertainties / problem statements	
Carbon Reduction Opportunities:	See Opportunities available to A1-A3, A4, A5, C2, C3 and C4.
Outputs	Carbon emissions shall be quantified as $kgCO_2e$ from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**B5 – In Use – Refurbishment**
Maturity:	Speculative and unpredictable.
Applicable aspects:	• Materials and manufactured products / components used in refurbishment. • Transportation of products / materials / plant & equipment / workers for refurbishment. • Fuel use and utilities consumption for refurbishment site activities. • Transportation of decommissioned products / materials. • Treatment for re-use, recovery or recycling of decommissioned products / materials. • Disposal of unrecoverable decommissioned products / materials.
Activity / data requirements:	• Infrastructure / asset design life. • Refurbishment intervals. • Speculative refurbishment scope. • Repeating cycles of A1-A3 data for refurbishment schedules. • Repeating cycles of A4 data for refurbishment schedules. • Repeating cycles of A5 data for refurbishment schedules. • Repeating cycles of C2 for decommissioned products / materials. • Repeating cycles of C3 for decommissioned products / materials. • Repeating cycles of C4 for decommissioned products / materials.
Practical considerations:	Requires clear agreement and declaration of which refurbishment activities will be included in the assessment and which will be excluded (i.e. the spatial boundaries).
Assumptions / caveats	Dependent on provisional estimates. May be modelled as a proportion (%) of: Construction phase A1-A3 emissions. Construction phase A4 emissions. Construction phase A5 emissions. Also needs a proportional allowance for: Transportation of decommissioned products / materials C2. Treatment of decommissioned products / materials C3. Disposal of decommissioned products / materials C4.
Uncertainties / problem statements	Unpredictable and speculative, due to Refurbishments being more specific to the location and asset condition than other modules.
Carbon Reduction Opportunities:	See Opportunities available to A1-A3, A4, A5, C2, C3 and C4.
Outputs	Carbon emissions shall be quantified as $kgCO_2e$ from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**B6 – In Use – Energy utilities consumption**
Maturity:	Reasonably predictable and quantifiable from a competent energy assessment.
Applicable aspects:	• Fuel use by fixed plant / equipment during asset operational life • Grid electricity use during asset operational life.
Activity / data requirements:	• Asset design life. • Fuel types. • Fuel use data per annum. • Fuel use carbon conversion factors. • Grid electricity use data per annum. • Grid electricity carbon conversion factors.
Practical considerations:	Requires a specialist competent energy assessment with clear technical brief to cover regulated and unregulated energy loads. Requires clear agreement and declaration of which energy consuming services / loads will be included in the assessment and which will be excluded (i.e. the spatial boundaries).
Assumptions / caveats	.Assume the Grid will not Decarbonise its power and focus design on low energy consumption.
Uncertainties / problem statements	
Carbon Reduction Opportunities:	Commission competent energy assessments to evaluate and forecast the energy loads; Research and apply industry best practice energy and thermal efficiency benchmarks in the design, specification and procurement of HVAC, mechanical and electrical services and building envelopes; Base investment and procurement decisions for HVAC and other mechanical and electrical services on long-term life cycle energy performance and life-cycle costs, including impact of future energy price projections; Specify renewable energy generation and storage technologies, only where the whole life carbon emissions of the energy generation and storage infrastructure will be neutralised; Apply effective commissioning procedures to check that new HVAC and mechanical and electrical services are operating to the designed efficiency specifications; Incorporate sub-metering for complex systems where granular data will support energy management; Design building management and control systems to optimise energy use and visualise energy performance data.
Outputs	Carbon emissions shall be quantified as kgCO_2e from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**B7 – In Use – Water utilities consumption**
Maturity:	Reasonably predictable and quantifiable from a competent water use assessment.
Applicable aspects:	• Mains / potable water use during asset operational life. • Recycled water use during asset operational life.
Activity / data requirements:	• Asset design life. • Mains / potable water services. • Mains / potable water use data per annum. • Mains / potable water carbon conversion factors. • Grey water services. • Grey water use data per annum. • Grey water carbon conversion factors.
Practical considerations:	Requires a specialist competent water consumption assessment. Requires clear agreement and declaration of which water services / demands will be included in the assessment and which will be excluded (i.e. the spatial boundaries).
Assumptions / caveats	
Uncertainties / problem statements	
Carbon Reduction Opportunities:	Commission competent water use assessments to evaluate and forecast water demands; Research and apply industry best practice water efficiency benchmarks in the design, specification and procurement of water services; Base investment and procurement decisions for water services on long-term life cycle performance and life-cycle costs, including impact of future water price or carbon levy projections; Specify grey water services where potable water is not required, only where the whole life carbon emissions of the grey water infrastructure will be neutralised; Apply effective commissioning procedures to check that new water services are operating to the designed specification; Incorporate sub-metering for complex water systems where granular data will support water management; Design building management and control systems to optimise water use and visualise water performance data.
Outputs	Carbon emissions shall be quantified as kgCO_2e from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**B8 – In Use – Emissions from other processes**
Maturity:	Reasonably predictable and quantifiable from a competent systems process analysis and procurement data.
Applicable aspects:	• Products and materials procured and used to enable the asset to operate and deliver its service. (Not to be double counted with products, chemicals and materials used during maintenance or repair activities.) • Treatment of wastes generated during asset operational life.
Activity / data requirements:	• Infrastructure / asset design life. • Annual intervals, schedules and scope for materials and products (consumables) required for the asset to deliver its operational function (excluding maintenance / repair). • Annual bill of quantities for repeating cycles of A1-A3 data for materials and products required for the asset to deliver its operational function (excluding maintenance / repair). See A1-A3 above for guidance. • Annual bill or quantities for repeating cycles of A4 data for transport of materials and staff for activities required for the asset to deliver its operational function (excluding maintenance / repair). See A4 above for guidance. • Annual bill of quantities for repeating cycles of A5 data for worksite activities that enable the asset to deliver its operational function (excluding maintenance / repair). See A5 above for guidance. • Environmental product declarations (EPDs) with GHG emissions factors for chemical products used.
Practical considerations:	Requires clear agreement and declaration of which process related carbon emissions for enabling the asset to deliver its operational function and service are included in the assessment, and which will be excluded (i.e. the spatial boundaries).
Assumptions / caveats	May require increased dependency on suppliers of goods / products providing environmental product declarations (EPDs) with GHG emissions factors.
Uncertainties / problem statements	To avoid double counting care is needed to differentiate emissions for processes and consumables associated with operating the asset and enabling it to deliver it's intended service, from those used to maintain or repair the asset.
Carbon Reduction Opportunities:	Prioritise products with low to zero carbon / GHG emissions. If that can't be achieved, either because no product is currently available or the GHG is an essential component in the Enabling of the Asset, priority should be given to designs that reduce the products use and R&D projects can be investigated to producing a replacement.
Outputs	Carbon emissions shall be quantified as kgCO_2e from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**B9 – In Use – User utilization of infrastructure**
Maturity:	Speculative and unpredictable.
Applicable aspects:	Represents activities associated with user's utilisation of the infrastructure during the use stage. This is defined by the principle of control versus influence so that the carbon emissions are considered B9 ('User's' utilisation) when they arise from an activity that the 'User' has **control** over while they set out to utilize a piece of infrastructure. The infrastructure owner / operator may still be able to exercise **influence** over the emissions. Rail infrastructure examples could include: • The mode of traction power used by a TOC or FOC. • The mode of transport that a passenger 'user' decides to take when travelling to / from a station (bus, private car, bicycle, etc.). With private vehicles the user choices extend to power type – petrol, diesel, electric and these could be **influenced** by the asset owner / operator through aspects such as availability of EV charging infrastructure. NB. Care will be needed when evaluating national transport carbon data for user travel, as this could end up as double counting with National Highways B9 carbon data.
Activity / data requirements:	• Asset design life. • Passenger numbers. • Demographics of travel in local area. • Predicted increase of service available to public.
Practical considerations:	Requires clear agreement and declaration of which aspects of user utilization of infrastructure will be included in the assessment and which will be excluded (i.e. the spatial boundaries). The User in this module includes passengers, tenants, TOCs and FOCs.
Assumptions / caveats	User utilisation of infrastructure assets is not in Network Rails control, so assumptions will have to be made.
Uncertainties / problem statements	Changes in 'user' behaviours and associated emissions in response to asset owner / operator influences and investments are difficult to predict and quantify.
Carbon Reduction Opportunities:	Consider installation of secure bike racks and EV charging points to promote low emission access to public assets. Consider installing public use assets in closer proximity to centres of residence and commerce, especially in remote areas where the public are reliant on personal vehicles. Consider stations as low emission transport hubs with integrated low emission transport connectivity. Consider the installation of assets that would reduce TOCs and FOCs reliance on fossil fuel traction power. Consider the installation of assets that improve access to paperless travel.
Outputs	Carbon emissions shall be quantified as kgCO_2e from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**C1 – End of Life – Deconstruction site activities**
Maturity:	Reasonably quantifiable and empirical parameters – but highly speculative volumes.
Applicable aspects:	• Fuel use by mobile plant / equipment / vehicle operations on site. • Fuel use by fixed plant / equipment for site operations and welfare. • Grid electricity use by fixed plant / equipment for site operations and welfare. • Water utilities consumption for site operations and welfare.
Activity / data requirements:	• Bill of quantities for mobile site plant / equipment. • Bill of quantities for fixed site plant / equipment. • Fuel types. • Fuel consumption data. • Grid electricity consumption data. • Mains/potable water consumption data. • Recycled water consumption data.
Practical considerations:	Requires clear agreement and declaration of which deconstruction site activities will be included in the assessment and which will be excluded (i.e. the spatial boundaries).
Assumptions / caveats	Dependent on provisional estimates. May be modelled as a proportion (%) of the construction phase site activity emissions (A5).
Uncertainties / problem statements	
Carbon Reduction Opportunities:	Fuel use for mobile plant and equipment, and site-based vehicles, should have the following restrictions: Prioritise hybrid/fully electric vehicles over red-diesel or other hydrocarbon-based fuels; Where fuel is necessary, opt for low carbon sources such as biofuel; Unnecessary vehicle movements and journeys are to be avoided; Tyre pressure is to be set at the appropriate level to obtain maximum efficiency; Ensure that generators are specified to optimum efficiency loadings (75 to 80 %); Operate plant/vehicles in an efficient manner by minimising idling time and using the appropriate power only. Where mains connections are not possible consideration should be given to hybrid / renewable alternatives.
Outputs	Carbon emissions shall be quantified as kgCO_2e from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**C2 – End of Life – Transportation**
Maturity:	Quantifiable and empirical – but highly speculative.
Applicable aspects:	• Deconstructed materials & products transport from site. • Demolition plant, equipment and temporary accommodation transport to / from site. • Other wastes transport from site. • Worker travel to / from site.
Activity / data requirements:	• Bill of quantities for items requiring transport. • Transport / travel modes and emissions data. • Transport / travel distances. • Number of transport cycles.
Practical considerations:	Requires clear agreement and declaration of which transport activities will be included in the assessment and which will be excluded (i.e. the spatial boundaries).
Assumptions / caveats	Dependent on provisional estimates. May be modelled as a proportion (%) of the construction phase transportation emissions (A4).
Uncertainties / problem statements	
Carbon Reduction Opportunities:	Fuel use for vehicles should have the following restrictions: Prioritise hybrid/fully electric vehicles over red-diesel or other hydrocarbon-based fuels; Where fuel is necessary, opt for low carbon sources such as biofuel; Unnecessary vehicle movements and journeys are to be avoided; Tyre pressure is to be set at the appropriate level to obtain maximum efficiency; Operate vehicles in an efficient manner by minimising idling time and using the appropriate power only.
Outputs	Carbon emissions shall be quantified as kgCO_2e from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**C3 – End of Life – Treatment**
Maturity:	Reasonably predictable and quantifiable from product / materials data acquired for A1-A3 and B4 (and B5??).
Applicable aspects:	• Carbon emissions from treatment and processing to recover, reuse and recycle waste materials arising from infrastructure. • Applies to all waste material outputs from dismantling, deconstruction or demolition of the infrastructure and covers all debris, construction products, materials or construction elements, etc. arising from the infrastructure.
Activity / data requirements:	• Bill of quantities data from A1-A3 and B4 (and B5??). • Proportional (%) bill of quantities of materials suitable for materials recovery / reuse. • Proportional (%) bill of quantities of materials suitable for recycling. • Industry benchmark waste treatment / processing carbon conversion factors.
Practical considerations:	Requires clear agreement and declaration of which deconstructed products / components / materials will be included in the treatments assessment, and which will be excluded. (i.e. the spatial boundaries).
Assumptions / caveats	
Uncertainties / problem statements	
Carbon Reduction Opportunities:	Priority should be given to assets, components and materials that can be reused, as this has no emissions impact except in transport, storage and installation to new assets. If reusable assets, components or materials are not available, then recyclable has greater priority over disposal options, as recycling produces less carbon.
Outputs	Carbon emissions shall be quantified as kgCO_2e from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**C4 – End of Life – Disposal**
Maturity:	Reasonably predictable and quantifiable from product / materials data acquired for A1-A3 and B4 (and B5??)
Applicable aspects:	• Carbon emissions from final disposal of demolition materials (neutralisation, incineration with or without utilisation of energy, landfilling with or without utilisation of landfill gases, etc.). • Also includes any treatments that are necessary before and to enable final disposal. NB. Any carbon emission benefits from exported energy (i.e. through substitution) shall be reported into module D.
Activity / data requirements:	• Bill of quantities data from A1-A3 and B4 (and B5??). • Proportional (%) bill of quantities of inert materials likely to go direct to landfill. • Proportional (%) bill of quantities of materials likely to go direct to landfill but with pre-treatments. • Proportional (%) bill of quantities of materials likely to go for incineration. • Proportional (%) bill of quantities of materials likely to go to energy from waste. • Proportional (%) bill of quantities of materials likely to go to anaerobic digestion. • Industry benchmark waste disposal carbon conversion factors.
Practical considerations:	Requires clear agreement and declaration of which deconstructed products / components / materials will be included in the disposal assessment, and which will be excluded. (i.e. the spatial boundaries).
Assumptions / caveats	
Uncertainties / problem statements	
Carbon Reduction Opportunities:	Priority should be given to assets, components and materials that can be recovered / reused recycled over disposal options. However, if recyclable options are not available then: Anaerobic digestion should be given higher priority than landfill. Energy from waste should be given higher priority than incineration.
Outputs	Carbon emissions shall be quantified as kgCO_2e from each contributing emissions calculation, with a sum for the entire module.

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PAS 2080 Module Ref:	**D – Carbon benefits / loads beyond the infrastructure life cycle**
Maturity:	Reasonably quantifiable and empirical parameters – but speculative.
Applicable aspects:	Quantifiable future carbon emissions that can be avoided **after** the life cycle of the infrastructure but are enabled by option decisions and outcomes made **during** the infrastructure / asset life cycle, including: • Future carbon avoided from deconstructed components / products / materials that are readily recovered / re-used (circular economy). • Future carbon avoided from deconstructed components / products / materials that are readily recycled (circular economy). • Low carbon energy generated from organic waste materials. • Carbon sequestration from tree planting and other blue-green infrastructure landscaping implemented by the project*. • Carbon avoided by implementation of semi-natural surface water drainage, flood attenuation, and natural water pollution attenuation. (*NB. Landscaping carbon impacts must take account of the net difference between carbon sequestration capacity lost through development and re-provided as mitigation. Landscape impacts can also be considered through Network Rail's duties and strategic commitments towards biodiversity. Network Rail has committed to using recognised industry biodiversity assessment tools on projects to deliver 'no net loss' biodiversity outcomes by 2024 and 'net gain' biodiversity by 2035.
Activity / data requirements:	Quantity of materials that can be recycled into future projects/bodies of work. Record of energy generated from renewable sources. Invoice or workorder for tree planting service with species and number of trees planted. Record of expected quantity of avoided natural water pollution attenuation.
Practical considerations:	Requires clear agreement and declaration of which types of future carbon benefits and loads will be included in the assessment (i.e. the spatial boundaries). Requires clear log of options and decisions made to reduce emissions, including the scope of each change.
Assumptions / caveats	A contemporary design option that has given attention to carbon reduction would be expected to yield lower whole life carbon emissions compared to an older design solution. However, the life cycle carbon avoided by the progressive design is not Module D avoidance.
Uncertainties / problem statements	Where / how does the business account for carbon avoidance from decisions not to invest in a built solution? This would not be a module D avoidance.
Carbon Reduction Opportunities:	Priority given to designing infrastructure assets with elements, components and materials that satisfy the principles of circular economy and the waste avoidance hierarchy: 1.Re-use >> 2. Repurpose >> 3. Recycle >> 4. Recover for energy generation >> 5. dispose Accelerate adoption of 'net gain' biodiversity outcomes to provide net increase in carbon sequestration capacity. Sharing your low carbon alternative products and methodologies on the Rail Carbon Tool will help reduce the time needed to produce whole life emission reports and carbon emissions from future projects.

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Outputs	Carbon emissions shall be quantified as kgCO_2e from each contributing emissions calculation, with a sum for the entire module.

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9. Shadow Carbon Pricing

Network Rail is piloting the introduction of a shadow carbon pricing mechanism. This involves placing a monetary value on the quantified life cycle carbon emissions associated with capital investment projects. This allows the social and environmental implications of projects to be quantified in terms of both carbon emissions ($kgCO_2e$) and a monetised valuation derived proportionately from the carbon emissions data. The monetised carbon index can be considered alongside other traditional project costs, particularly during key investment appraisal decisions such as option selection, and design. This should significantly increase the incentive and mechanism for Network Rail to account for carbon emissions during project investment decisions and promote low carbon solutions that are consistent with Network Rail's net-zero carbon target.

The carbon emissions used in the shadow carbon pricing exercises will be derived from the assessment of whole life carbon described in this guidance note.

It is anticipated that project managers will apply shadow carbon pricing to inform investment decisions at PACE milestones ES3 and ES4. The shadow carbon pricing will be based on the whole life carbon estimates available for the various options being considered at PACE milestones ES3 and ES4.

For further guidance on Network Rail's shadow carbon pricing process please see Guidance Note NR/GN/ESD40.

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10. Management of carbon through PACE phases

Network Rail is ultimately accountable for leading and creating a culture where carbon reduction is a value metric for delivery of new rail infrastructure.

The following RACI matrices (see definitions) set out illustrative activities and responsibilities for carbon management through the project work stages and milestones as defined by the PACE (project acceleration in a controlled environment) governance process:

PACE Phase 1: Strategic Development & Project Selection Milestone ES1 (Client requirements defined and baselined)	Client / Asset Owner	Lead Designer	Constructors	Product / Material Suppliers
Define carbon reduction requirements, outputs and outcomes within the Client Remit and Sponsor's Instruction	R/A	C	I	I
Confirm which PAS 2080 modules will be mandatory or optional for determining the carbon emissions of the project (see section 6.1 for PAS 2080 life cycle boundaries)	R/A	C	I	I
Confirm which physical elements, components (hardware) and activities will be assessed for carbon emissions in **each** PAS 2080 module (the spatial boundaries)	R/A	C	I	I
Confirm the life cycle reference study period over which the carbon emissions will be assessed (typically 60 years or 120 years)	R/A	C	I	I
Consider setting a project carbon reduction target.	R/A	C	I	I
Establish the governance arrangements (e.g. progress review meetings and leadership decision making) through which performance against project requirements and targets will be tracked and reviewed.	R/A	C	I	I
Establish early engagement on carbon reduction goals with value chain partners.	R/A	C	I	I
Specify the use of the RSSB Rail Carbon Tool for carbon emissions quantification.	R/A	C	C	C

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PACE Phase 1: Strategic Development & Project Selection Milestone ES2 (Constraints identified and project feasibility confirmed)	Client / Asset Owner	Lead Designer	Constructors	Product / Material Suppliers
Embed carbon reduction requirements in procurement activities for top tier suppliers and challenge suppliers to deliver innovation.	R/A	C	C	C
Define the reference baseline (the design solution and construction delivery method that would most closely represent the conventional rail infrastructure solution).	R/A	R	I	I
Maintain engagement on carbon reduction goals with value chain partners.	R/A	C	C	C

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PACE Phase 1: Strategic Development & Project Selection Milestone ES3 (Single option identified and endorsed)	Client / Asset Owner	Lead Designer	Constructors	Product / Material Suppliers
Define an outline Rail Carbon Tool (RCT) project tree to enable high level comparison of alternative options. High level options assessments may use a simplified RCT project tree, folders and packages with sufficient accuracy to: • Align the option carbon assessment with the PAS 2080 life cycle modules agreed as applicable to the project; • Quantify carbon emission 'hot spots*' within each applicable PAS 2080 module; • Enable the options to be compared and ranked in terms of their relative carbon emission hot spots. *Note: 'Hot spots' are the products/materials, elements, design features, construction methods, activities or end of life treatments which have high carbon emissions. Note: Network Rail RCT templates such as Project ID 775529 or ID 810153 may be used to create PAS 2080 compliant project trees.	R/A	R	C	I
Use the simplified Rail Carbon Tool project tree to prepare 'high level' carbon emissions estimates for each significant option.	I	R/A	C	C
Quantify the reference baseline (the design solution and construction delivery method that would most closely represent the conventional rail infrastructure solution).	R/A	R	C	C
Compare and rank projected carbon emissions for each option to inform option selection	R/A	R	C	I
Apply Network Rail shadow carbon pricing process to inform carbon economics during option selection	R/A	R	C	I
Challenge the need for a new asset.	R	R/A	C	C
Collate written evidence to support the option selection decision, particularly where the preferred option does not indicate the lowest carbon emissions across the PAS 2080 modules applicable to the project.	R/A	R	C	C

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Maintain engagement on carbon reduction goals with value chain partners.	R/A	C	C	C
ES3 milestone statement to confirm that the project is on track to deliver the carbon reduction requirements, outputs and outcomes agreed within the Client Remit and Sponsor's Instruction.	R/A	R	C	C

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PACE Phase 2: Project Development & Design Milestone ES4 (Design standards approved and Approval in Principle)	Client / Asset Owner	Lead Designer	Constructors	Product / Material Suppliers
Define the detailed Rail Carbon Tool project tree, folders and packages structure for full carbon assessment of the chosen project solution. The detailed Rail Carbon Tool project tree will: • Align the project carbon assessment with all PAS 2080 life cycle modules; • Account for all the agreed spatial boundaries (components, products, materials, and activities) to be included in each PAS 2080 module that is applicable to the project. Note: Network Rail RCT templates such as Project ID 775529 or ID 810153 may be copied to create PAS 2080 compliant project trees.	R/A	R	C	I
Use the detailed Rail Carbon Tool project tree to prepare the ES4 milestone carbon emissions assessment for the chosen option.	R/A	R	C	I
Detailed quantification of anticipated project carbon emissions compared to the reference baseline and reduction target (where set).	R	R/A	C	I
Detailed analysis of carbon hot spots (design and construction elements with the greatest carbon emissions). Hot spots should be used to validate the spatial boundaries of each PAS 2080 module to assure that key carbon emission contributions are not left out of the assessment.	R	R/A	C	I
Engage value chain to seek innovation and identify opportunities for carbon reduction by design/ construction/waste disposal method. Note: Design workshop(s) may be useful to focus the value chain on carbon reduction innovation, circular economy and other sustainability themes.	R	R/A	C	C
Confirm which carbon reduction solutions or changes to construction methods will be applied and approved without compromising the engineering integrity	R	R/A	I	I

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of the design, or other project success criteria or benefits realisation.				
Apply Network Rail shadow carbon pricing to inform carbon economics of design decisions	R/A	R	C	I
Set out design, construction and waste disposal specifications to deliver carbon reduction.	R/A	R	C	C
Prepare a '*Design-stage Whole Life Carbon Reduction Report*' to confirm which design and construction method carbon reduction solutions were specified and state the estimated carbon and cost reduction compared to the 'reference baseline' rail infrastructure solution and target (where set).	R	R/A	I	I
ES4 milestone statement to confirm that the project is on track to deliver the carbon reduction requirements, outputs and outcomes agreed within the Client Remit and Sponsor's Instruction.	R/A	R	C	C

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PACE Phase 2: Project Development & Design Milestone ES5 (Construction ready design approved)	Client / Asset Owner	Lead Designer	Constructors	Product / Material Suppliers
Finalise which carbon reduction design solutions or changes to construction methods will be applied and approved without compromising the engineering integrity of the design, or other project success criteria or benefits realisation.	R	R/A	I	I
Finalise design, construction and waste disposal specifications to deliver carbon reduction.	R/A	R	C	C
Finalise '*Design-stage Whole Life Carbon Reduction Report*' to confirm which design and construction method carbon reduction solutions were specified and state the estimated carbon and cost reduction compared to the 'reference baseline' rail infrastructure solution and target (where set).	R	R/A	I	I
Update the detailed Rail Carbon Tool project tree to prepare the ES5 milestone carbon emissions assessment for the project.	R/A	R	C	I
ES5 milestone statement to confirm that the project is on track to deliver the carbon reduction requirements, outputs and outcomes agreed within the Client Remit and Sponsor's Instruction.	R/A	R	C	C

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PACE Phase 3: Project Delivery Milestone ES6 (Construction complete)	Client / Asset Owner	Lead Designer	Constructors	Product / Material Suppliers
Embed carbon reduction requirements in procurement activities and challenge the value chain to deliver innovation beyond the design specification.	R	C	R/A	C
Update the detailed Rail Carbon Tool project tree to prepare the ES6 milestone carbon emissions assessment for the project. This revised ES6 project tree should be defined as the 'as-built' project tree.	R/A	C	R	I
Revision of the project whole life carbon emissions assessment (the 'as-built project tree') based on as-built information. Note: As-built carbon assessment revisions should address any aspects of the whole life carbon emissions, across the agreed life cycle and spatial boundaries, that have been altered as a result of construction phase changes, or become more accurate as a result of availability of actual data.	I	I	R/A	C
Confirm any additional carbon reductions, in the as-built report, that will be possible by changing value chain construction methods / materials / logistics / site behaviours, without compromising other project success criteria (including safety) or benefits realization.	I	C	R/A	C
Prepare an *As-Built Whole Life Carbon Reduction Report*' to confirm the overall carbon reduction from the 'as-built' design solution and actual construction activities, compared to the 'reference baseline' and target (where set).	R	C	R/A	I
ES6 milestone statement to confirm that the project is on track to deliver the carbon reduction requirements, outputs and outcomes agreed within the Client Remit and Sponsor's Instruction.	R/A	R	R	C

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PACE Phase 4: Project Close Milestone ES7 (Project demobilised and handed back to Sponsor)	Client / Asset Owner	Lead Designer	Constructors	Product / Material Suppliers
Update the detailed Rail Carbon Tool project tree to prepare the ES7 milestone carbon emissions assessment for the project.	R/A	C	R	I
ES7 milestone statement to confirm that the project has delivered the carbon reduction requirements, outputs and outcomes agreed within the Client Remit and Sponsor's Instruction.	R/A	R	R	C

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11. Case Studies

As a business we will consolidate our decarbonisation effort more quickly and effectively if we share the carbon reduction achievements and lessons learned from projects. Case studies offer a good mechanism to summarise successes and lessons for other projects.

A case study should typically include the following core elements:

- Name of project or package
- A suitable project description Confirmation of the system boundaries of the project carbon assessment, including:
    - Life cycle boundaries (i.e. which PAS 2080 modules were assessed) see sections 5 & 6
    - Spatial boundaries for each applicable PA 2080 module (i.e. which activities, products, components were assessed) see sections 5 & 8
    - Reference study period (RSP)
- How roles and responsibilities for carbon assessment were managed
- What reference baseline was used to compare and quantify carbon and cost reduction
- What carbon reduction was achieved, compared to the reference baseline
- What cost reduction was achieved, compared to the reference baseline
- Any other transferrable project learning
- A named contact for follow-up enquiries.

A case study template is available on Safety Central.

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Appendix A – PAS2080 modules

Summary of whole life-cycle carbon modular scope (derived from PAS 2080:2016 Annex A, Tables A 2; A 3; A 4; A 5)

BEFORE USE Pre-Construction	A0:	Represents carbon emissions associated with preliminary studies and works; for example strategy and brief development, architecture, design activities, EIA and cost planning. Most if not all these functions will be largely office based with devolved contributions from across the value chain. In this case carbon emissions might normally be associated with office based energy and water use and transportation demands. Note: When comparing options the A0 valuations may be descoped because the activity is common to all options and is unlikely to represent an option variance.
BEFORE USE Product Stage	A1-A3:	Represents carbon emissions associated with raw material extraction, precursor product processing, and final product manufacture, including energy use, water use and waste management within these processes. It will include any use of recycled or reuse materials and the process associated with making them ready for incorporation in infrastructure (but not processes that are part of the waste processing of the previous product system). Transportation will include all movement of materials and goods within the supply chain up to the point of final factory gate. Manufacture includes the final product used in the infrastructure but also any pre-product elements it might demand. Packaging and other material demands that may be necessary should also be included.
BEFORE USE Construction Stage Transportation	A4:	Represents carbon emissions from transportation (including intermediate storage and distribution) of products/materials and construction equipment (e.g. an asphalt paving machine or a crane) to the infrastructure construction site from point of production (or point of storage in the case of plant and machinery) to site works. This category might also record any carbon emissions associated with environmental conditions required to keep materials in a required state. If waste occurs due to spillage or damage during transport then waste processing of this and provision of new material and subsequent carbon emissions would be recognised here.

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BEFORE USE Construction Stage Site Works	A5:	Represents carbon emissions associated with construction site works activities including: • temporary works, ground works, and landscaping • materials storage and any energy or otherwise need to maintain necessary environmental conditions • transport of materials and equipment on site • installation of materials and products into the infrastructure asset • emissions associated with site utilities (energy and water) demand • waste management activities (transport, processing, final disposal) associated with waste arising from the construction site • production, transportation, and waste management of materials/products lost during works.
USE Installed materials emissions	B1:	Called 'Use' this represents the GHGs / carbon emitted directly from the fabric of products and materials once they have been installed as part of infrastructure and it is in normal use.
USE Maintenance, repair, replacement and refurbishment cycles	B2-B5:	Represents carbon emissions associated with the works activities and new materials for the maintenance, repair, replacement and refurbishment of the infrastructure during the prolonged use stage / operation of infrastructure. This is notionally described as capital carbon. However, depending on organisational interpretation, and the way that such activities are delivered through capital and/or operational expenditure budgets, they might alternatively be described as operational carbon emissions.
USE Energy consumption	B6:	Represents the carbon emissions resulting from the energy used by infrastructure-integrated technical systems to enable it to deliver its service during operation. This might be to provide heating and cooling, ventilation, lighting, auxiliary energy for pumps, control and automation. Both direct and indirect energy sources might be used for such systems including the combustion of fuels in plant and equipment and the consumption of electricity from energy grids. In the case that hot water or steam is purchased to enable infrastructure operation, it should also be included in this module.
USE Water consumption	B7:	This represents the carbon emissions resulting from the consumption of water required by infrastructure to enable it to operate and deliver its service. It will include all water used and its treatment (pre- and post use) during the normal operation of the infrastructure. For transport this might include aspects such as water for washing and cleaning trains; or in the case of highways water used for cleaning road surfaces by street cleaning plant. Energy usage associated with providing water to and from

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		infrastructure (e.g. pumping) shall be included in the module B6.
USE Emissions from other processes	B8:	Represents other process carbon emissions arising from infrastructure to enable it to operate and deliver its service including management of operational waste. An example is chemicals used in the treatment of water and wastewater or emissions arising from chemical reactions during the wastewater treatment process.
USE User utilization of infrastructure	B9:	Represents the activities associated with user's utilisation of the infrastructure during the use stage. This is defined by the principle of control and influence so that the carbon emissions are B9 ('User's' utilisation) when they arise from an activity that the 'User' has control over while they set out to utilize a piece of infrastructure. An example is highway vehicle carbon emissions where the 'user' makes the decision as to which type of vehicle they purchase (petrol, diesel, electric etc.), the route they travel, and the load they carry. Note: A rail version of this example could be the mode of transport that a 'user' decides to take when travelling to a station, although this could end up as double counting with highways B9 carbon data.
END OF LIFE Deconstruction	C1:	Represents the carbon emissions arising from on-site activities of deconstructing, dismantling and demolishing the infrastructure. For example, emissions arising through the use of plant and transport on site.
END OF LIFE Transportation	C2:	This represents all carbon emissions due to transport to disposal and/or until the end-of-waste state of waste materials arising.
END OF LIFE Treatment / processing	C3:	Represents the carbon emissions from activities associated with treatment and processing for recovery, reuse and recycling of waste materials arising from infrastructure. This includes use of all waste material outputs from dismantling, deconstruction or demolition of the infrastructure and covers all debris, all construction products, materials or construction elements, etc. arising from the infrastructure. All waste processing carbon emission shall be accounted for up until the material reaches the end-of-waste state as defined in BS EN 15978:2011.
END OF LIFE Disposal	C4:	The boundary includes the carbon emissions resulting from final disposal of demolition materials (neutralisation, incineration with or without utilisation of energy, landfilling with or without utilisation of landfill gases, etc.). Any carbon emission benefits from exported energy (i.e. through substitution) shall be reported into module D. This category also includes any possible post transportation treatment that is necessary before final disposal.

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Carbon benefits and loads beyond life-cycle	D:	Includes avoided carbon emissions associated with the infrastructure asset including potential for re-use, recovery and recycling of materials, and/or energy and water associated carbon emissions beyond the system boundary. CJ additions: Module D could take into account life cycle carbon emissions avoided by renewable energy generation. Where relevant module D might also be used to record benefits or loads arising from additional functions of infrastructure, for example carbon sequestration by blue-green infrastructure - but this must take account of the net balance between sequestration capacity lost to development and new sequestration capacity provided by the development.

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Appendix B - Terms and definitions

Baseline

The scenario, and associated carbon emissions, that would occur if normal conventional practices were followed and planned measures to reduce carbon were not applied. This marks a defined starting point from where a comparison is made.

Note: For Network Rail the reference baseline would be the design solution and delivery method that most closely represents the conventional railinfrastructure solution before any new, innovative carbon reduction measures were applied.

Capital carbon

Carbon and GHG emissions associated with the creation, extended life (through major replacement and refurbishment) and end of life treatment of an asset.

NOTE: The term capital carbon has been adopted in the infrastructure sector as it accords with the concept of capital (Capex) funded goods and services.

Carbon reduction

The process of minimising greenhouse gas (GHG) emissions during the planning, development, delivery and operation of new or refurbished infrastructure assets, or during the end of life treatment of assets.

Carbon dioxide equivalent (CO_2e)

Carbon dioxide (CO_2) is the most abundant greenhouse gas emitted from man-made activities by volume, so it is normal practice to relate all GHG contributions to the equivalent quantity of CO_2 that would have the same global warming effect. The term carbon dioxide equivalent (CO_2e) has become the standard unit for quantifying GHG emissions.

Carbon hot spot

A rather subjective term used to denote and highlight aspects during the creation, refurbishment, or end of life treatment of assets, where the carbon emissions (or carbon dioxide equivalent emissions) are particularly high.

Note: Carbon hotspots can provide a useful guiding principle to focus attention on finding reductions in the more carbon intense aspects. However, hotspots should not distract from seeking efficiency gains in all parts of the carbon value chain.

Climate Declaration

A single-issue declaration, normally within the context of an Environmental Product Declaration (EPD), but focused on the carbon footprint of a product. The emissions of

greenhouse gases of a product are reported in kg CO_2 equivalents from the different life cycle stages of the product.

Climate Declarations may be published based on a registered EPD, or where full information about the other types of environmental impact of the product is available upon request. In the latter case the Climate declaration shall give information on how to obtain information on the full environmental impact from the declared product.

Cradle to gate

A specific system boundary which covers the GHG emissions associated with the creation of materials and products from the extraction of raw materials, processing and manufacturing, but only as far as the product manufacturer's factory gates. This is a restricted scope of assessment and can only be used to represent the 'embodied carbon' of the specified products or materials.

Cradle to site

An extended system boundary which covers the cradle to gate GHG emissions of materials and products, but with the addition of GHG emissions from transporting the products to the work site where they will be used.

Embodied carbon

Refers to the carbon and GHG emissions associated with the creation of products or materials. Embodied carbon is typically qualified by the term *cradle-to-gate* meaning that it covers emissions from extraction of raw materials, processing and manufacturing up to the point that the product or material leaves the manufacturer's premises.

Note: The term embodied carbon can only truly be used in the context of products or materials. The wider term capital carbon can be used at an asset level as it potentially encompasses all GHG emissions associated with the creation, construction and end of life treatment of entire assets such as buildings or infrastructure.

Environmental Product Declaration (EPD)

A verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products. The relevant standard for Environmental Product Declarations is ISO 14025, where they are referred to as "type III environmental declarations". A type III environmental declaration is created and registered in the framework of a programme, such as the International EPD® System. EPDs need to be stated as 'conformant with ISO 14025'.

Note: Having an EPD® for a product does not indicate or imply that the product is environmentally superior to alternatives — it is simply a transparent declaration of the life-cycle environmental impact.

Global warming potential (GWP)

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A factor describing the radiative forcing (global warming) impact of one kilogram or Tonne of a given greenhouse gas, relative to the same mass-based unit of CO_2, over a given period of time.

Greenhouse gases (GHGs)

A greenhouse gas (GHG) is any gas in the atmosphere, both natural and man-made, that absorbs and emits radiation at wavelengths within the infrared radiation spectrum emitted by the Earth's surface, the atmosphere, and clouds, and in so doing causes warming of the atmosphere. There are seven main recognised greenhouse gases including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), nitrogen trifluoride (NF_3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Land use carbon

Changes in land-use can directly affect the exchange or retention of greenhouse gases between terrestrial ecosystems and the atmosphere. Clearing woodland for development, or changing from woodland to an alternative type of vegetation will result in changes in carbon storage factors. Similarly the provision of new woodland can increase the carbon storage factors associated with the land.

Lifecycle Boundaries

The declaration of which PAS 2080 life cycle modules have been applied to a project carbon assessment.

Operational carbon

Carbon and GHG emissions associated with the operation and maintenance of infrastructure or assets during the delivery of their intended function of services.

NOTE: The term operational carbon accords with the concept of operational (Opex) funded goods and services.

RACI Matrix

A conventional method for representing the allocation of duties across a range of project participants and stakeholders, in accordance with the following terminology:

R – Responsible – Allocated to any parties who are expected to deliver and implement a designated action. It is acceptable to have multiple responsible parties for an action.

A – Accountable – Allocated to the single party who is deemed to be 'accountable' for overseeing and assuring that designated actions have been completed, normally by other parties. It is normal convention to have only one accountable party for each action. The Accountable party may also be responsible (R), but could be accountable only with no delivery responsibilities.

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C – Consult – Allocated to any party whose opinion is considered to be valuable as a consultee when developing solutions or delivering actions. Responsible parties should be taking the views of Consultees into consideration.

I – Inform - Allocated to any party who needs to be informed about outcomes but does not need to be consulted when developing the solution.

Reference Study Period

The declared time period over which the whole life carbon emissions of infrastructure will be assessed. Typically 60 years or 120 years.

Science-based targets

Business carbon reduction targets are described as 'science-based targets' if they have been independently verified and endorsed by the science-based targets initiative (SBTi). To receive endorsement the targets must fit into a plan to keep the business's proportion of GHG emissions within the limits of 1.5˚C temperature increase above pre-industrial levels, or no more than 2˚C above pre-industrial levels.

The Environmental Commitments of Network Rail can be found here: https://networkrail.sharepoint.com/sites/myconnect/technicalauthority/Documents/Forms/AllItems.aspx?id=/sites/myconnect/technicalauthority/Documents/NR%20Environmental%20Strategy%20FINAL%20published%2023%20Sept%202020.pdf&parent=/sites/myconnect/technicalauthority/Documents

Scope 1 emissions

Introduced by the Greenhouse Gas (GHG) Protocol as one of three globally recognised metrics for classifying organisational GHG emissions: Scope 1 emissions cover Network Rail's direct carbon and GHG emissions from burning fossil fuels in operations owned and managed by Network Rail e.g. burning of fuels in boilers for heating premises or consumption of fuels in Network Rail cars and vans.

Note: Our 2017/18 baseline estimated that Scope 1 emissions account for ~1% of Network Rail's total GHG emissions footprint.

Scope 2 emissions

Introduced by the Greenhouse Gas (GHG) Protocol as one of three globally recognised metrics for classifying organisational GHG emissions: Scope 2 emissions cover Network Rail's indirect carbon and GHG emissions from electricity, steam, heat and cooling used in Network Rail owned and managed premises and operations. While the volume of consumption comes under Network Rail's direct operational control the carbon emissions occur with other generation parties.

Note: Our 2017/18 baseline estimated that Scope 2 emissions account for ~2% of Network Rail's total GHG emissions footprint.

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Scope 3 emissions

Introduced by the Greenhouse Gas (GHG) Protocol as one of three globally recognised metrics for classifying organisational GHG emissions: Scope 3 emissions cover all other indirect carbon and greenhouse gas emissions that occur within Network Rail's value chain for activities associated with running and developing the business, including building, managing, servicing, maintaining, and decommissioning business assets, property and infrastructure.

Note: Our 2017/18 baseline estimated that Scope 3 value chain activities account for ~97% of Network Rail's total GHG emissions footprint.

Spatial Boundary

The declaration of which materials, products, components and activities have been included in a carbon emissions assessment. To ensure openness and transparency the spatial boundary must be specified for each individual PAS 2080 module that is agreed for inclusion in the project carbon assessment.

System Boundaries

The collective criteria that specify the life-cycle boundary, the spatial boundaries, and the reference study period of a carbon assessment.

Note: It is important to be transparent about which factors have been included and/or excluded from a carbon assessment so that resultant data can be interpreted with proper understanding of the context and constraints, particularly if the data might be compared with other assessments.

Target

The desired quantity of carbon emissions (defined either as an absolute value, or as a reduction amount against a baseline value) that an asset or programme of works is to achieve during infrastructure delivery.

Note: A target should be specific and appropriate to an asset or programme or works. It must be measurable and time-bound.

Value chain

Organisations and stakeholders involved in creating and managing infrastructure assets, including asset owners/managers, designers, contractors, and product/material manufacturers/suppliers.

Whole life carbon

The sum of GHG emissions from all stages in the life-cycle of a product or asset and within the specified system boundaries of the product or asset.