Institution of Civil Engineers

Construction Leadership Council

The Green Construction Board

Guidance Document for PAS 2080

Practical actions and examples to accelerate the decarbonisation of buildings and infrastructure

April 2023

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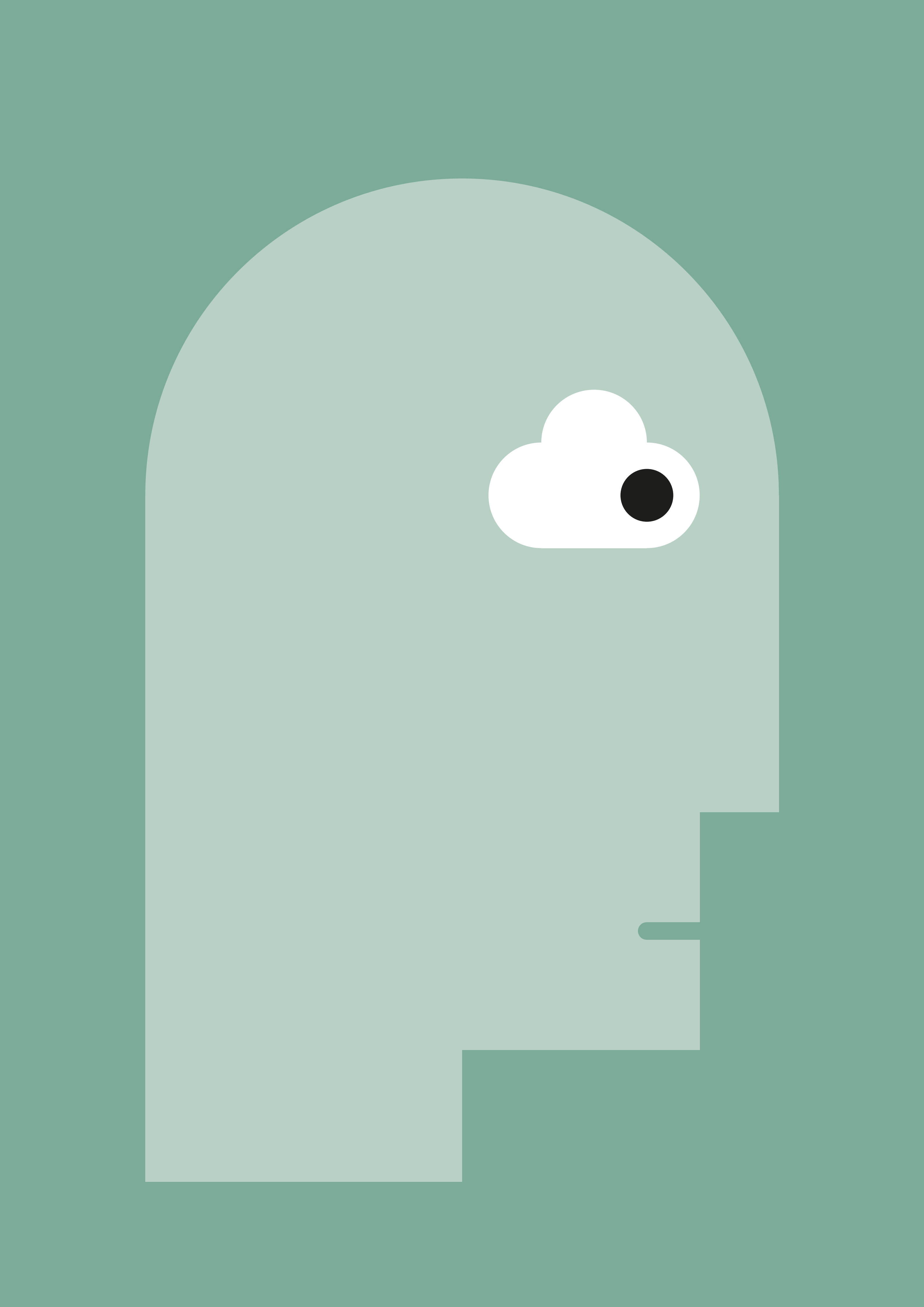

Welcome

PAS 2080 – the world's first specification for managing whole-life carbon in infrastructure – has been updated in 2023 to respond to the urgency of the climate emergency and to consider the wider built environment.

It is an essential strategic approach that will enable our industry to support cities and countries globally to reduce greenhouse gas emissions to net zero. Responding to the accelerating number of statutory and regulatory targets – and the impact of these on the built environment – requires collaboration, leadership, innovative thinking and a common approach to decarbonisation.

As the technical author team from Mott MacDonald and Arup explain in this Guidance Document, the updated PAS 2080 empowers the behavioural change required. It reflects the interdependency of infrastructure and buildings and the fact that the built environment itself comprises a complex system of systems. Not only should project teams consider carbon at the earliest possible opportunity, they also need to understand how climate resilience, biodiversity gain and the circular economy can be embedded into the approach to work.

This Guidance Document helps every organisation involved in a project to understand the carbon-related impact of their assets on the wider network. Using a wide range of case studies and worked examples, this is a comprehensive guide that organisations can use to take a whole-life view of carbon reduction. By identifying the roles and responsibilities of all participants in the project value chain, it brings transparency to every stage of the lifecycle.

The new PAS 2080 also walks users through how to build decarbonisation into procurement. This is a critical update because, when the original specification and Guidance Document were published in 2016, there were no mechanisms in place to contractually empower carbon reduction. This changed in August 2021, when the Institution of Civil Engineers (ICE) published the new X29 contract clause as a secondary option built into the NEC4 contract.

The findings of the Infrastructure Carbon Review in 2013 ensured that the message "cut carbon, cut costs" was heard and understood. In a review of this work in 2021, the Construction Leadership Council (CLC) and the Green Construction Board (GCB) found that progress was good, but not happening fast enough. The new PAS 2080 is how we accelerate the pace of change as we design, construct and operate the low-carbon projects of tomorrow.

Keith Howells
ICE President 2022-23

Foreword

Since the launch of PAS 2080 in 2016, some of the largest infrastructure organisations have gained verification and used it to reduce their carbon emissions. However, the scale and urgency of carbon reduction in the infrastructure and building sectors has not been at the pace needed against the backdrop of the climate crisis. We need to move from actions targeting carbon reduction in individual assets to actions targeting net-zero outcomes at the systems level across the entire built environment.

When it was launched, PAS 2080 was a remarkable document and a global first in providing a framework for managing carbon in infrastructure and recognising the importance of leadership and collaboration across the value chain in reducing carbon and cost. This PAS 2080 update takes it further. It recognises the importance of integrating the carbon management framework to include both infrastructure and buildings, reflecting their clear interdependencies. It also takes a systems view, connecting individual assets to the networks they operate within.

Equally important in the revision is the new emphasis on ensuring that climate and environmental resilience are considered as part of the carbon management and decision-making process. This provides consistency in the language, behaviours and actions we take collectively in making critical decisions on how to reduce whole-life carbon when planning for projects and programmes that meet the needs of end users, are climate resilient and benefit the natural environment.

PAS 2080 and the Guidance Document have been revised to take into account one of the largest consultation responses to a PAS – via BSI (the British Standards Institution) and feedback from discussions with stakeholder groups in the buildings and infrastructure community. The result is a simplified, inclusive guide that is as relevant to organisations starting their carbon journey as it is to those on a more mature pathway to net zero.

Over a number of years, I have witnessed many examples of low-carbon solutions being implemented and showing real reductions. These do not happen by chance, but by a proven process that the technical authoring team have detailed with a clear and structured approach. By reading the Guidance Document and applying the PAS 2080 process, organisations and individuals can access the knowledge required to play their part in responding to the climate emergency.

Chris Newsome
Chair of the Infrastructure Working Group, Green Construction Board

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01
Introduction

1.1 What has changed in the world since PAS 2080 was first published?

In the past few years there has been a shift in the political and public perception of the impacts of climate change and environmental degradation. The scientific community has issued stark warnings about the repercussions of the linear economic model and its effects on the stability of the global climate system.

1.1.1 Planetary health

The planetary boundaries framework (see Fig 1.1, page 11), which evaluates the nine global environmental systems that regulate the Earth's stability and resilience, was first established in 2009. Crossing these boundaries increases the risk of triggering irreversible global tipping points, beyond which the planet cannot recover. The latest update, in 2022, shows that five of the nine planetary boundaries have been crossed.

PAS 2080 focuses on climate change mitigation through decarbonisation only, but recognises the direct link with, and complexity of, wider environmental impacts. The planetary boundaries framework helps to contextualise these environmental dependencies and the carbon implications associated with them.

1.1.2 International agreement

The COP21 Paris Agreement in 2015 set the legally binding international treaty on climate change with the goal to limit global warming to 1.5C, compared with pre-industrial levels. Nationally determined contributions (NDCs) are at the heart of the Paris Agreement, embodying the efforts by each country to reduce national emissions and adapt to the impacts of climate change. The Intergovernmental Panel on Climate Change (IPCC) has provided the science behind the 1.5C goal, and the necessity to transition to net-zero greenhouse gas emissions (GHGs) by 2050.

1.1.3 The carbon gap

The 2022 UN Environment Programme (UNEP) Emissions Gap Report states that, at the current rate of emissions, we are heading towards a 2.8C warmer world by the end of the century – even with the implementation of the NDCs under the Paris Agreement. The report also highlights the gaps in several policy scenarios and ways to deliver the emissions cuts (see Fig 1.2, page 12) of many gigatonnes of GHGs required. This carbon gap makes the urgency for implementation of meaningful decarbonisation even more compelling, particularly for the built environment sector.

1.1.4 National, regional and corporate climate policies

The Paris Agreement and the growing public awareness of the climate emergency have led to the widespread adoption of net-zero legislation by countries (for example, the UK, EU members, Canada, Japan, New Zealand and South Korea), states (such as Massachusetts and Nevada in the US) territories and corporations (such as ArcelorMittal, BP, BT and Walmart). This, in turn, has led to the fast-paced introduction of new climate and environmental laws.

At least 240 cities globally have set net-zero carbon targets for 2050 or sooner. Copenhagen and Adelaide are leading the pack, targeting net zero by 2025, 25 years earlier than Denmark and Australia's national targets. In the UK, local authorities have declared climate emergencies and set their regional targets for as early as 2030, which is also more ambitious than the national target of 2050.

In this context, and recognising that regional, national and international policies will continue to evolve at an unprecedented rate, PAS 2080 provides a common approach to reflect and respond to these statutory and regulatory targets and requirements in projects and programmes of work of organisations across the built environment.

PAS 2080 is a framework to help future-proof organisations and protect their businesses, providing an approach to decarbonisation that minimises the risk from climate transition. PAS 2080 puts forward a practical way for organisations, regions and governments to be at the forefront of climate action, delivering resilience, value and competitive advantage.

1.1.5 Climate resilience and nature-based solutions

Even with the fastest decarbonisation implementation, accumulated GHGs are causing an inevitable warming of the planet, and climate change. As well as the commitments on mitigation, the Paris Agreement includes the need for boosting climate resilience.

Still, climate resilience in the built environment must be considered hand-in-hand with decarbonisation and not as a separate issue. The carbon implications of climate change resilience solutions are likely to be significant, particularly if approached in a reactive, siloed way – for example, building high walls to keep flooding under control, or installing more air conditioning to combat higher temperatures.

The scientific evidence is unequivocal that the impacts of climate change are exacerbated by the degraded state of the natural environment in and around buildings, cities and infrastructure (see also Section 1.1.1). Treating environmental regeneration as a holistic resilience solution can have significant decarbonisation benefits that are also more cost-effective, while simultaneously achieving carbon sequestration.

Nature-based solutions (NBS) can sustainably manage and restore natural and engineered ecosystems, which address these challenges effectively and adaptively. NBS can be a key enabler for climate resilience, while preventing the worsening of these impacts, and can also demonstrate carbon reduction benefits. Some of the most effective implementations, particularly those related to land-use change (such as sponge cities, sustainable agroforestry and coastal wetland protection), have been found to bolster both climate mitigation and adaptation.

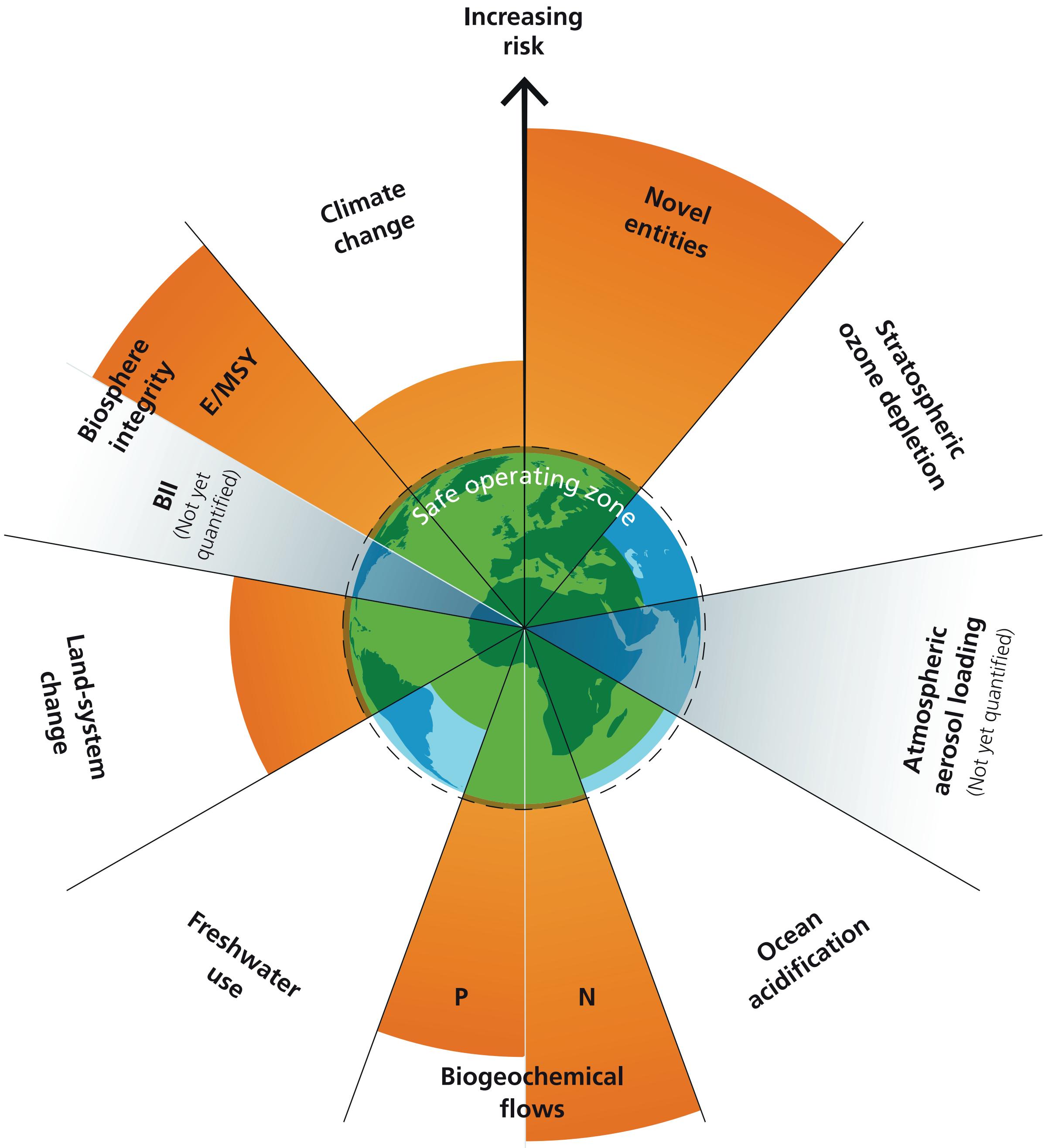


Fig 1.1: Planetary boundaries – the earth science framework evaluating the ability of the planet to support life as we know it. Climate change and biodiversity loss are the primary and interconnected threats to global stability, exacerbating the others of land use, water, nutrients and pollution. Today, five of the nine boundaries have been exceeded (source: Stockholm Resilience Centre, 2022).

BII = Biodiversity Intactness Index
E/MSY = Extinctions per million species-years
P = Phosphorus
N = Nitrogen

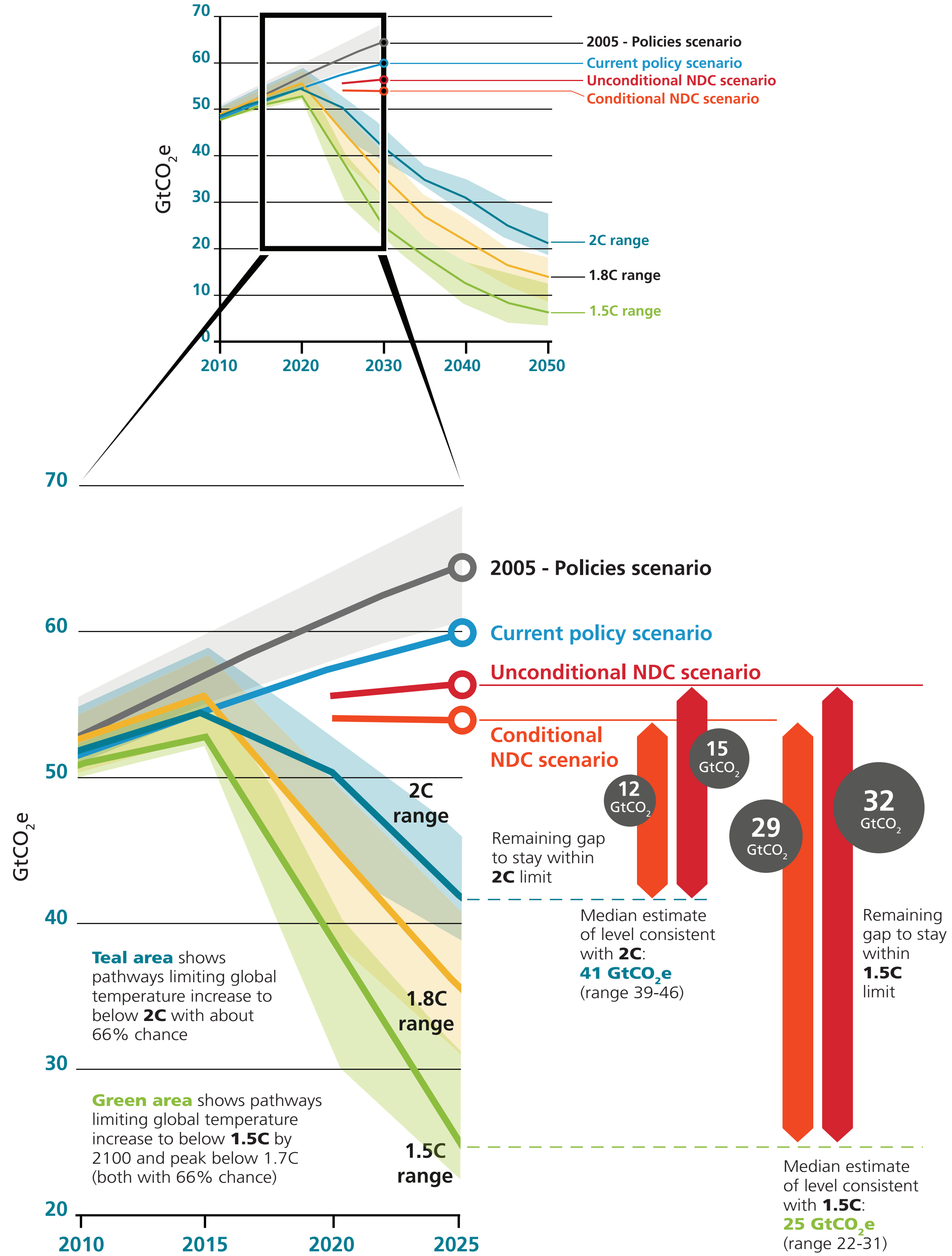


Fig 1.2: Global emissions trajectories under different scenarios and the carbon gap

(Source: UNEP Emissions Gap Report 2020)

1.2 How has the industry performed?

The UK Construction Leadership Council (CLC) and the Green Construction Board (GCB) are the organisations that commissioned the development of the UK Infrastructure Carbon Review (ICR), published in 2013, and subsequently PAS 2080, originally published in 2016. The ICR included the call to "cut carbon, save cost". In 2020, the CLC also responded to the UK's legal obligation for net zero by launching the CO_2nstructZero initiative, which sets priorities for the construction sector's contribution to net zero.

In the same year, the ICE's Carbon Project commissioned Dr Jannik Giesekam to research how the industry had responded since the ICR. The results, first presented in the Unwin Lecture 2020, confirmed that the proportion of carbon emissions deriving from infrastructure was still more than half (54%) of the UK's total, and that this proportion was likely to increase as the UK's carbon footprint decreased.

The research also showed that while between 2010 and 2018 there was a 23% reduction in total carbon emissions relating to UK infrastructure's construction, operation and use, this annual rate of reduction of 3% is not fast enough for the UK to meet its legal commitment to reach net zero by 2050. For that, an annual reduction rate exceeding 4% is now required. Or, in other words, as a minimum, we need to reduce the UK's annual carbon emissions from infrastructure more than 30% faster than we are doing now. As the Infrastructure Carbon Review: Seven Years On report, published by the CLC and the GCB in March 2021, put it: "Good progress but not fast enough".

Despite several good carbon reduction examples, there was no evidence of the step change needed to address the climate emergency outlined in Section 1.1. The lessons learnt from the GCB's review were clear:

- There are no procurement incentives for decarbonisation and no commercial recognition of the need for decarbonisation.
- Decarbonisation efforts are limited because the industry mostly operates in silos, without any cross-sector collaboration.
- Most carbon reduction is focused on the 'low-hanging fruit' and capital carbon (emissions associated with the creation of an asset), without proper consideration of the implications of whole-life carbon.
- Relative carbon reduction against business as usual, rather than absolute decarbonisation.
- Immature systemic thinking: decarbonisation of a building or asset is viewed as a standalone consideration, without taking into account the carbon implications of the asset on the wider system of which it is a part.
- The carbon from land-use change/environmental degradation is unaccounted for, as are the carbon implications of lack of climate resilience and the need to increase resilience.
- There is no consideration of the carbon being locked in the highly inefficient existing infrastructure systems and the urgent need for retrofitting.
- Carbon leadership is still lacking, with decarbonisation not yet embedded in organisational decision-making.

The application of carbon management and PAS 2080 on projects to date has mainly focused on carbon quantification and assessment tools and methodologies. Most of its applications involved capital and operational carbon in the direct control of the asset owner, with a lack of acknowledgement of the whole-life carbon that can be influenced as a result of the project or programme of works, including user and end-of-life emissions.

Furthermore, target-setting and baselining in practice were undertaken relative to a business-as-usual hypothetical scenario, with the aim of not increasing emissions by as much as they would have been otherwise. There was no recognition that absolute carbon, at the system level, could potentially increase as a result of a new project.

The PAS recognises that not all asset owners/managers have produced a baseline and, in that case, it encourages designers or constructors to challenge this. In the absence of a baseline in a project or programme of work, it would be difficult for designers or constructors to produce one, mainly due to the fact that they would have limited visibility of the wider system and any targets set at that level. Therefore, asset owners/managers, governments and regulators will be key to promoting system-level thinking, as they will have a full understanding of emissions and decarbonisation priorities.

1.3 Direction of travel

Since PAS 2080 was first issued in 2016, there has been growing recognition that infrastructure and buildings are interdependent, and it is important that they are considered together as part of a wider system. Consequently, in 2022, the scope of the revised PAS 2080 was extended to include buildings. The revised PAS 2080 has a renewed focus on decarbonisation of the built environment, with a paradigm shift to a systems-thinking approach that ensures alignment with the net-zero carbon transition.

The PAS 2080 update is still highly relevant to all parts of the built environment value chain, including smaller organisations (such as for tier 2, 3 etc contractors and/or product/material suppliers) and other niche SMEs. These will often bring great benefits to the decarbonisation of projects and programmes of work, up to the system level.

1.4 Purpose of the Guidance Document

This Guidance Document, curated by the ICE, aims to elaborate on the whole-life carbon management principles outlined in the PAS 2080 document, and includes practical examples and case studies that bring these to life. Table 1.1 (see next page) demarcates the roles of PAS 2080 and the Guidance Document, highlighting how the Guidance Document should be used to support the effective use of PAS 2080.

Document element	PAS 2080	Guidance Document
Specification of carbon management in the built environment	**Yes**	**No**
Specification of value-chain member responsibilities for carbon management in the built environment	**Yes**	**No**
Practical guidance on implementing carbon management by all value-chain members in delivering projects/programmes of work	**No**	**Yes**
Case studies and worked examples of carbon management components	**No**	**Yes**

Table 1.1: Content split between PAS 2080 and guidance documents

1.5 What's new in this revision?

PAS 2080 has been renamed Carbon Management in Buildings and Infrastructure to reflect that it now encompasses buildings, infrastructure and the interfaces between the two. The main themes in the revision are:

- Decarbonisation requirements at the asset, network and system levels
- Alignment to the net-zero transition
- Emphasis on decisions and actions that reduce whole-life carbon, rather than looking at capital (or embodied), operational or user carbon in isolation
- Interrelationships of nature-based solutions, climate resilience interventions and carbon emissions
- Procurement mechanisms to accelerate decarbonisation
- Strengthening value-chain relationships and ways of working to promote collaboration, challenge and innovation

The above themes are reflected in the revised PAS 2080 as follows:
Clause 0: Context; Clause 1: Scope – substantially rewritten to recognise the emergent new themes and policy changes since the 2016 version. Namely, concepts around net zero and system-level change (particularly the relationship between assets, networks and systems), but also the importance of integrating the carbon implications of climate resilience and prioritising nature-based solutions.
Clause 3: Terms and definitions – updated with new definitions that cover, among other things, buildings, systems thinking, net-zero carbon and nature-based solutions.
Clause 4: Decarbonisation principles – substantially rewritten, setting out the fundamental concepts in PAS 2080, including control and influence, whole-life carbon and the carbon reduction hierarchy. The concept of systems thinking (Section 1.3) is a step change for the built environment, driven collaboratively by asset owners, designers, constructors and product/material suppliers. It also requires input by government, regulators, planning authorities and the investment community.
Clause 5: Leadership – now focused solely on leadership. Governance aspects are now included in Clause 6.
Clause 6: Integrating carbon management into decision-making – completely rewritten to incorporate elements from Clause 11 in the 2016 version and structured around whole-life work stages, as well as value-chain members. This clause presents requirements that directly guide specific work-stage activities. It now addresses carbon in both the control and influence of decision-makers.

Clause 7: Whole-life carbon assessment principles to support decision-making – significantly changed to ensure consistency in the assessment process, with reference to the relevant quantification standards, such as EN 15804, 17472 and 15978. This resolves underlying differences and conflicts between quantification standards (outside of the control of PAS 2080), following extensive discussions with standards experts. Accordingly, the modular approach is no longer presented. The clause outlines the quantification principles for consistency of approach and with consideration of systems-related carbon (not in the scope of any other standard), with more detail now presented in Annex A (informative).
Clause 8: Target-setting and baselines – includes aspects on target-setting that is aligned with the net-zero carbon target set at system level.
Clause 9: Monitoring and reporting – monitoring aspects incorporated; minor changes overall.
Clause 10: Procurement – a new clause that covers contracts, procurement and engagement activity.
Clause 11: Continual improvement – minor updates to emphasise collaborative behaviours, linking back to Clause 6 requirements.
Clause 12: Claims of conformity – minor updates to the self-validation option.

The Guidance Document has been updated to reflect the main changes in PAS 2080 and is structured as follows:

Section 1: Introduction – covering the policy and industry changes since 2016 and the main changes in the PAS update.

Section 2: Responsibilities of the value chain for implementing PAS 2080 – this section builds on the previous Guidance Document and provides the core PAS 2080 value-chain responsibilities.

Section 3: PAS City worked example – using a practical worked example of a fictional redevelopment project called PAS City, this section summarises how the PAS 2080 requirements and the additional advice for practitioners found in this Guidance Document can be implemented in the context of a programme of works that involves buildings and infrastructure.

Section 4: Carbon management process and implementation – this section builds on the previous Guidance Document and provides guidance on what value-chain members need to do at each stage of the delivery process to implement the requirements of PAS 2080. This is complemented by a series of worked examples for the new concepts introduced in the PAS 2080 update, such as improving baselines; assessing whole-life emissions in buildings and infrastructure, and the differences behind those; emissions from land use; and carbon removals, among others.

Section 5: Key enablers and accelerators – this section focuses on how organisations in the value chain will need to improve their carbon management maturity and focus on a number of key enablers to help accelerate decarbonisation. For each enabler, a summary is provided of relevant case studies and examples from the industry where the concepts have been successfully implemented.

Section 6: Case studies – this section includes a selection of industry case studies that have been mentioned in Section 5. These showcase good decarbonisation practices in both buildings and infrastructure.

02
Responsibilities of the value chain for implementing PAS 2080

2.1 Introduction

Infrastructure and buildings are delivered, operated and maintained by a wide range of value-chain member organisations. PAS 2080 is targeted at practitioner-level individuals in these organisations who are responsible for different aspects of delivery in the built environment where carbon management has a role to play.

The built environment value-chain members in the PAS 2080 Guidance Document are:

- Asset owners/managers
- Designers
- Constructors
- Product/material suppliers

The PAS recognises that the built environment value chain involves further stakeholders, such as government, regulators, investors, academia, insurers, local planning authorities and users, among others. The requirements do not apply to all of these additional stakeholders with normative clauses, but additional guidance is provided in the Annex on how some of these stakeholders can influence whole-life carbon management in the built environment. Building developers fall under "asset owners" in PAS 2080 – see the definitions clause in the specification.

It is acknowledged that more than one value-chain member may reside within a single organisation. For example, the asset owner/manager or constructor may also undertake some of the design work. Therefore, it is important to see the value chain as a set of roles to be fulfilled, rather than as specific organisations.

2.2 Key roles and responsibilities for the successful implementation of PAS 2080

Note: roles may vary depending on different value chains and organisational structures.

Fig 2.1 (see page 19) illustrates the degree of control and influence of different value-chain members in delivering projects and programmes of work and highlights the important linkages between them. Different parts of the value chain have different degrees of direct control in the delivery process. However, early engagement and collaboration that will allow their level of influence for decarbonisation is encouraged. Clause 6 in the PAS summarises the requirements through the delivery process for how each value-chain member can best control and influence whole-life carbon management at the asset, network and system levels.

Every member of the value chain is responsible for contributing to the successful development and implementation of a PAS 2080-compliant carbon management process. The responsibilities of individual practitioners are summarised in Table 2.1 (see following pages).

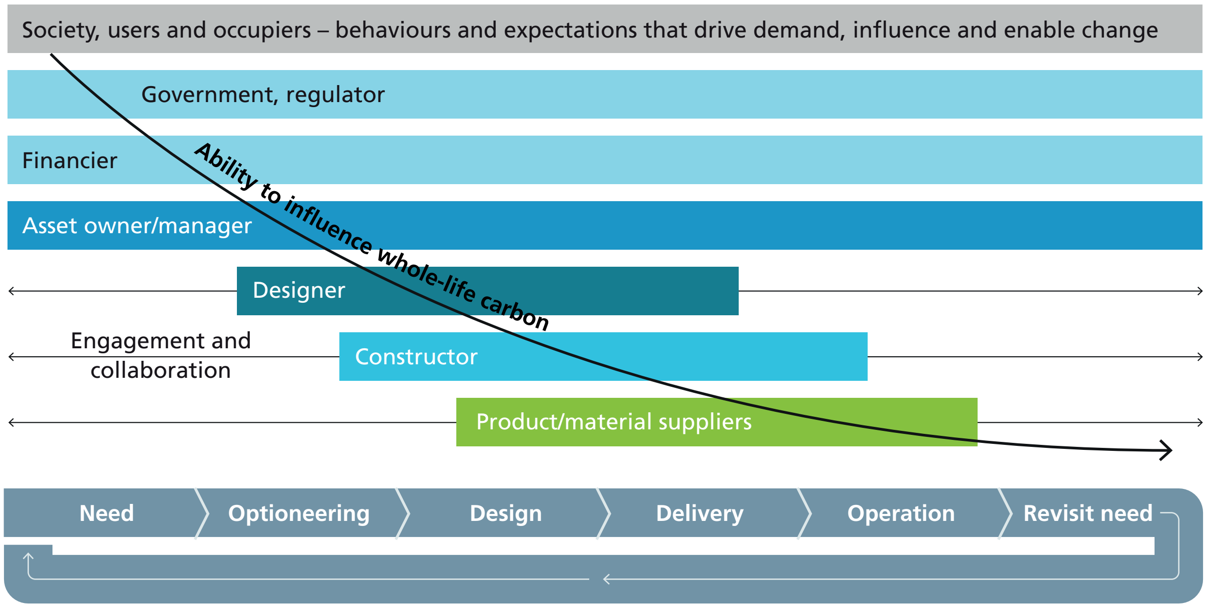


Fig 2.1: Value-chain members' ability to accelerate decarbonisation throughout the delivery process

Table 2.1 Responsibilities for each value-chain member to implement the PAS 2080 carbon management process

Everyone

Practitioner	Responsibilities
Everyone	Understand the carbon management objectives of the organisation and how these affect their role
	Take ownership of carbon management within their team to transfer organisational policy to day-to-day working practice and integrate carbon reduction in all decision-making
	Promote collaboration and engagement with value chain and stakeholders to influence whole-life carbon reduction across the networks and systems of which they are part. Engage with those in similar roles in the value chain and other internal practitioners to ensure alignment between working practices and sharing of best practices for optimising reduction of carbon within their control
	Contribute towards continual improvement and innovation for carbon reduction
	Proactively embed climate change-related learning into continuous professional and skills development
	Share knowledge and information

Asset owners/managers

Practitioner	Responsibilities
Leadership team	Set the overall carbon management direction compatible with the net-zero transition of the system of which they are part – including targets and governance for decarbonisation, both in the control and influence of the organisation – and communicate to the value chain
	Align investment decisions and business strategic planning with decarbonisation plans, demonstrably integrating carbon reduction in the decision-making across the organisation
	Ensure staff have adequate carbon management skills through training or recruitment
Communications team	Focus on communicating, both internally and externally, decarbonisation plans, stories and achievements in projects and programmes of work
Strategy planner	Ensure strategic plans for new and existing assets incorporate clear carbon objectives and targets. Engage early with other asset owners, government and/or regulators and other stakeholders to align objectives of project/programme of work with the net-zero carbon transition of the network/system of which they are part. If no targets or objectives are set at network or system level, challenge other stakeholders to develop some jointly, wherever possible
	Define study boundary for whole-life carbon emissions and removals within the control and influence of the organisation
	Identify the carbon implications of climate resilience, or lack of, at the asset, network or system level, and integrate them in the carbon management framework for decision-making, prioritising nature-based solutions where appropriate
Procurement manager	Procure products/materials/services promoting low-carbon solutions to achieve the organisation’s carbon objectives, incentivising proposals that avoid carbon, switch to lower-carbon alternatives, or improve resource use
	Set clear carbon management objectives and incentives in procurement, as set out in the PAS. Reflect responsibilities in contracts across all work stages
	Periodically review the procurement categories that support the delivery of projects or programme of works and identify those with a material carbon impact
	Assess how requirements in contracts for designers, constructors or product/material suppliers, or within the delivery model, could support carbon targets

Asset delivery manager	Engage across the value chain to ensure that technologies and solutions proposed and implemented are in line with carbon targets
	Apply and encourage application of the carbon reduction hierarchy, particularly considering opportunities for avoiding emissions, for example: by utilising existing assets/networks; opportunities to switch to alternative lower-carbon options, such as replacing hard flood defences with upstream natural flood management; and opportunities to improve the use of resources and design life of the asset/network
	Define carbon monitoring and reporting requirements (objective/frequency/KPIs) and communicate them to the value chain
	Set up a carbon data/tools sharing environment for all value-chain members and promote collaboration to identify hotspots
Operator/operations manager	Implement monitoring and reporting requirements and mechanisms to inform progress against the organisation’s whole-life carbon targets and improve benchmarking for future projects/programmes of works
	Ensure asset maintenance and replacement strategies follow the carbon reduction hierarchy, avoiding carbon – for example, by extending the design life of assets; switching to lower-carbon technologies where appropriate; and improving the carbon and efficiency of assets
	Track carbon reduction baseline/targets and refine assessment as data from construction works becomes available

Designers

Practitioner	Responsibilities
Leadership team	Understand the carbon objectives of asset owner/managers and ensure their own organisational targets are aligned
	Promote a carbon reduction culture throughout the organisation, ensuring carbon management principles are fully integrated into all design service offerings
	Ensure technical teams have the appropriate training and skills to facilitate the development of low-carbon solutions in accordance with the carbon reduction hierarchy, with design approaches that avoid carbon, can switch to lower-carbon technologies and improve resource use
	Put mechanisms in place to ensure collaboration with constructors and product/material suppliers to examine the feasibility of low-carbon solutions
	Challenge the asset owner/manager’s asset standards and/or scope, to drive low whole-life carbon solutions

	Where appropriate, identify incentive mechanisms for outperformance of carbon targets, promote options that avoid carbon (maximising the use of existing assets or re-using material), switch to design approaches that reduce conservatism, improve material and performance specifications for lower-carbon products, longer design life and future adaptability and material recovery
	Support risk-allocation approaches that promote innovation and the inclusion of low whole-life carbon solutions
Designer/technical adviser	Put governance structures in place to identify, promote and implement whole-life carbon reduction opportunities following the carbon reduction hierarchy when delivering projects and programmes of work. When integrating whole-life carbon reduction in the design development, challenge design requirements where additional whole-life carbon is incurred and provide lower-carbon solutions
	Assess low-carbon solutions (strategically, in outline and in detailed design) using appropriate tools and understanding the impacts of specific design decisions around materials and process suggested. Challenge asset standards and scope to enable low-carbon performance
	Support the asset owner/manager's carbon management approach during strategy, brief, concept, definition and design. Instigate collaborations that enhance innovative design for carbon reduction
	Ensure carbon assessment of existing assets, promoting design interventions in accordance with the carbon reduction hierarchy, avoiding carbon through extending the design life, switching to more efficient technologies or improving material/performance specification for the replacement components, where applicable
	Set requirements in specifications that support low-carbon solutions for the constructors and asset operators to follow

Constructors

Practitioner	Responsibilities
Leadership team	Understand the carbon objectives of asset owner/managers and ensure own organisational targets are aligned
	Promote a carbon reduction culture throughout the organisation, instigate appropriate training and implement best construction-practice approaches that avoid carbon, can switch to lower-carbon construction technologies and improve the use of resources through circular economy principles, to realise low-carbon objectives
	Ensure carbon management principles are integrated into delivery systems

	Promote early involvement in buildings and infrastructure delivery and put mechanisms in place to ensure collaboration with asset owners/managers, designers and material/product suppliers. Challenge scope and programme requirements that incur extra carbon; propose lower-carbon delivery options
Procurement manager	Develop proportionate criteria for inclusion in tenders that support the selection of suppliers who can avoid carbon-intensive products/services, switch to lower-carbon alternatives or improve resource use to deliver low-carbon solutions. Also, where required, identify and integrate low-carbon solutions within their proposed responses to tenders
	Periodically review the procurement categories that support the delivery of low-carbon solutions
Construction manager	Employ low-carbon construction techniques/products/materials and challenge design decisions and construction-programme requirements, as required, to deliver low-carbon outcomes
	Monitor and report whole-life carbon emissions of construction activities using the approach defined by asset owner. Identify and communicate highest emissions and where future reductions can be made

Suppliers

Practitioner	Responsibilities
Leadership team	Understand the carbon objectives of asset owner/managers and ensure their own organisational targets are aligned
	Promote a carbon reduction culture through the organisation and ensure technical teams have appropriate training to develop low-carbon solutions
	Showcase their low-carbon products/materials through the value chain; challenge scope and specification requirements that incur additional carbon and propose lower-carbon alternatives
	Ensure carbon management principles are integrated into delivery systems
Procurement manager	Embrace low-carbon procurement criteria for avoiding carbon-intensive products, switching to lower-carbon technologies and improving resource use. Cascade them to lower tiers of the value chain
Material/product developer	Establish a process to engage with other designers, constructors and product/materials suppliers to keep up to date with innovation in the industry that will drive whole-life carbon reduction at asset, network and system levels
	Put in place a process to assess the skills and capability within the organisation with regard to the understanding of GHG assessment, baselines, targets, low-carbon solutions and low-carbon procurement. Provide further training where necessary

03

Overarching worked example: ‘PAS City’

3.1 Overarching worked example: 'PAS City'

The following worked example is provided to illustrate how to apply the PAS 2080 carbon management process and the key decarbonisation principles across the value chain and across selective delivery stages in a project or programme of work. The programme of work is called 'PAS City'.

The PAS City programme is the regeneration of an old industrial site, located outside a city, into retail, housing and office buildings. The site has been selected but the project is at a very early stage. The value-chain members involved in this programme are:

- Developer (asset owner/manager)
- Local government/planning authority
- Other asset owners – water, transport, energy
- Designers
- Constructors
- Product/material suppliers

Programme outcome of PAS City: A future-proofed development that (i) fits the requirement and addresses the scope in the least carbon-intensive way; and (ii) produces a capital, operational/user carbon footprint that, over its life, is compatible with a net-zero carbon economy.

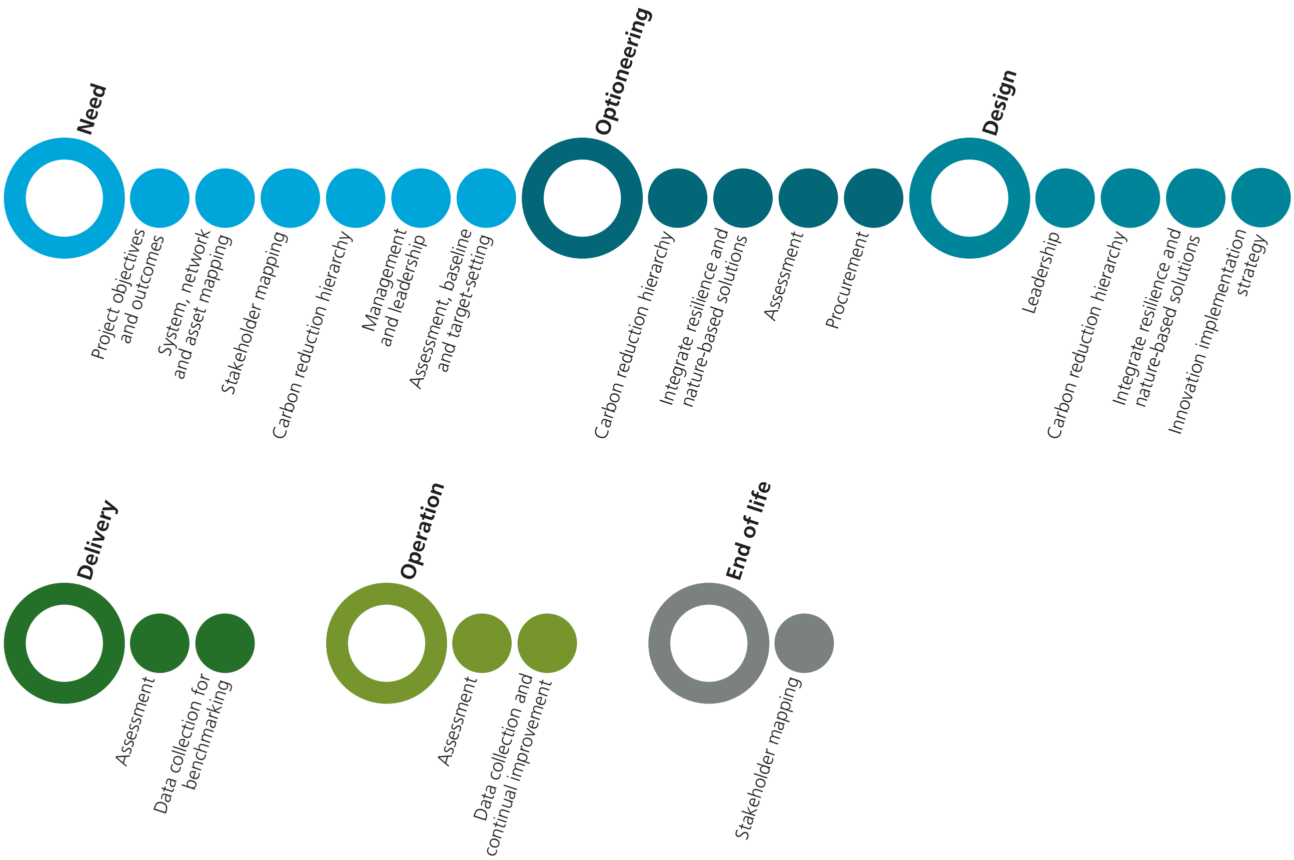
The diagram on the following pages illustrates how different value-chain members, particularly the asset owner/manager initiating this programme, engage others and follow the requirements of PAS 2080 to systematically manage whole-life carbon across the programme. The diagram focuses on providing practical examples of selective activities that need to be taken by a value-chain member in the context of PAS City, why these are required, and the associated benefits for managing whole-life carbon.

These examples are structured around the PAS 2080 delivery stages. For each activity included in the PAS City diagram, there is cross-referencing of the relevant PAS clauses and Guidance Document sections where further information can be found.

Project description: Regeneration of old industrial site (located outside a city) into retail, housing and office buildings.

Value-chain member starting out: Site developer (i.e. asset owner/manager)

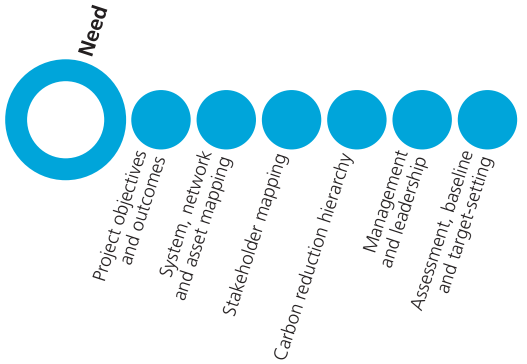
Fig 3.1 PAS City: managing whole-life carbon across the PAS2080 delivery stages – some priorities for the developer and collaborations with the value chain



***Note:** this diagram, and the tables that follow, show some of the key actions that the asset owner/manager (i.e. the developer, in this case) needs to initiative and manage, in collaboration with other members of the value chain, to set and achieve an ambitious carbon reduction target for the proposed programme.*

This is not an exhaustive list of all actions that an asset owner/manager would need to take to satisfy the requirements of the PAS; rather, it is intended to provide guidance to value-chain members on elements of the PAS to help illuminate how one might approach some of the requirements at each stage, through the lens of a worked example.

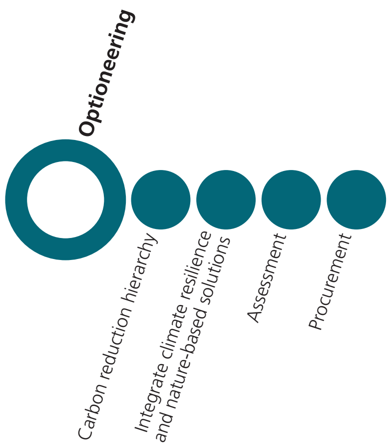
Key: Guidance Document section number (grey circle) · PAS Clause number (black circle)



Project site not yet selected

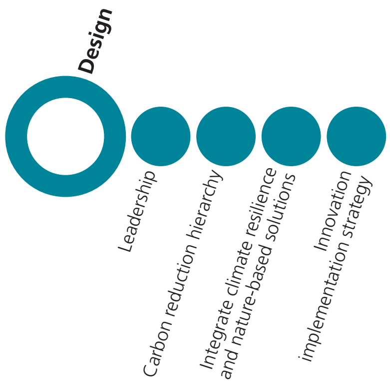
What	How	Carbon management benefit	Collaboration	Example section in Guidance Document	PAS requirement
Project objectives and outcomes	Define outcomes of the project: ■ Provide housing, office space, retail, transportation, water and energy for X people Define key objectives of the project: ■ Align with the UK's net-zero target; deliver resilience against an X-degree scenario Define life of the project – how long do we expect the development to exist and be operational? ■ X years Define areas of control and influence (see also stakeholder mapping)	Outcomes clearly defined within the context of how the project aligns with and will support the transition to net zero at system level	Developer Local government/ planning authority	4.4.1	6.1.1 6.2.1-2
System, network and asset mapping	Develop high-level map of the system, network and assets in the project and interrelationships with existing networks/systems: ■ What are the buildings currently onsite? What is the status/condition of those buildings? ■ Who will be the users of this development? Where will they be coming from, and how will they get there? ■ How would this development affect water networks? What connections exist currently? ■ How would this development affect energy networks? What connections exist currently? What connections might exist in the future, e.g. for power, hydrogen, natural gas? ■ How would this development affect transport systems? What transport connections/hubs exist currently? What connections might exist in the future, e.g. rail, road? ■ What is the existing carbon locked in the region, and how much of that might be within the control and influence of the project? How does the project affect the system-level baseline?	More opportunities for carbon reduction by looking at assets as part of a wider network and system. For example, reduced energy generation/ distribution for the network by capturing opportunities for onsite renewables or district heat, or improved user carbon on the surrounding network by incorporating active travel and public transit considerations	Developer Local government/ planning authority Other asset owners – water, transport, energy Designer	4.4.1	6.2.2 4.1
Stakeholder mapping	Map value-chain members and other stakeholders relevant to the planning, delivery and operation of the project, based on asset, network and systems interrelationships, including their ability to take decarbonising decisions: ■ Developer (asset owner/manager) ■ Local government/planning authority ■ Other asset owners – water, transport, energy, telecoms, buildings ■ Designer(s) ■ Constructor(s) ■ Product/material suppliers ■ Users/consumers ■ Occupiers/retailers	Additional influence over procurement choices, stronger collaboration, identification of innovations that are available in the market, understanding of key constraints beyond the project boundary. All of this takes place at early stages of the project, where carbon reduction opportunity is greatest	Developer Local government/ planning authority Other asset owners – water, transport, energy, telecoms, buildings Designer Constructor Supplier	4.4.1	4.1 6.2.1-2

What	How	Carbon management benefit	Collaboration	Example section in Guidance Document	PAS requirement
Carbon reduction hierarchy	Following the carbon reduction hierarchy at the early pre-bid stage, what are the questions that need to be asked? How can the defined outcome be delivered in the lowest-carbon way? ■ **Avoid:** What are the existing assets in the development that can be repurposed (buildings, energy, water, telecoms, transport infrastructure) by extending their life? ■ **Switch:** What materials could be recovered and re-used onsite? Are there technologies and/or materials that could be incorporated? Are there opportunities to engage with product suppliers early to implement low-carbon solutions? ■ **Improve:** Is there an opportunity to set out a vision for Design for Manufacture Assembly (DfMA) for the development to lock low-carbon materials and leaner construction practices?	Systematic way of assessing all carbon reduction opportunities and prioritising them from an early stage. This focuses the efforts of all stakeholders from the start	Developer Designer Constructor Supplier	5.3.3	4.3
Management and leadership	Develop a carbon management process and set out governance structures: ■ Set the right governance of ownership of the decarbonisation progress and execution of the reduction opportunities ■ Set targets that align with the net-zero transition of the relevant system ■ Define baselines ■ Set monitoring and reporting requirements ■ Establish procurement gateways ■ Engage continual improvement processes ■ Determine how this process and requirements will be communicated to the market – e.g. hold a 'call for ideas' for the project and invite value-chain members based on stakeholder mapping – to bring out the best challenge early, before design and construction is initiated	Clarity, transparency and focus for all value-chain members for their roles and responsibilities for reducing whole-life carbon throughout the duration of the project	Developer	2.3	4.4 5.1-2 6.1.1-2 6.2.1 9.1-2
Assessment baseline and target-setting	Target-setting: ■ What are the decarbonisation targets in the region in which the development is located? ■ Engage with local/regional government, planning authority and other asset owners to understand what is the allowable (whole-life) carbon for the development to meet regional net-zero targets (if any) ■ What are the targets of other asset owners in transport, water, energy, telecoms and buildings to which the development will connect? Baseline and assessment: ■ Use PAS 2080 whole-life carbon management framework to map all likely emissions from the development at all project stages ■ Use 'red, amber, green' approach initially, to understand the likely hotspots ■ Map the relevant standards that can be used to develop an assessment approach to help make the right decisions early ■ Use benchmarks for buildings (e.g. Royal Institution of Chartered Surveyors) and develop/use benchmarks for infrastructure – e.g. engage with infrastructure developers identified in stakeholder mapping to obtain benchmarks where possible ■ Set out data requirements and data sources, and decide what assessment tools to use/develop throughout all stages to ensure consistent comparison – e.g. utilise carbon data from the University of Bath Inventory of Carbon and Energy	Innovation and collaboration incentivised by ambitious targets Metric for monitoring progress, highlighting where the biggest efforts should be made for carbon reduction	Developer Local government planning authority Other asset owners – water, transport, energy	4.4.1	4.1 6.2.1-2 7.1 8.1-2



Site selected; options for site regeneration (i.e. what is being built, and where) being developed and reviewed

What	How	Carbon management benefit	Collaboration	Example section in Guidance Document	PAS requirement
Carbon reduction hierarchy	Which development options will deliver the outcome in the lowest-carbon way? Example: application to stormwater management in the development: ■ **Avoid:** Is it possible to have no stormwater infrastructure onsite, and instead implement sustainable urban drainage systems (SuDS) and separate sewage and stormwater systems? ■ **Switch:** If stormwater infrastructure is needed, can it be delivered by re-using materials onsite? Would some options deliver the same stormwater management outcome with fewer materials/interventions? ■ **Improve:** Are there construction techniques that could be incorporated to allow a stormwater system to be installed in a low-carbon way, e.g. without the use of boring machines?	Development consists of retrofit of buildings, good public transport connections and green infrastructure with multiple purposes, including sequestration and resilience	Developer Designer Constructor Supplier	5.3.3	4.3
Integrate climate resilience and nature-based solutions (NBS)	■ Reflect the carbon implications of lack of climate resilience in the system (carbon from damage/disruption in an extreme event and likelihood of it happening) and the carbon required to retrofit resilience ■ Prioritise NBS where appropriate – e.g. upstream catchment flood management, SuDS, green space for urban heat island mitigation, etc. Ensure NBS design maximises carbon sequestration potential	Development consists of green infrastructure with multiple purposes, including sequestration and resilience	Developer Designer	4.3	4.1 6.1.1 6.2.2 7.1.1
Assessment	What is the projected whole-life carbon impact on the control and influence of the project or programme of work? ■ Assess using initial quantities based on optioneering exercise and utilising generic carbon factors, or benchmarks where required ■ Be transparent in assumptions and identify gaps	Clarity of where the carbon is and how this could be incorporated into procurement (e.g. for setting targets for the supply chain) Baseline enables monitoring of reductions to compare benefits during optioneering	Developer Designer Constructor Supplier	4.3	7.1
Procurement	Select procurement method: ■ e.g. design and build (D&B) ■ Example decarbonisation requirement for targets and performance requirements ■ Qualitative/KPI approach to performance, rather than financial incentive ■ Ensure incentivisation of whole-life carbon reduction – not relative to arbitrary baselines ■ Penalties to reflect the future implications of failure to achieve net-zero transition and increased cost of resilience ■ Address risk-sharing for innovation implementation ■ Contractual value obligations to reflect the need for decarbonisation ■ Contractual programme obligations to reflect the time to innovation maturity	Clarity and incentives for the supply chain on the intended outcomes Clear, unambiguous risk allocation that enables collaboration	Developer Designer Constructor Supplier	5.3-4	10.1



Developments options assessed and selected; design not yet finalised

What	How	Carbon management benefit	Collaboration	Example section in Guidance Document	PAS requirement
Leadership	Align carbon management with other business processes, for example: ■ Map out and communicate key design review dates, and align carbon assessment and reduction opportunity identification requirements to those dates ■ Monitor carbon reductions and progress towards targets alongside cost, risk, schedule etc and include as agenda items within design reviews	Accountability for designing in carbon reduction	Developer Designer	2.3	5.1-2-3 9.1
Carbon reduction hierarchy	Following the carbon reduction hierarchy in the design stage might look like: ■ **Avoid:** Are there alternative solutions to building a certain component/segment? Could one space serve multiple uses? Can existing piles or structural elements onsite be re-used? What condition monitoring/testing needs to be done? ■ **Switch:** Which materials would deliver the lowest-carbon outcome, e.g. timber vs bricks? ■ **Improve** etc	Innovation from the supply chain integrated into the project Optimised, lean and clever design – for example, multi-purpose assets (i.e. heat export from wastewater to district heating using biogas recovery) Efficient and circular use of resources	Developer Designer	5.3.3	4.3
Integrate climate resilience and nature-based solutions	■ Design NBS that reduce/replace hard assets in the development for the provision of drainage, flood attenuation, wastewater treatment and urban heat island mitigation ■ Evaluate the carbon reduction (and cost reduction) benefits from the carbon avoided (from construction of the hard assets and the operational disruption from extreme events), as well as the potential for carbon sequestration from the change of land use ■ Design a long-term instrumentation and monitoring strategy that provides evidence of carbon sequestered during the life of the project	Landscape design that protects from flooding and avoids urban heat island effect	Developer Designer Constructor Supplier	4.3	4.1 6.1.1 6.2.2 7.1.1
Innovation implementation strategy	Develop a process to encourage innovation throughout the design process, including innovation related to delivery, climate change resilience and integration of NBS, as well as circular economy principles and opportunities	Clear steps to implementation to inform procurement in construction and operation	Developer Designer Constructor Supplier	5.3.5	5.2 11.1-2-3

Design finalised; handover to constructor to implement

What	How	Carbon management benefit	Collaboration	Example section in Guidance Document	PAS requirement
Assessment	Work collaboratively with the constructor to implement a system to capture data required to assess emissions during construction – for example: ■ Early in the delivery process, establish a list of the required data sources and identify how, by whom and when that data will be collected ■ Design a data collection spreadsheet or utilise a digital tool to capture construction data on an ongoing basis	Evidence of implemented carbon benefits	Developer Designer Constructor Supplier	4.3	7.1
Data collection for benchmarking	As construction/delivery continues, there is an opportunity to continually improve processes by feeding back data (including activity data and carbon values) to inform future baselines, which, in turn, will inform future decision-making. This could be undertaken by publishing an updated set of benchmarks for different elements of the development	Data to inform future baselines and better benchmarking	Developer Designer Constructor Supplier	5.3.6	11.1 11.2

Development in operation; users and occupiers in place and engaged

What	How	Carbon management benefit	Collaboration	Example section in Guidance Document	PAS requirement
Assessment	Calculate operational carbon emissions in accordance with the appropriate methodology, which could further support (and be supported by) the asset owner/manager's organisational carbon reporting. For example, if the asset owner/manager produces an annual report of facility emissions as part of its organisational carbon footprinting, it is likely that it also collects information on its occupiers and tenants for Scope 3 emissions assessment	Evidence of implemented carbon benefits	Developer Designer	4.3	7.1
Data collection and continual improvement	During operation, as during earlier work stages, there is an opportunity to continually improve processes by feeding back data to inform future baselines, which, in turn, will inform future decision-making. This could be undertaken by publishing an updated set of operational benchmarks for different areas of the development	Data to inform future baselines and better benchmarking	Developer Designer Constructor Supplier	5.3.6	11.2 11.1

Development at end of its envisaged service life; decisions to be made about what to do with the asset(s)

What	How	Carbon management benefit	Collaboration	Example section in Guidance Document	PAS requirement
Stakeholder mapping	As the development approaches the end of its original service outcome, the asset owner/manager should return to the Need stage to identify how the asset may best continue to serve a function to the system. This could take the form of undertaking an additional stakeholder mapping to understand the state of the different components of the assets, which networks and systems they connect with, and which stakeholders may have an interest in the future decisions to be made around the asset	Engaged stakeholders for future redeployment of existing assets and resources – for example, re-use of recovered components into local/regional regeneration schemes	Developer Local government/ planning authority Other asset owners – water, transport, energy	4.3	6.2.4

04
Carbon management process and implementation

4.1 Introduction

This section provides guidance for all value-chain practitioners on how to develop and implement the PAS 2080 carbon management process when delivering projects or programmes of work at the asset, network or systems levels.

Although the asset owner/manager is a pivotal member of the value chain in the built environment, the greatest carbon reduction potential occurs when all value-chain members are fully engaged and jointly implementing the asset owner/manager's carbon management process to deliver assets, buildings and programmes of work.

The objective is to reduce whole-life carbon emissions in buildings and infrastructure projects and programmes of work across each of the six different work stages, as defined in PAS 2080.

Guidance on the carbon management process requirements (as described in PAS 2080) is provided for each work stage in the form of responsibility charts, to help practitioners to understand when such requirements should be addressed and which organisation from the value chain is best placed to address them, most notably for the new concepts in the PAS 2080 revision. Key principles are illustrated through a number of worked examples from different infrastructure and building sectors, presented in this section.

4.2 Clause chart

Table 4.1 (see page 35) summarises value-chain members with overarching responsibility for each of the clauses in PAS 2080. For each delivery stage, a number of responsibility charts are presented in this section to provide further details.

4.3 Overview of the new concepts in the PAS 2080 update

System-level considerations
Every organisation must align their pipeline of projects and/or programmes of work with the scope and timeline for the net-zero carbon transition at the systems level (see Sections 1 and 5 of this Guidance Document). Climate resilience and decarbonisation commitments are set at national level, with some indication of apportionment at sector or geography level, but they are invariably incomplete.

Any carbon reduction targets at the asset or network level should be tested where possible for alignment at the system level. The PAS expects that net-zero targets are set at the system or network level and not the asset level. This is to avoid any unintended consequences of focusing on offsets or other removals measures, instead of prioritising deep carbon reductions. See worked example 1: Setting baselines at Need stage, and worked example 2a: Top-down approach to target-setting in absence of sector budgets.

	Need/ planning	Optioneering	Design	Delivery	Operation	End of life
Overarching responsibility	Asset owner	Asset owner, designer	Asset owner, designer	Asset owner, constructor	Asset owner/ manager	Asset owner, designer
Collaborating with	Designer Constructor Supplier Other asset owners	Constructor Supplier Other asset owners	Constructor Supplier	Designer Supplier	Designer Constructor Supplier	Constructor Supplier Other asset owners
Relevant clauses	Leadership Integration with decision-making Targets and baseline Procurement	Assessment Targets and baseline Integration with decision-making Monitoring and reporting	Assessment Targets and baseline Integration with decision-making Monitoring and reporting	Assessment Targets and baseline Monitoring and reporting	Assessment Targets and baseline Monitoring and reporting Continual improvement	Procurement Integration with decision-making

Table 4.1: PAS 2080 clauses mapped to delivery stages of a project and programme of work

Removals, land-use change and nature-based solutions

When planning for net zero in projects and programmes of work, value-chain members should consider the following in the decision-making process relevant to emissions removals. These should be considered as part of the PAS 2080 whole-life carbon management framework for decision-making (Clause 4):

- ***Removals*** It is important that carbon removals from the atmosphere are reported separately to the emissions of an asset, to understand quickly the level of reductions achieved.
- ***Land-use change*** When a project instigates land-use change, it is important to consider both the carbon impact relative to the existing land use (e.g. release of vegetation and soil carbon when a greenfield site is built over and the local natural ecosystems are depleted/removed) and the projected future condition of the land (e.g. inability for natural ecosystems to thrive and store carbon in the soil because of hard-surface disruption and spatial constraints). This is particularly prevalent in large-scale developments and linear projects where there is disturbance to the land and supporting natural functions (freshwater, nutrient cycles etc) at scale.
- ***Nature-based solutions*** The implementation of NBS can be used as a more sustainable low-carbon alternative to avoid building new conventional hard-infrastructure systems.

Carbon emissions and removals through land-use change are relatively unfamiliar to built environment practitioners, and are new additions in the PAS 2080 update, so specific worked examples are provided. See worked example 3 – Removals, land-use change and co-benefits; worked example 4 – Carbon sequestration and nature; worked example 5 – Timber, crushed concrete, and whole-life benefits/impacts; worked example 6 – Offsets and ‘carbon-neutral’ products; and worked example 10 – Reporting emissions and removals to support decision-making.

A general observation through the worked examples and beyond: carbon removals through nature-based solutions and land-use change are the only proven interventions that contribute towards the ‘net’ part of the net-zero carbon equation. Yet, the carbon that can be sequestered in the soil and the natural, biodiverse ecosystems is small, relative to the carbon emitted from the construction and use of the build environment.

Assessment

The PAS 2080 update takes a more strategic approach to the requirements for assessing whole-life carbon in projects and programmes of work. It focuses on assessment requirements for buildings and infrastructure using a new whole-life carbon framework for decision-making (Clause 4).

The framework has been developed to fill the industry gap in GHG assessment standards, which focus on assets or products, rather than wider networks and systems where more complex interactions of assets exist within and beyond the project boundary. Such interactions need closer analysis to ensure carbon reduction opportunities within and beyond the project boundary are maximised, and that unintended consequences (mainly other emissions, such as from land-use change) are minimised.

The updated PAS 2080 requires the value chain to:

- Assess whole-life carbon emissions early in the delivery process, focusing on the significant emissions/hot spots, rather than only on accuracy, to help maximise carbon reduction opportunities early
- Use existing standards and methodologies for assessing whole-life carbon (in terms of data quality, sources, quantification approaches etc), instead of providing bespoke assessment methodologies
- Look beyond the project boundary for associated emissions increases and reductions when assessing whole-life carbon at the early stages

See the worked examples on assessments (infrastructure and buildings): worked example 7a – Building carbon assessment following BS EN 15978:2011; worked example 7b – infrastructure carbon assessment following BS EN 17472:2022; and worked example 8 – Whole-life carbon assessment at the design stage can drive whole-life reductions.

End of life/retrofit/revisiting need
As part of decarbonisation planning, it is important to consider the end-of-life opportunities in a project/programme of work by revisiting need and focusing on potential retrofit solutions and extending asset life, where appropriate. This applies both to existing assets or networks when identifying needs in a new project, and when assessing the future repurposing/re-use potential of any new assets or networks being planned.

Guidance for end-of-life considerations are included in Section 5, and in selective case studies on revisiting the need for additional capital works in Sections 5 and 6. See worked example 9 – Continual improvement and innovation; and worked example 12 – Considering impacts from end of life.

Climate resilience
The value chain should recognise the need for meeting climate resilience (as set out in laws and policy), but also anticipate the carbon implications from the grey infrastructure needed to achieve such resilience, or the carbon emitted by damage and disruption due to lack of resilience in extreme weather events. As such, climate resilience should be an integral part of the carbon management process, ensuring that lower-carbon alternatives to hard defences are identified (e.g. natural flood management instead of flood walls). These should be assessed early in the delivery process.

4.4 Implementation across the whole-life stages

4.4.1 Need stage
The Need work stage is where the asset owner/manager defines the needs for its assets and networks in a manner that supports the net-zero transition of the system and outcomes expected of a project/programme of work to meet this need. Other value-chain members are involved in this stage and have the opportunity to challenge the asset owner/manager's decisions. A Need stage that aligns with the system's net-zero carbon transition is the earliest and biggest opportunity to avoid generating carbon (refer to the carbon reduction hierarchy).

Key actions for asset owners/managers to maximise carbon reduction opportunities in the Need stage are:

- Showing clear leadership
- Engaging with government, regulators, other asset owner/managers and other actors with influence at the system level to agree common needs and targets
- Setting bold targets and clear outcomes
- Engaging with the value chain early to share carbon opportunities
- Removing any constraints to collaboration
- Defining corporate governance
- Embracing a culture of challenge and change
- Encouraging and incentivising innovation throughout the value chain
- Assessing carbon impacts at a system level and identifying opportunities for refurbishment/re-use/repurposing of existing assets

The elements of the PAS 2080 carbon management process to be addressed during the Need work stage, together with the specific responsibilities of the key value-chain members, are summarised in Table 4.2 (see page 41). The levels of responsibility for each activity are defined in the key.

4.4.2 Optioneering stage

This stage is where the asset owner/manager undertakes initial scoping and evaluations of options for an asset and/or network, followed by the selection of the preferred option before detailed design. The asset owner/manager is encouraged to consult designers and constructors at this point.

The Optioneering stage provides opportunities to avoid carbon, switch to lower-carbon design approaches and improve material and performance specifications for lower carbon and resource efficiency (refer to the carbon reduction hierarchy).

Key actions to maximise carbon reduction opportunities in the Optioneering stage are:

- Maximising early collaboration opportunities between asset owners, designers, constructors and product/material suppliers. An iterative approach is required and will have to continue throughout all of the delivery stages
- Defining the right service outcomes, challenging the need for new assets, and reviewing opportunities to further utilise/repurpose existing assets
- Clearly communicating desired service outcomes, but allowing value-chain freedom in how these outcomes are achieved to allow maximum scope for innovation
- Selecting procurement routes (for other members of the value chain) that address whole-life performance and incentivise low-carbon solutions
- Engaging constructors early to assess innovative construction techniques and materials
- Engaging product/material suppliers early to showcase low-carbon alternatives to be considered during the concept and Design work stages
- Consideration of system decarbonisation and whole-life carbon performance during optioneering, including:
  - Optimal use of passive design principles
  - Optimal balance between capital carbon and operational carbon
  - Reducing capital carbon by building less and opting for lower-carbon materials
  - Capitalising on industry-level efforts to adopt modern construction methods (e.g. hydrogen fuels during construction, autonomous plant, offsite manufacturing) to reduce capital carbon
  - Reducing operational carbon by lowering operational energy and resource use, and through integration of building and infrastructure systems
  - Assessing user carbon to determine which option could reduce whole-life carbon emissions
  - Influencing end-user behaviour through design to further reduce user carbon
  - Considering end-of-life scenarios and associated carbon emissions to inform asset layout and materials used

The elements of the carbon management process to be addressed during the Optioneering work stage, together with the specific responsibilities of the key value-chain members, are summarised in Table 4.3 (see page 42).

4.4.3 Design stage

This deals with the detailed design of the preferred option. At this work stage, further opportunities for carbon reduction should be considered and the relevant construction activities planned.

The Design stage provides opportunities to avoid carbon, switch to lower-carbon design approaches and improve material and performance specifications for lower carbon and resource efficiency (refer to the carbon reduction hierarchy).

Key actions in the Design work stage to maximise carbon reduction opportunities are:

- Optimising resource use and energy efficiency of the preferred design option through low-carbon materials, leaner design methods and smart communication (instrumentation, control and automation – ICA) systems for operational efficiency
- Early engagement between value-chain members and stakeholders to influence specifications, sourcing, procurement and permits
- Consideration of end-of-life carbon during materials selection
- Designing for disassembly and material re-use at end of life

The elements of the carbon management process to be addressed during the Design work stage, with the specific responsibilities of the key value-chain members, are summarised in Table 4.4 (see page 42).

4.4.4 Delivery stage

This stage includes the procurement and physical delivery of infrastructure. By the end of this stage, the capital carbon emissions will no longer be predicted, but will have already occurred. The Delivery stage provides opportunities to switch to lower-carbon construction technologies and improve material specifications and resource use (refer to the carbon reduction hierarchy).

Key actions during the Delivery work stage to maximise carbon reduction opportunities are:

- Embracing innovative construction techniques to minimise waste and plant fuel use
- Optimising energy use to reduce capital carbon from construction/commissioning activity
- Minimising use of resources (e.g. water, electricity, fuel) during construction operations
- Capturing as-built carbon emissions and feedback as part of the continual improvement process

The elements of the carbon management process to be addressed during the Delivery work stage, with the specific responsibilities of the key value chain members, are summarised in Table 4.5 (see page 43).

4.4.5 Operation stage

The infrastructure or building is operational during this work stage. The primary focus will be on optimising its performance to reduce carbon emissions as far as possible, or to extend its function. Emissions quantification should be based on measured activity or use data, although some predictive modelling may be undertaken.

The Operation stage provides opportunities to improve resource use and operational approaches for lowest whole-life carbon (refer to the carbon reduction hierarchy). Key actions during the Operation work stage to maximise carbon reduction opportunities include:

- Reducing further operational and maintenance carbon emissions through measures such as real-time control optimisation and proactive condition monitoring and maintenance regimes
- Identifying improvements to existing assets through optimisation and refurbishment – noting that, in some cases, new infrastructure might be required to deliver better performance
- Identifying alternative consumable projects that have lower impacts than those of existing suppliers

The elements of the carbon management process to be addressed during the Operation work stage, plus the specific responsibilities of the key value-chain members, are summarised in Table 4.6 (see page 43).

4.4.6 Purpose/performance review stage

This stage of existing assets should be considered with the same mindset as if dealing with a new asset. Key actions in this work stage to maximise carbon reduction opportunities are:

- Exploring possibilities to extend the asset life and re-using or recycling assets for the same or different uses
- Assessing the possibility of 'build nothing solutions' and looking to re-use existing assets
- Assessing beneficial asset-re-use potential in any assets about to be made redundant – can these be re-used onsite and/or can any resources be recovered to use in other assets or markets?
- Adopting collaborative ways to find the best options for re-using/recovering materials and equipment

The elements of the carbon management process to be addressed during the Purpose/performance review work stage, together with the specific responsibilities of the key value-chain members, are summarised in Table 4.7 (see page 44).

Tables 4.2-4.7: Responsibility charts

Key:

Responsible	Main responsibility/doer of the activity
Accountable	The value-chain member accountable for ensuring the activity is completed to the level required
Consulted	Value-chain member who is actively engaged and contributes input to the doer of the activity
Informed	Value-chain member who is kept aware of how and when the activity is being completed and is ready to provide inputs if necessary

Asset owner	Designer	Constructor	Product/material supplier
Align investment decisions for projects/programmes of work with decarbonisation plans and objectives at the national, network and/or system level			
The asset owner/manager should identify the carbon implications of climate resilience, or lack of, at the asset, network, or system level, and integrate them in the carbon management framework for decision-making			
Prioritise nature-based solutions to reduce carbon and increase resilience, where appropriate			
Define the study boundary for whole-life carbon emissions and removals within control and influence			
Set carbon reduction baseline and targets considering national and sector-level targets/budgets	Provide relevant data and support to inform/improve the baseline. Comply with targets. Challenge targets if necessary. Support the development of targets if none have been set	Provide relevant data, support and recommendations to inform/improve the baseline. Comply with targets. Challenge targets if necessary. Support the development of targets if none have been set	Provide relevant, support, and recommendations to inform/improve the baseline. Comply with targets. Challenge targets if necessary. Support the development of targets if none have been set
Develop and implement a carbon management process and communicate it to the value chain	Submit carbon reduction proposals to the process where possible. (Benchmarks or provide options to support decarbonisation)	Submit carbon reduction proposals to the process where possible. (High-level, low-carbon construction management plan/temporary works)	Submit carbon reduction proposals to the process where possible. (Low-carbon materials or technologies available)

Table 4.2: Need stage responsibility chart: the earliest and biggest opportunity for avoiding carbon (In PAS 2080 carbon reduction hierarchy: avoid/switch/improve)

Asset owner	Designer	Constructor	Product/material supplier
Apply and encourage application of the carbon reduction hierarchy. In particular, consider opportunities for utilising existing asset/networks			
Define carbon monitoring and reporting requirements (objective/frequency/KPIs) and communicate them to value chain	Understand reporting requirements and have the mechanisms in place	Understand reporting requirements and have the mechanisms in place	Make carbon data materials/products easily accessible to the value chain
Set up a carbon data/tools sharing environment for all value chain members and promote collaboration	Collaboration/data sharing	Collaboration/data sharing	Collaboration/data sharing

Table 4.3: Optioneering stage responsibility chart: biggest opportunity for avoiding carbon and switching thinking on materials, technologies to be deployed and other opportunities (In PAS 2080 carbon reduction hierarchy: avoid/switch/improve)

Asset owner	Designer	Constructor	Product/material supplier
Collaborate and engage with value chain and stakeholders	Collaborate and engage with value chain and stakeholders	Collaborate and engage with value chain and stakeholders	Collaborate and engage with value chain and stakeholders
Set design requirements that align to net-zero transition and whole-life decarbonisation	Integrate whole life carbon reduction in the design development, challenge design requirements where additional whole-life carbon is incurred and provide lower-carbon solutions		
Track carbon-reduction baseline/targets set at the Need stage and refine the assessment as data and design details become available	Adopt targets and challenge where opportunities for improvement are spotted. Where targets are not already set, engage with asset owner accordingly	Engage early with asset owners/managers to assist with baseline/targets	Contribute with data (e.g. carbon factors of products) to inform targets and recommend improvements if necessary
Implement monitoring and reporting requirements defined in the Optioneering stage and encourage mechanisms to allow parallels between risk and cost management with carbon management	Monitor and report whole-life carbon emissions of design options using the approach defined by the asset owner. Identify and communicate carbon hotspots at regular intervals and encourage the design team to identify reduction opportunities		
Encourage value-chain members to assess options and provide recommendations for low-carbon solutions. Engage with product/material suppliers to ensure that low-carbon products/materials meet performance requirements	Incentivise options that maximise use of existing assets and low-carbon products, as well as re-use of material. Consider future adaptability and material recovery		Engage with asset owners/managers to ensure low-carbon products/materials meet performance requirements

Table 4.4: Design stage responsibility chart: maximum opportunities for switching to lower-carbon technologies and materials (in PAS 2080 carbon-reduction hierarchy: avoid/switch/improve)

Asset owner	Designer	Constructor	Product/material supplier
Collaborate and engage with value chain and stakeholders	Collaborate and engage with value chain and stakeholders	Collaborate and engage with value chain and stakeholders	Collaborate and engage with value chain and stakeholders
	Set requirements in specifications that support low-carbon solutions for the contractor to follow	Integrate whole-life carbon reduction in construction and capture data on innovative construction techniques, materials and product use	Develop and deploy low-carbon solutions, technologies, materials, products or methods
Track carbon reduction baseline/targets and refine assessment as data from construction works becomes available		Early engagement to work with asset owner to refine targets based on the delivery scope of work	Contribute data for targets and recommend improvements if necessary
Implement monitoring and reporting requirements and mechanisms aligned with the construction programme		Monitor and report whole-life carbon emissions of construction activities using the approach defined by the asset owner. Identify and communicate highest emissions and where future reductions can be made	Engage and liaise continually with other value-chain members to push low-carbon solutions
Set guidance for constructors to prioritise low-carbon solutions and minimise use of natural resources	Support constructors to identify low-carbon alternatives/solutions during works (since many designers work for Design and Build contractors, for example)	Minimise use of resources (e.g. materials, water, energy), transport to site and construction waste, and maximise opportunities for re-use/recycling/recovery	

Table 4.5: Delivery stage responsibility chart: maximum opportunities for improving carbon reductions from achieving further efficiencies in construction effort and resource recovery, as well as switching to alternative materials (In PAS 2080 carbon reduction hierarchy: avoid/switch/improve)

Asset owner	Designer	Constructor	Product/material supplier
Continue to optimise the operational performance of assets/networks to minimise emissions and use of natural resources		Constructors to ensure early stages of the operational cycles within their warranty period meet the operational targets	
Follow low-carbon assets maintenance schedules developed in earlier stages		Follow low-carbon assets maintenance schedules developed in earlier stages	
Monitor progress against targets, report progress at lifecycle milestones to detect any changes in asset performance	When appropriate, assist asset owner/manager in engagement with other value-chain members and stakeholders for operational performance of assets/networks		Provide measuring means for collecting operational data and share collected data back to asset owner and designer to use for future baseline
Develop a monitoring system that captures operational GHG emissions and feeds back to improve baselines	Use collected data from asset owner to review design maintenance schedules, specifications, benchmarks and assessments	Share collected data (operational and maintenance) back to asset owner and designer to use for future baselines	Suppliers to engage with asset owner/manager to check whether the operational data provided during design is factual and embedded lessons learnt to their environmental product declarations (EPDs), data sheets, or similar
Identify any needs for repair, replacement and refurbishment and consider whole-life carbon reductions during decommissioning of any redundant assets		Consider alternative low-carbon solutions when repairing, replacing or refurbishing assets/networks	Consider alternative low-carbon solutions when repairing, replacing or refurbishing assets/networks

Table 4.6: Operation responsibility chart: maximum opportunities for Improving carbon performance through operational optimisation (In PAS 2080 carbon reduction hierarchy: avoid/switch/improve)

Asset owner	Designer	Constructor	Product/material supplier
Assess and report actual emissions and performance against targets in accordance with reporting principles			Consider whole-life carbon beyond the material/product territory to avoid a negative impact on emissions elsewhere
Identify and prioritise opportunities for re-use, retrofit and refurbishment, or alternative solutions, before deciding on end of life	Liaise with asset owners/managers and constructors to review performance of assets/networks to inform design of future works considering re-use and recycling potential		Engage with asset owners/managers and constructors to review and assure end-of-life factors are realistic for products and materials
Revisit the need for the asset within the revised net-zero carbon transition of the network/system of which it is part. Refer back to Table 4.2	Work collaboratively to establish and implement circular economy opportunities for the re-use, refurbishment, retrofit or end-of-life decommissioning of the asset in question		

Table 4.7: Purpose/performance review responsibility chart: opportunities for avoiding building new assets and re-using existing assets (In PAS 2080 carbon reduction hierarchy: avoid/switch/improve)

WORKED EXAMPLES

WORKED EXAMPLE 01

Setting baselines at Need stage

PAS 2080 provides the requirements for setting a baseline for a project or programme of work. This worked example summarises further practical guidance in developing baselines that can be used for monitoring whole-life carbon progress during the various stages of the delivery process.

Fig 4.1 illustrates the main steps to consider when developing a baseline, and further explanation is provided below:

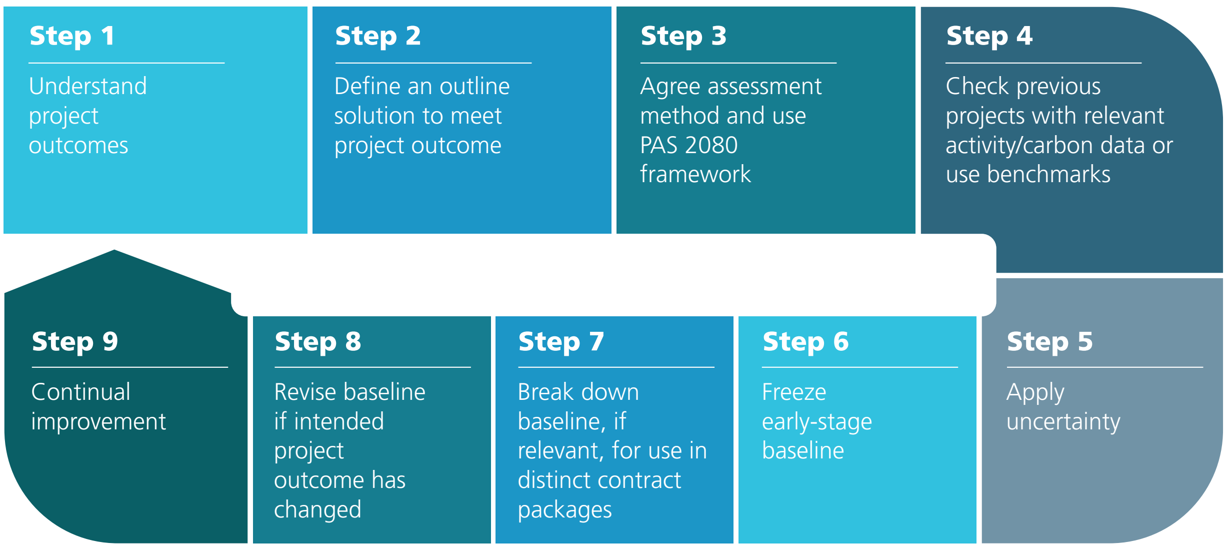


Fig 4.1: Steps to consider when developing a whole-life carbon baseline

Step 1: Understand project outcome at the Need stage
PAS 2080 emphasises the need to clearly understand project outcomes and not focus solely on outputs. In defining a project outcome, it is important to define a relevant functional unit for the project. For example, move x passengers and/or goods over y distance, instead of asking to increase road capacity for x passengers/goods over y distance; or protect x properties from flooding, instead of constructing y metres of flood wall.

Step 2: Define an outline (notional) solution to meet the project outcome
When the project outcome is well understood, it is important that an initial outline/baseline solution is chosen that will meet that outcome. When selecting an outline solution, the PAS requires that industry good practices need to be considered.

For example, if the outline solution is a railway, avoiding trains that use fossil fuels is considered to be good practice. Another example would be a flood defence wall being selected for a baseline/outline solution (made of concrete), in which the content of cement replacement in the concrete has to be captured at the outline solution stage, in line with current industry good practice, instead of assuming 100% Portland cement. This is to avoid overestimating a baseline that would show significant percentages of carbon reductions.

Step 3: Agree whole-life carbon assessment methodology to be used
It is important that, from the start, the project uses a consistent assessment methodology and scope and boundary of activities and emissions (and removals). PAS 2080 recognises this and requires that all projects start from the baseline stage (during Need stage) to use the specification's whole-life assessment framework for decision-making and the PAS 2080 decarbonisation principles. These require participants to look at impacts and opportunities outside the project boundary (at the system level) and consider all emissions and removals – capital, operational and user carbon – over the entire life of the project outcome. See worked examples 7a (page 55) and 7b (page 57) on how to select assessment methodologies.

Step 4: Check whether available activity and carbon datasets exist
At the early stages of a project, where detailed activity and carbon emissions data is not available, it is important to check whether previous similar projects to the outline solution selected exist. This will allow the as-built whole-life emissions (activity and carbon emissions data) to be used to estimate the baseline whole-life carbon. Asset owners with repeatable capital programmes are more likely to have this information. Such information should be assessed and applied in the context of the selected functional unit of the outline solution. For carbon emissions data, refer to worked example 7c (page 59).

If no activity or carbon data is available from previous projects that are similar to the outline solution, industry/organisational benchmarks should be used, where available. The building sector recognises guidance such as LETI (Low Energy Transformation Initiative) and other similar industry databases for quickly assessing the whole-life carbon of specific types of buildings for different materials and occupancy rates. Further detail is included in worked example 7c (page 59). Such resources may be more limited for infrastructure assets and are being developed. Asset owners/managers are encouraged to share their as-built project emissions data to help improve industry benchmarks.

If available, the easiest way to create a baseline is to use existing industry benchmarks. If selecting such benchmarks, as with cost benchmarks, it is important to ensure that a consistent assessment methodology and scope and boundaries of emissions are used. All assumptions, limitations and caveats must be transparent.

A hybrid approach to developing the project baseline for different project components may be possible (e.g. a train station versus a road, a pipeline versus a pumping station or treatment works, a retail development with associated infrastructure), as long as the assumptions are clear and transparent. In doing so, all assumptions must be clearly recorded, and all scope and boundaries of emissions and removals should be consistent.

Where there are still gaps in assessing whole-life carbon of specific components in the outline solution, or other impacts, such as land disturbance or sequestration benefits (within and outside the project boundary), then these should be filled in from first principles using engineering judgement and the latest sources of emissions factors.

Step 5: Consider whole-life carbon uncertainty
Similar to cost assessments at the early stages of the delivery process, it will be important to include a level of uncertainty in the baseline, given the project information (activity and carbon data) is not well known. It is recognised that there is no consistent or widely used approach to estimating uncertainty for whole-life carbon emissions in infrastructure or buildings. Therefore, the asset owner/manager may choose to follow a similar methodology to assessing cost uncertainty.

Uncertainty will reduce as the delivery process progresses, so it is important for this to be considered during the baseline stage to avoid the unintended consequence of the whole-life carbon impact of a solution increasing as the project information becomes more available or more accurate.

Step 6: Freeze early-stage baseline
In this stage, the baseline should be frozen and used as a starting point to inform progress against targets and/or the best option to take forward during the Optioneering stage and as the design progresses.

Step 7: If the baseline is to be used in distinct contract packages, break down into components, as appropriate
It will be important for each contract to have the project outcome baseline, as well as components of it that represent the scope of the outline solution parts, relevant to each contract package. For example, the procurement strategy of a project/programme of work may be that individual project components are delivered by different designers/contractors. It will be important for each contract scope to reflect the appropriate parts of the project/programme baseline, so that progress can be monitored and targets met.

An important PAS requirement is to ensure that any claims for carbon reduction are consistent and aligned to the baseline assumptions and represent real reductions. When a baseline is communicated in a contract, it is important to clearly communicate the assessment method, sources of emissions/removals, activity data, scope and boundary, uncertainty, assumptions and caveats and other information for the notional solution details.

Step 8: Revise the baseline only if the project outcome has changed
A baseline should be revised if the intended project outcome has substantially changed – for example, if fewer or more megalitres of water are to be supplied over the same distance, or a transport system outcome is to cover a different number of passengers. It is important that changes in the project outputs (e.g. materials used, diameter of tunnels, length/width of roads) should not trigger a change to the baseline. Selecting the right functional unit for the project outcome and functional units for the project components of the outline solution are, therefore, important at the early stages.

The PAS recognises that there has been confusion in the industry over revising the baseline when more accurate information becomes available on the project scope, activity data and/or emissions factors. Such data improvements relate to narrowing of the uncertainty, rather than changes to the project outcome. Therefore, it is important for asset owners/managers to improve their understanding and maturity for setting an outcome-based baseline and the right level of uncertainty in the different stages of the delivery process. This is a similar approach as that used for cost estimation.

Step 9: Continual improvement process for improving future baselines
Lastly, a key requirement in PAS 2080 is for the value-chain members to capture whole-life carbon information (activity and carbon data) using the right functional units, in the right format and transparently. This is to feed into the development of good as-built data and, in time, more comprehensive industry carbon benchmarks for capital, operational and user carbon, as well as removals.

WORKED EXAMPLE 02a

Top-down approach to target setting in absence of sector budgets

Setting a top-down target during the early stages of a project (policy/strategy-level analysis in projects and programmes of work) is critical for establishing an overall carbon budget for the solution and focusing decision-making on decarbonisation. Ideally, sectors would have decarbonisation trajectories to align with. However, in the absence of such trajectories, other techniques can be used to provide guidance to decision-makers and design teams.

One such approach is cost-based, which can follow this logic:

1. National annual carbon budgets covering the project's duration are calculated and plotted alongside annual national GDP projections for the same period.
2. Economy-level emissions intensity is calculated as the carbon budget divided by GDP for each year.
3. A project carbon budget (target) is calculated under each reduction pathway by multiplying the economy's carbon intensity by forecast project cost.

Project A is estimated to cost £10bn, with a delivery time frame covering five years from 2023 to 2027 (coinciding with the UK's fourth carbon budget period). Table 4.8 (see next page) shows the projected evolution of GDP alongside national carbon budgets, national carbon intensity ($MtCO_2e$/£bn) and a total carbon budget for the project assumed to be split equally across the delivery period.

	2023	2024	2025	2026	2027
National carbon budget ($MtCO_2e$)	1,950	1,950	1,950	1,950	1,950
National GDP (£bn)	2,863.44	3,040.42	3,208.84	3,375.27	3,534.93
Emissions intensity ($MtCO_2e$/£bn)	0.681	0.641	0.608	0.578	0.552
Project cost (£bn/year)	£2bn	£2bn	£2bn	£2bn	£2bn
Project carbon budget (cumulative total $MtCO_2e$)	1.36	2.64	3.86	5.02	6.12

Source: Developed by PAS 2080 team using published information and hypothetical project cost information

Table 4.8: Projected evolution of GDP alongside national carbon budgets and total project carbon budget

This assessment provides a carbon budget of 6.12 $MtCO_2e$ at the end of the five-year delivery (split equally across the period), which can act as a reference point to inform decision-making in the early stages of a project in the absence of more robust emissions-reduction pathways.

Note that this approach addresses only the construction carbon impact of the project, without consideration of the whole-life carbon implications during its operational life. The whole-life carbon benefit ratio would require a different target approach.

WORKED EXAMPLE 02b

Setting intensity targets

Intensity targets are normalised metrics developed to specify carbon performance relative to a functional unit of relevance to the subject of the target, e.g. tCO_2e/km of road or pipeline. As the built environment transitions to net zero, these targets are typically considered to be of little use in terms of driving absolute reductions in absolute emissions.

However, there are cases when intensity targets can be useful to asset owners/operators. When an organisation has a highly variable and uncertain pipeline of work, such as meeting maintenance requirements for a water network, it can be difficult to set an absolute reduction target with any certainty. In such situations, defining intensity targets focused on a meaningful functional unit can result in meaningful reductions.

For example, if PAS City (see Section 3) were to be hit by severe flooding, causing the local water company (PAS Co) to invest in emergency, carbon-intensive remediation work, this could compromise absolute emissions reduction efforts. However, if PAS Co were to set an intensity target (e.g. tCO_2e/£m invested) for maintenance/repair-related emissions, it would be able to target reductions in emissions per unit of spend on unforeseen activities.

This is not ideal for achieving net zero, as there will be an increase in the level of investment and, therefore, absolute emissions. Nevertheless, this metric could be beneficial for a PAS 2080-aligned organisation, better informing it about how to improve carbon efficiencies associated with the emergency remediation activities, driving continuous improvement over time.

WORKED EXAMPLE 03

Removals, land-use change and co-benefits

Context: A water company is constructing a new pipeline system, which involves the installation of both the linear pipeline and associated treatment works/pumping stations. In accordance with PAS 2080 requirements, the company is seeking to understand the carbon impact of land disturbance and change associated with the works. The company takes the following steps (see Tables 4.9-4.11):

1. Map possible emissions sources and declare scope of assessment

Land-use change emissions	Disturbance emissions
Change in carbon flux between the original land-use scenario and the project scenario Included and assessed in this worked example	Emissions associated with disturbing carbon stores during construction Should be included in assessment – not assessed by this worked example

Table 4.9: Considering the carbon impact of land-use change

2. Identify area of impact – the following information for the project should be identified:

- Total footprint of area to be disturbed (length of pipeline, footprint of associated permanent works, and footprint of temporary works)
  - Length of pipeline = 1km
  - Assume buffer zone around a pipeline, e.g. 10m width
  - ~10m x 1km = ~10,000m^2
  - Total footprint of associated permanent works (above ground infrastructure) = 5,000m^2 (e.g. obtained from GIS – geographic information system mapping – or design information)
- Permanent or temporary impact (will the existing land use be reinstated?)
- Map of the existing land-use type(s)

	Area (total m²)	Current land use	Current area (m²)	Area after construction (m²)	Net change in total area (m²)
Pipeline	10,000	Grassland	4,000	4,000	0
		Peat (near natural)	6,000	0	-6,000
		Peat (modified)	0	6,000	+6,000
Pumping station and water treatment works	5,000	Grassland	5,000	0	-5,000
		Urban hardstanding	0	5,000	+5,000

Table 4.10: Identifying area of impact

3. Assessment of change in stocks

■ Apply relevant physical metrics (tonnes CO_2e sequestered per hectare), e.g. from the UK Government Enabling Natural Capital Approach (ENCA) Services Databook or other relevant sources. ENCA provides a template for undertaking an initial assessment of the natural capital effects of a project or policy.

	Area (total m²)	Current land use	Net change in total area (m²)	Net change in total area (hectares)	Carbon emissions (+) or sequestration (-) rate, tonnes CO_2e/ha/yr	Source	Net change in carbon emissions (+) or sequestration (-) rate (tonnes CO_2e/yr)
Pipeline	10,000	Grassland	0	0	-0.36*	**Natural England (Improved grasslands)**	0
		Peat (near natural)	-6,000	-0.6	1.08*	**Peatland code**	-0.648
		Peat (modified)	+6,000	+0.6	2.54*	**Peatland code**	1.524
Pumping station and water treatment works	5,000	Grassland	-5,000	-0.5	-0.36*	**Natural England (Improved grasslands)**	0.18
		Urban/ hardstanding	+5,000	+0.5	0	**JBA Consulting for the UK Committee on Climate Change**	0
	TOTAL						**1.056**

*Additional detail and alternative values may be available depending on the source. The user could look at rates depending on the level of habitat detail available, or potentially report a range of values

Table 4.11: Assessing change in stocks

WORKED EXAMPLE 04

Carbon reduction and nature

As emphasised at 2022's UN Biodiversity Conference, COP15, the climate and nature crises are global emergencies that are interdependent. Even if all carbon emissions from the built environment were switched off tomorrow, the global average temperature rise would not be limited to 1.5C[1] without reinstating the natural functions in land use degraded by human intervention. Both climate mitigation and resilience rely heavily on environmental regeneration that rebalances the natural carbon cycle and "allows the planet to remain hospitable for life".

The role of nature in the built environment is a fundamental consideration when managing carbon, as it is the only proven intervention for carbon removal (the 'net' in the net-zero equation). Nature-based solutions are also important carbon-avoiding interventions as they can effectively replace the need for hard engineering assets, particularly, but not only, related to water management, temperature control and soil erosion.

NBS are affordable, available and scalable alternatives to water management and climate resilience interventions. In carbon terms, they work by both increasing carbon sequestration and avoiding GHG emissions. In the case of a watershed reforestation project, for example, carbon is sequestered by the trees, vegetation and, particularly, the soil – almost 80% of the total carbon in terrestrial ecosystems is stored in soil. Climate change losses (human, capital, natural, and associated emissions) are also reduced due to increased resilience in the watershed. All of these benefits accrue if natural habitats or ecosystems are restored and biodiversity is increased.

Similarly, restorative and regenerative land management (RLM) can be designed into projects so that it protects the built environment within its reach, while being protected by it. For example, when determining the alignment of a new road or railway, asset owners that adopt regenerative land principles could spare land conversion and enable carbon sequestration to help climate change mitigation and in estimating the emissions impact of land-use change – all while improving land-use practices by their stakeholder landowners and integrating the scheme into existing landscapes.

It is an essential solution, particularly for linear infrastructure owners, private commercial landowners, developers and utility companies, which have the ability to determine how significant portions of land are used. Likewise, RLM ensures that land use is aligned with current and future investors' values – e.g. Task Force on Climate-related Financial Disclosures (TCFD) and Taskforce on Nature-related Financial Disclosures (TNFD) frameworks.

1 See definition of net-zero carbon – main PAS 2080 Glossary

Certainly, there are challenges when dealing with nature- and land-sparing interventions in projects, such as availability of skills, data certainty (e.g. for soil carbon sequestration), and the need for a monitoring/maintenance programme required to estimate/report benefits.

The industry is rapidly developing relevant processes and databases to quantify benefits (e.g. Natural England's NERR094 Carbon Storage and Sequestration by Habitat), while value-chain members are working collaboratively to fund and deliver schemes that combine traditional solutions with NBS and RLM practices to generate long-term value (e.g. National Highways' A30 'Green Ribs' project).

WORKED EXAMPLE 05 Timber, crushed concrete and whole-life benefits/impacts

Structural timber, as a low-carbon alternative material to steel and concrete, has been widely used in the construction industry, particularly in buildings. To understand the role of structural timber in a project and its relevance to carbon management, practitioners need to consider its whole-lifecycle benefits and impacts.

From a carbon perspective, there are two main aspects to consider: biogenic carbon (carbon stored in the timber mass), as alternative materials emit emissions only, and lower upfront carbon (timber keeps carbon out of the atmosphere for an extended period of time). In addition, its end-of-life emissions need to be assessed to consider realistic scenarios, e.g. burning waste timber, landfill or transferring/ recovering potential.

As illustrated in the following example (Table 4.12, next page), the scale of sequestration rates and respective end-of-life emissions need to be put into a whole-life context to inform decision-making and demonstrate whether timber is the most suitable material for a construction project or not.

$kgCO_2e/m^2$	A1-A5	B1-B5	B6-B7	C1-C4	D	A-C
GWP-fossil	403	165.4	90	22	-57	680.4
GWP-biogenic	-102	0	0	102	0	0
GWP-land use/land use change	0	0	0	0	0	0
GWP-total	301	165.4	90	124	-57	680.4
GWP fossil	**403**	**165.4**	**90**	**22**	**-57**	**680.4**
GWP-fossil removals	0	-0.6	0	0	-107	-0.6
GWP-fossil emissions	403	166	90	22	50	681
GWP biogenic total	**-102**	**0**	**0**	**102**	**0**	**0**
GWP bio removals	-207	-40	0	-1	-90	-248
GWP bio emissions	105	40	0	103	90	248
GWP land use/land-use change	**0**	**0**	**0**	**0**	**0**	**0**
GWP-total	**301**	**165.4**	**90**	**124**	**-57**	**680.4**
GWP-removals	**-207**	**-40.6**	**0**	**-1**	**-197**	**-248.6**
GWP-emissions	**508**	**206**	**90**	**125**	**140**	**929**

Table 4.12: Example of emissions/removals assessment for a residential timber building (GWP = Global Warming Potential). Source: Assessing the carbon-related impacts and benefits of timber in construction products and buildings, Technical Paper, November 2021, Timber Development UK (https://ttf.co.uk/download/tduk-technical-paper/, accessed in December 2022)

However, decision-makers need to consider other whole-lifecycle aspects. Sourcing of timber for construction forms a complex supply chain, making it difficult to trace emission sources and scale it up to the level required for the construction industry. The assessment/quantification process still carries many uncertainties – e.g. emissions associated with the use of fertilisers/herbicides/pesticides, forgone sequestration capacity, and decay/combustion of logging residuals. Lastly, existing design standards and specifications for structural timber have stringent requirements, leaving room to encourage monoculture and intensified forest practices, which are net carbon-emitting.

Similarly, concrete carbonation is another subject of research by the construction materials industry – the potential of crushed concrete to sequester carbon at its end-of-life stage (post-demolition). The latest research[2] states that carbonation post-demolition has to be managed and built into the design; is subject to site-specific conditions; requires close measurement and historical knowledge of the site, and the significance of removals considering whole-life emissions of a project typically falls under cut-off rules (i.e. not significant enough for decision-making).

In both scenarios, further research of the whole-life impacts of these materials is required before using them as a 'silver bullet' for construction projects. Their use needs to be assessed on a project-by-project basis following assessment and reporting principles, as outlined in PAS 2080, to effectively inform decision-making and drive decarbonisation.

2 Ehsan Jorat M, Kraavi K, Manning D (2022) Removal of atmospheric CO_2 by engineered soils in infrastructure projects, Journal of Environmental Management

WORKED EXAMPLE 06 Offsets and 'carbon-neutral' products

The focus of PAS 2080 is on establishing a carbon management process to deliver carbon reduction. Accordingly, the PAS does not attempt to provide requirements or guidance on the use of offsets. While organisations can and do make their own decisions on offsets, the focus should be on maximising carbon reduction and removal opportunities within the project or programme.

However, within the context of the built environment, one situation in which practitioners may encounter carbon offsets is through 'carbon-neutral' products. They may wish to purchase products that contribute to wider decarbonisation beyond the product's boundary, as is the case where the carbon-neutral product claim is derived from a market-based offset.

Value-chain members should focus on purchasing materials that will result in the lowest-carbon outcome (e.g. significantly fewer tonnes of a higher-carbon material may be needed to deliver the same outcome) and, similarly, focus on products that result in the lowest gross emissions without considering the use of offsets.

If the above principle has been satisfied and the value-chain member wishes to purchase a product that utilises offsets as part of its neutrality claim, they should refer to the requirements of the particular methodology they are following (see Clause 7 of PAS 2080) for how to account for those emissions. If there is ambiguity about this in the methodology, the following should be considered:

- Practitioners should not subtract the offset amount from the carbon footprint of the asset and should calculate emissions based on the lifecycle impact of the product.
- Provided this does not conflict with their chosen methodology, they may report the offset separately as a benefit/impact of the purchase of the material. The use of an offset, however, should not be used to reduce the carbon impact of the asset in question.

WORKED EXAMPLE 07a Building carbon assessment following BS EN 15978:2011

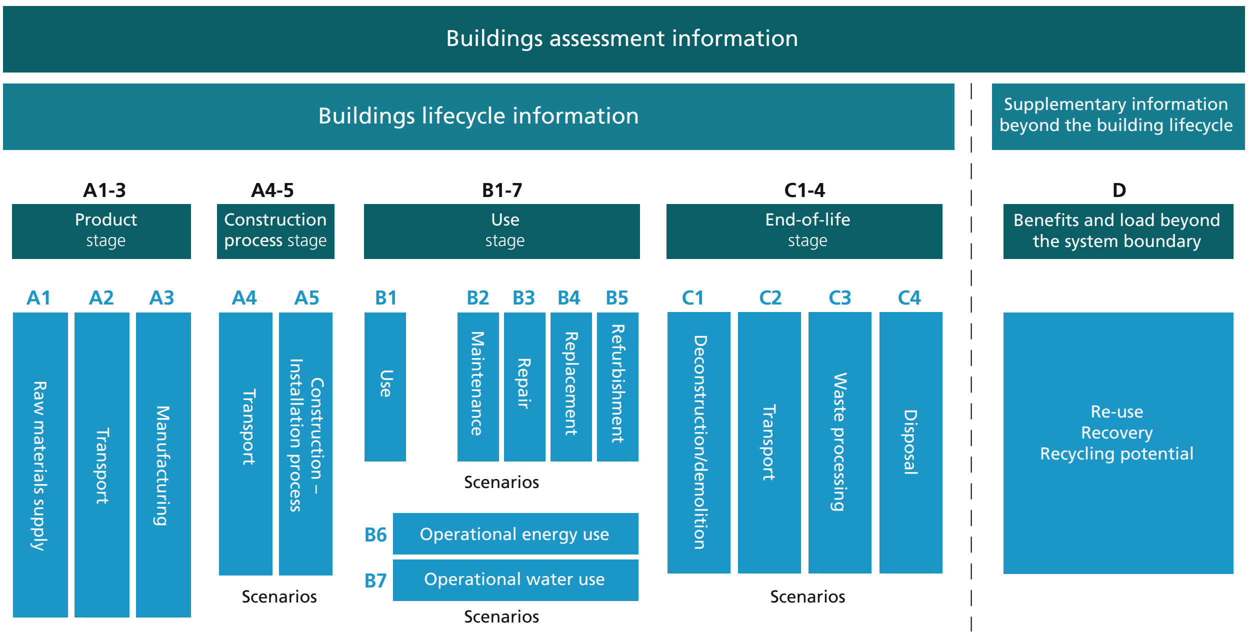
BS EN 15978:2011 sets out the methodology for assessing whole-life carbon in buildings. This standard sets out a consistent approach to assessing the environmental performance of new and existing buildings, including their carbon emissions.

The criteria and principles for undertaking whole-life carbon assessments include considerations regarding data quality, functional equivalents, reference study period and boundary setting. For data sources of emissions factors, refer to worked example 7c (page 59).

Therefore, when combining the BS with PAS 2080, carbon managers are able to embed the principles set out in Clause 7 to the whole-life carbon assessments of projects and programmes of work. This enables a common carbon management language across different asset/network/system typologies.

The diagram below is an extract from the BS EN 15978:2011 standard and reflects the lifecycle stages of the building works assessment. When compared with the PAS 2080 whole-life carbon management framework for decision-making, the following aspects should be considered:

- All lifecycle assessment (LCA) methodologies, including BS 15978:2011, were developed for the reporting of the direct environmental impact of a product or asset. They cannot accommodate assessment of carbon implications at systems level, hence the need to integrate the BS methodology with the systems-thinking approach for emissions and removals within/beyond the project/programme boundary, as described in Clause 4 of PAS 2080.
- The PAS 2080 framework is intentionally simple to ensure that practitioners focus on decision-making without distractions from the requirements of detail and level of accuracy that may not be relevant in making the decision at the appropriate stage. Nevertheless, there is a good correspondence between the detailed LCA modules and the whole-life carbon at asset level – e.g. A1-A5 emissions are combined as part of 'capital emissions'.



Source: BS EN 15978:2011

Fig 4.2: Lifecycle stages of building works assessment

To exemplify the above, consider the construction of a new residential building. From the developer perspective, the following activities (non-exhaustive list) are examples of what forms part of the LCA considering a modular approach and PAS 2080 principles:

- **A1-A3:** sourcing and transportation of building materials; manufacturing of construction products; structural elements – reinforced concrete and structural timber; no significant land-use change emissions (only at masterplan level); sequestration from biogenic carbon in timber

- **A4:** transportation of materials/products to site
- **A5:** earthworks and site clearance; installation of ducts for water provision and wastewater drainage; installation of electrical and heating/cooling systems; landscaping of external works
- **B1-B7:** use of equipment and services for operating and maintaining the building, including the provision of heating, cooling, lighting, water, vertical transport, non-regulated energy; cleaning and repair, replacement or refurbishment of elements in the building; no significant removals
- **C1-C4:** removal of internal elements, such as furniture, fixtures, and cables; removal of internal structures, such as lifts, boilers and vent ducks; deconstruction, dismantling, demolition or set to repurpose of building structure/equipment; transport of waste to landfill or processing centre to be re-used or recycled; waste treatment of discarded material (e.g. landfill, incineration, energy from waste recovery); timber end-of-life emissions; no significant removals
- **D** (beyond the project/programme lifecycle): emissions associated with additional traffic in the road network and upgrades to substations/wastewater treatment plant due to the development; repurpose of building's core structure; re-use of construction materials; re-use of elements such as furniture or air conditioning units; recycling of cables and textiles; no significant removals

By combining the criteria and calculation methods outlined in BS EN 15978:2011 with the management principles of PAS 2080, whole-life carbon assessments of buildings can effectively influence decision-making and provide clear, relevant information for monitoring and reporting purposes.

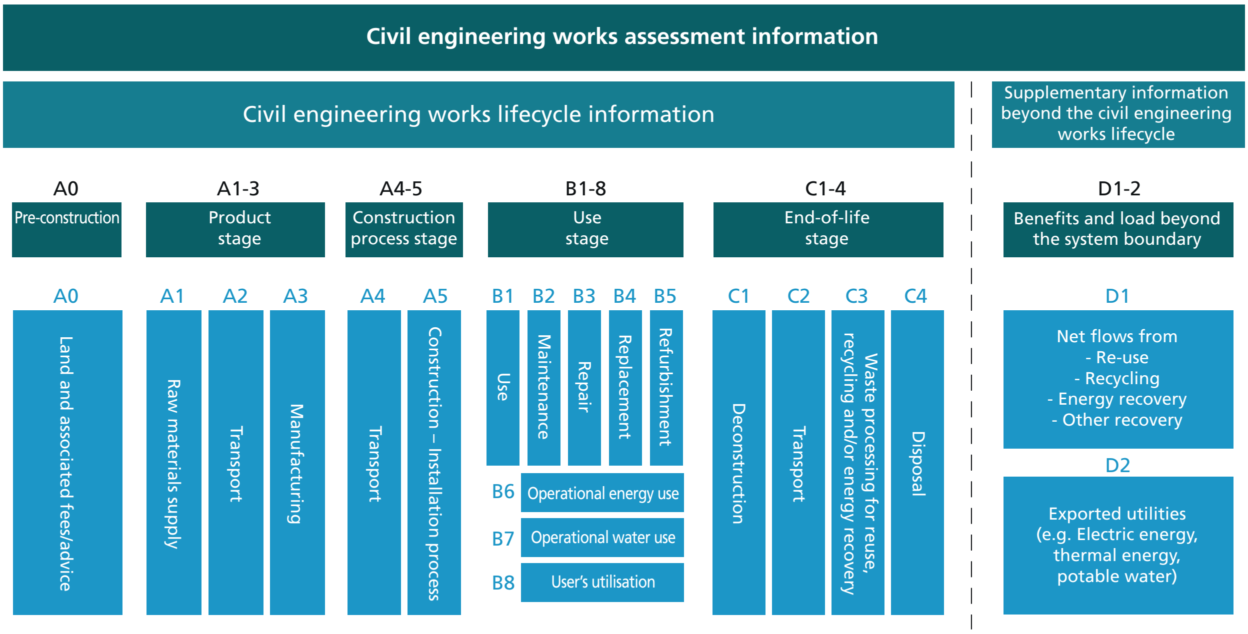
WORKED EXAMPLE 07b

Infrastructure carbon assessment following BS EN 17472:2022

BS EN 17472:2022 describes the specific methods, scenarios and criteria for the assessment of whole-life carbon emissions in infrastructure and civil engineering works, including considerations regarding data quality, cut-off rules, functional units, boundary setting and selection of data. It differs from ISO 21930:2017 (international LCA standard) as it has been developed to reflect the specificities and complexities of civil engineering works, such as additional functions, uses, lifespan and scale. For data sources of emissions factors, refer to worked example 7c (page 59).

Fig 4.3 (see page 58) has been extracted from the standard and reflects the lifecycle stages of civil engineering works assessment. In addition to the aspects described in the worked example 7a, the following should be considered when comparing it with PAS 2080's carbon management framework:

- The modular approach was developed for LCA reporting, whereas the PAS 2080 framework is for value-chain members to collaboratively decarbonise projects by identifying emissions/removals within their control and influence.
- Module D is not well-defined and is often omitted from the assessment boundaries. It includes materials and energy externalities, but not the interdependency of assets across a network.
- The importance of reporting emissions and removals separately to support decision-making (see worked example 10, page 66), as shown in the PAS 2080 framework.



Source: BS EN 17472:2022

Fig 4.3: Lifecycle stages of civil engineering works assessment

To exemplify the above, consider the power network supply of a new neighbourhood. From the developer perspective, the following activities (non-exhaustive list) are examples of what forms part of the lifecycle assessment considering a modular approach and PAS 2080 principles:

- **A0-A5:** earthworks associated with site clearance and trenching; sourcing and installation of ducts, cables, chambers etc; improvements to the local network (duct banks, transformers, feeder pillars, temporary equipment etc); no significant removals
- **B1-B7:** land-use changes due to new substations compared with original land use (e.g. greenfield area); losses to transmit and distribute (T&D) electricity; repair, replacement and refurbishment of electrical equipment; activities and resources to operate and maintain the substation and power network; no significant removals
- **B8:** electricity consumption of the development
- **C1-C4:** partial removal and disposal of ducts (considering most of them remain abandoned in the ground or are damaged during demolition, hence limited recycling opportunities); transport of waste to landfill or processing centre for re-use (where applicable); deconstruction of temporary equipment; no significant removals
- **D:** substation upgrades and T&D network extension (assumed owned and operated by others); no significant removals

WORKED EXAMPLE **07c**

Carbon assessment data sources and reference guides

Applying the worked examples to projects and programmes of work will require a range of different data sources and reference guides. It is important to highlight that data for whole-life carbon assessments consists of activity/asset data and sources of emissions factors. For the latter there are several databases available, while for the former there is a more limited set where actual industry benchmarks have been developed that could be used by value-chain members at the early stages where activity/asset data is limited.

Such benchmarks are more developed for buildings, as compared with infrastructure, and are mainly useful for comparing options at the initial stages of delivery. When setting targets in contracts during the design and delivery stages, it is important that value-chain members refine the detail of assessment using project-specific asset/activity data. This is a similar approach undertaken for costing.

Table 4.13 (below) provides a non-exhaustive list of emissions data sources, ranging from building-based benchmarks (e.g. accounting for both industry average activity/asset data and the relevant carbon emissions of such activities) to environmental product declarations (EPD) databases with their suitability to buildings and infrastructure projects noted. Some of these databases are open source, others not – as indicated in the table.

Reference name	Overview	Data type	Buildings	Infrastructure	Open source
UK Green Building Council (UKGBC) Net-zero carbon: energy performance targets for offices	UKGBC benchmark targets for commercial offices	Building benchmark targets	Yes	No	Yes
RIBA 2030 Climate Challenge Version 2 (2021)	RIBA benchmark targets for domestic and non-domestic buildings	Building benchmark targets	Yes	No	Yes
LETI Climate Emergency Design Guide	LETI benchmark targets for housing, schools and commercial offices	Building benchmark targets	Yes	No	Yes
LETI Climate Emergency Retrofit Guide	LETI benchmark targets for refurbishment projects	Building (retrofit) benchmark targets	Yes	No	Yes
Civil Engineering Standard Method of Measurement (CESMM4)	ICE CESMM4 provides an estimate of the cost and carbon emissions for a range of construction activities and processes. The emissions for each activity account for the materials using a cradle-to-gate boundary, i.e. emissions associated with the production of the material and a consideration of plant emissions in the construction processes (A1-A3 and A5).	Activity-based emissions factors	Yes	Yes	No

Table 4.13: Emissions data sources (continues next page)

Reference name	Overview	Data type	Buildings	Infrastructure	Open source
Department for Environment, Food & Rural Affairs (Defra): Enabling a Natural Capital Approach	A workbook that collates a wide range of UK natural capital and environmental valuation data sources, tools and studies	Sequestration data source	Yes	Yes	Yes
Rail Safety and Standards Board (RSSB) Rail Carbon Tool (RCT)	The RSSB RCT is an online carbon assessment tool primarily focused on carbon-baselining work in the rail industry. The tool uses the Inventory of Carbon and Energy database as its primary source of reference and includes a number of premodelled packages for commonly found rail infrastructure elements, e.g. permanent way, roads, bridges and drainage elements.	Material, fuel, transport and waste carbon factors and typical product carbon packages	No	Yes	Yes*
National Highways carbon emissions calculation tool	National Highways has a publicly available carbon-assessment tool. The tool provides a range of material carbon factors and some highways-specific product packages, e.g. road-lighting columns.	Material, fuel, transport and waste carbon factors and typical product carbon packages	No	Yes	Yes
Department for Business, Energy & Industrial Strategy (BEIS)/Defra: Greenhouse gas reporting: conversion factors	BEIS has published emission conversion factors for the purposes of company reporting each year. These include (but are not limited to) factors for fuel usage, transport and waste processing. These are seen as the industry standard for emission footprinting in the UK.	UK-based factors for fuel usage, transport and waste processing	Yes	Yes	Yes
British Research Establishment (BRE) Verified BS EN 15804 EPD	EPDs for specific products, with a range of modules	Product carbon factors (from EPDs)	Yes	Yes	Yes
Inventory of Carbon and Energy Embodied Carbon Database V3	This database includes a wide range of conversion factors to estimate the emissions associated with a wide range of commonly used construction materials. The factors are based on EPD data collected from a wide range of suppliers of each material category.	Material carbon factors	Yes	Yes	Yes

*Where used on Network Rail projects

Table 4.13 (continued)

Note: this table has a UK focus in terms of the data sources and factor sets. For further information on global data sources, refer to the Institution of Structural Engineers' How to Calculate Embodied Carbon guide.

WORKED EXAMPLE 08

Whole-life carbon assessment at the Design stage can drive whole-life reductions

The traditional separation of capital programmes from asset management and operations has encouraged value-engineering practices that minimise construction costs and, often, carbon. As capital expenditure and operational expenses are delinked, the relationship between asset/network geometry and optimisation of operations is often overlooked, sometimes with the unintended consequence of increasing the operational energy requirements, resulting in higher whole-life carbon overall.

The role of a designer is to devise an asset that is fit for purpose throughout its operational life. Most of the structures we are designing now will be operational in 2050 and beyond, in a resource-constrained, net-zero-carbon economy.

Take, for example, a railway tunnel, which is expensive to build. Making its diameter as small as practically possible will save excavation, concrete and steel and, hence, reduce the cost and carbon of construction. This is a value-engineering success, but one that may prove to be a false carbon and cost economy over its lifetime. Railway tunnels are built for trains to run through, so the engineering principles that govern their operational performance must be considered: aerodynamic drag is the dominant resistance that a train running at high speed through the tunnel must overcome – the so-called piston effect. The smaller the diameter, the more energy the train must expend to get through it. Even if the energy provision is decarbonised, it is still expensive in resource use and economically.

Research[3] demonstrates that the variance in capital cost from the larger tunnel diameter would be repaid within eight years by operating-cost savings, using 2017 energy prices and onward lower costs.

The capital carbon of the tunnels increases with tunnel length and diameter, but the operational energy to run the trains – and, hence, user carbon – is less for the increased diameter (see Fig 4.4, next page). Fig 4.5 (next page) details capital and operational carbon over the 20-year design life. The 9.75m-diameter tunnel has lower whole-life capital and operational carbon than the 8.75m-diameter tunnel, due to the greater operational carbon saving with a +1.0m diameter increase.

3 Pantelidou H, Stephenson S, Alexander J, Sturt R (2017) Designing tunnels for whole-life value, Railway Engineering railwayengineering.com doi: 10.25084/raileng.2017.0124

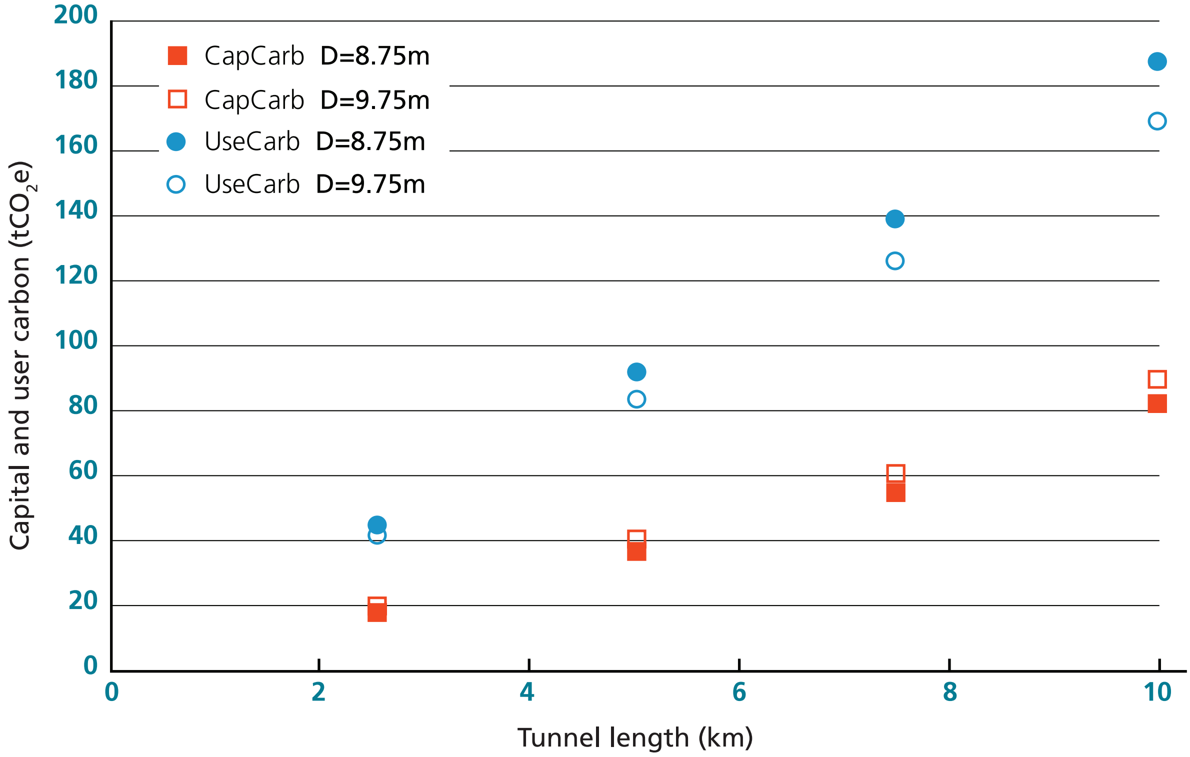


Fig 4.4: Capital and user carbon over 20 years for different tunnel diameters (assumed 14 high-speed trains per hour)

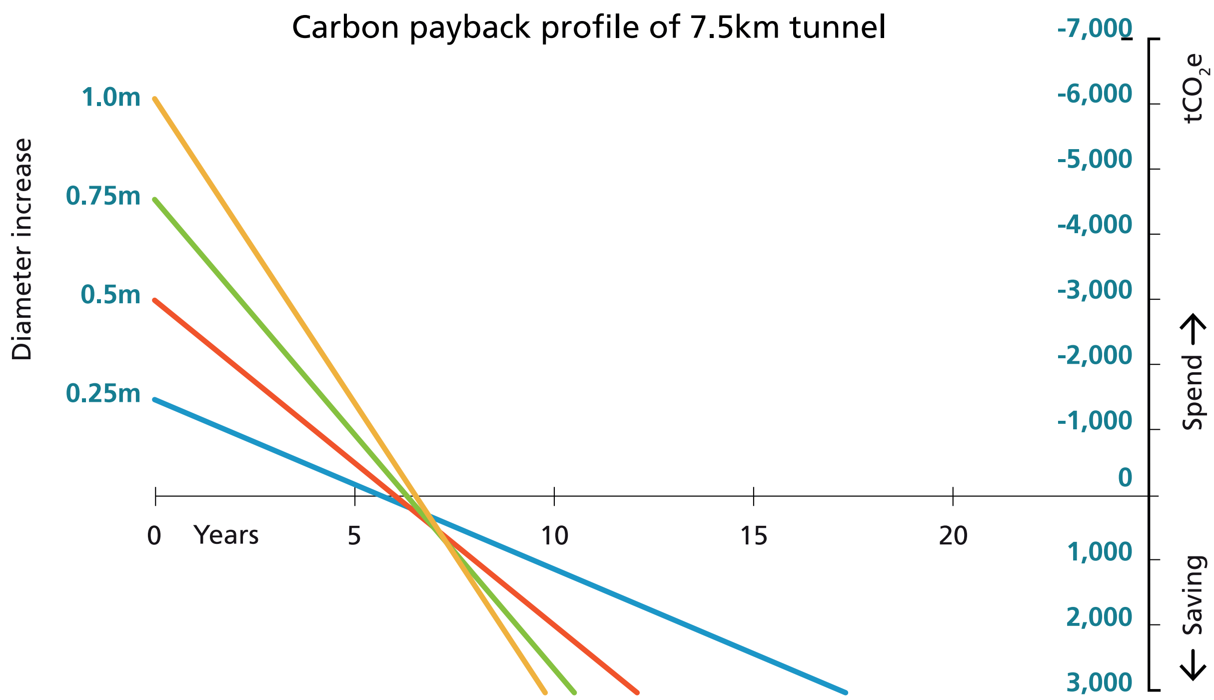


Fig 4.5: Payback of capital carbon for different tunnel diameter changes

Table 4.14: Calculation assumptions

Tunnel parameters:

The following details the tunnel parameters assumed for the carbon calculation.

Parameter	Value	Unit	Notes
Lining thickness	0.4	m	Assumed
Invert area	4.4	m^2	Ref: Carbon Insights
Steel fibre	35	kg/m^3	Assumed
London clay density	2040	kg/m^3	Assume London clay $20kN/m^3$

Carbon factors:

The following sections detail the material carbon factors (A1-A3), transport carbon factors (A4), waste factors (A5w), construction activity factors (A5a) and operational energy factors (B6) used in this calculation.

A1-A3

Material class	Select material	Details	Density kg/m^3	Embodied carbon ($kgCO_2e/kg$)	Notes
Concrete C40/50 - precast concrete unreinforced	Concrete C40/50	Average UK cement mix	2,400	0.178	IStructE Guide v2
Steel reinforcement	Steel	UK	7,800	0.76	IStructE Guide v2

A4

Material	A4 transport scenario	km by road
Concrete C40/50 - precast concrete unreinforced	Local	50
Steel reinforcement	European	1,500
Earthworks	Local	50

Reference: IStructE Guide v2

Transport (laden)	Input unit	Material type	Carbon factor ($kgCO_2e/kg.km$)
HGV	km	Energy and fuel	0.00010445
Rail	km	Energy and fuel	0.00002782
Ship	km	Energy and fuel	0.00001323
Average	**km**	**Energy and fuel**	**0.0000485**
Transport (unladen)	**Input unit**	**Material type**	**Carbon factor ($kgCO_2e/kg.km$)**
HGV	km	Energy and fuel	0.00078375
Rail	km	Energy and fuel	0
Ship	km	Energy and fuel	0
Average	**km**	**Energy and fuel**	**0.0002613**

Reference: National Highways Carbon Tool

A5w

Material class	Select material	Details	Waste rate standard (%)	Waste factor (WF)	Reference
Steel	Steel, Rebar	Steel, Rebar	5	0.053	IStructE Guide v2
Concrete	Concrete in situ		5	0.053	IStructE Guide v2

A5a

ECFA5a = CAEF x Project Cost/£100,000

Parameter	Value	Unit	Reference
CAEF	700	$kgCO_2e$/£100,000	Construction Activities Emissions Factor (CAEF) for superstructure and substructure, IStructE Guide v2

B6

Activity	Country	Unit	Year	Total kg CO_2e/unit	Reference
Electricity generated	Electricity: UK	kWh	2022	0.19338	BEIS GHG spreadsheet, UK Gov

WORKED EXAMPLE 09

Continual improvement and innovation

Continuous improvement is critical to achieving net-zero outcomes across the built environment (Clause 11). When an innovative approach to delivering a carbon reduction has been developed and embedded within a project or programme of works, it should become the base position for all future projects with similar characteristics.

For example, a designer for a highways project identifies a surfacing material and construction process that reduces whole-life carbon by 20% against the project baseline. The asset owner incorporates the material and process mitigations from project 1 as the base position for project 2, so it becomes business as usual, enabling new mitigations to be identified and embedded iteratively across further projects (see Table 4.15).

	Base position per KM (tCO_2e)	Mitigations embedded within design (tCO_2e)
Project 1	2,000	-400
Project 2	1,600	-150
Project 3	1,450	

Table 4.15

Similarly, as projects progress from design to construction, the realities of carbon impact will become more apparent. Processes should be put in place to ensure that these realities are communicated back to design teams, so they can be embedded in future projects and programmes of work.

By capturing innovative solutions and sharing them, new projects will benefit when entering the capital delivery process from that repository of ideas, embedding them in the baseline of future projects. Mitigations and outcomes achieved should be part of the base position for future projects and shared with the supply chain and other industries.

WORKED EXAMPLE 10

Reporting emissions and removals to support decision-making

Reporting is a fundamental aspect of the carbon management process. It allows asset owners/managers to demonstrate progress of projects and programmes of work against decarbonisation targets. Moreover, beyond the compliance process, reporting can provide insights for decision-making, particularly when GHG emissions and removals are reported separately – as shown in the PAS 2080 whole-life carbon management framework (Clause 4).

For instance, prioritising land-use change towards nature-based interventions (e.g. parks, wetlands and regenerative agriculture) in a new development project can only be assessed from a carbon perspective (i.e. sequestration rates, carbon reduction measures) if emissions and removals are reported separately as an overall balance. This is fundamental to properly compare options and justify the end solution.

Combined reporting of emissions and removals can also have unintended consequences. In a hypothetical scenario, bridges (or buildings) A and B can have the same overall emissions balance, but option B relies on greater removal measures to weigh against carbon-intensive materials. They are two distinct solutions that would be equally treated from a carbon perspective, were appropriate reporting measures not in place.

Therefore, just as the breakdown of income versus spend is crucial for cost management, differentiation between carbon emissions and removals is equally important to carbon management, providing clear information to allow decision-makers to prioritise projects that promote decarbonisation effectively.

WORKED EXAMPLE 11

Climate change requirements in procurement – NEC clause X29

NEC Contracts issued its secondary option X29 Climate Change clause in August 2022. This is intended to prompt asset owners/managers to include climate change requirements as a part of their project scope and set up a performance table with targets to track progress with incentives/penalties.

Table 4.16 (see page 67) provides guidance on how different members of the value chain can apply X29 at the different construction work stages of a project. It also shows how the climate change requirements of X29 align with the PAS clauses.

PAS terms/ requirements	Climate change requirements	Pre-tender	Tender process	Outline design	Delivery
Value chain members	Climate change partners	Identify key members of the value chain involved in the project/ programme of works Early contractor involvement	If there is any change in the contract, climate change partners to be updated Early major supplier involvement at pre-tender or tender stage (large savings can be made on innovation, material optimisation and transport distances)	If there is any change in the contract, climate change partners to be updated	If there is any change in the contract, climate change partners to be updated
Carbon management process	Climate change plan	Asset owner to include a climate change plan in the climate change requirement	Constructor to submit, either as part of a tender or after specified time after contract award, details of how they expect to meet climate change requirements Process or mechanisms for scheme-wide collaboration/innovation across the value chain must be formalised (including when multiple major contractors are required to deliver the scheme) e.g. innovation process, carbon cluster groups, carbon integration in design process	Constructor to submit, either as part of tender or after specified time after contract award, details of how they expect to meet climate change requirements	Constructor to follow climate change plan during construction
Baseline	Baseline	Establish baseline within the tender documents, either absolute (with enough granularity and transparency), or if the data is not available, based on industry guidance If possible, the constructor should be involved in the baseline so they are clear about assumptions/emission factors used Consider the percentage range of uncertainties around baselines and how this could affect the future performance table and monitoring	The constructor can challenge the baseline and asset owner to alter if required. Baseline to be agreed and closed out by contract award The asset owner and constructor should set out a change control process in the climate change plan Any identified discrepancies or agreed changes to baseline must be communicated promptly to all tenders	If there is a change of scope, the baseline should be updated	Constructor to monitor and report emissions against baseline If there is a change of scope the baseline should be updated A process should be in place to track material use ‘actuals’, not just as-built information
Targets	Targets	Set targets, written into the performance table – either full project absolute carbon targets or targets for specific components If unsure, use benchmarks or review and assess what savings are possible using technically feasible solutions in the market	The constructor can challenge the targets, within a time frame set by the asset owner Separate targets can be set for different value-chain members or phases, depending on contract type i.e. design and build, design, construction etc Separate targets created for specific components can allow release of incentives prior to project completion on large multi-year schemes	Put measures in place to monitor and record emissions	Constructor to monitor and report emissions with the aim of achieving or exceeding the target(s)

Table 4.16: Applying secondary option X29 to different work stages

PAS terms/ requirements	Climate change requirements	Pre-tender	Tender process	Outline design	Delivery
Assessment	Performance table	Highlight key performance metrics that will be measured and sit outside the scope, including positive incentives and shortcomings Performance metrics could be broken into components or time periods with incentives for each component	The parties agree the cost of incentives/ shorcomings in the performance table	Parties define how the constructor will measure and report against the key performance metrics	Constructor to monitor and report against the key performance metrics during construction
Monitoring and reporting		Climate change requirements should set out an expectation for clear timescales of monitoring and reporting (could be constructor measuring itself or appointing a third party)	Constructor responds as part of tender process within the climate change plan of what monitoring frequency and reporting require-ments are proportionate		Person responsible to monitor and report
Continual improvement		Baseline should have enough granularity to be continually updated when more accurate data becomes available from past projects etc. Climate change requirements set out the need to capture as-built data and use it to inform insights into future improvement A process should be in place at an organisational level for clients to adopt and scale best practice across multiple projects			As-built data must be collected to drive robustness of requirements on future projects

Table 4.16 continued

WORKED EXAMPLE 12

Considering impacts at end of life

The strength of combining the PAS 2080 whole-life carbon framework for decision-making, the PAS 2080 carbon management process and the principles of existing lifecycle assessment standards is that, by removing the focus on which value-chain member 'owns' which emissions sources, all value-chain members have a single source of information about the carbon emissions/removals in a project or programme across all delivery stages, and work collaboratively to reduce and manage carbon. That is, the focus is not on which value-chain member's Scope 1, 2 or 3 emissions a certain module might belong to, but instead on what emissions are attributable to the asset in question, the responsibility for which is shared by all value-chain members at different stages of the project or programme.

The revised PAS 2080 takes this a step further, in emphasising that value-chain members should aim to deliver the lowest-carbon outcome at system level through their projects and programmes. For example, at Need stage for a renewable energy developer, the best carbon outcome at system level might be to build a wind farm, even though this will increase the developer's own emissions, as well as the emissions attributable to the project.

Alternatively, for an industrial site producing materials, closing production may lower its attributional emissions, but it does not necessarily lead to carbon reduction at a planetary level if that steel is produced elsewhere in a less carbon-efficient way.

This principle is similarly relevant when an asset reaches the end-of-life stage. The revised PAS 2080 prompts the value-chain member to consider how that asset can most effectively be redeployed or re-used to support additional carbon reduction by avoiding the need to build something new.

What should be avoided is the claiming of carbon reductions or removals that could disincentivise this re-use. For example, there may be a case in which, from a purely attributional perspective, a value-chain member may consider demolishing or deconstructing an asset, accounting for any carbon removals associated with the carbonation of concrete and avoiding accounting for any carbon associated with refurbishment work.

However, if that asset were left standing, this could help to avoid the need for additional construction in the future (even if it doesn't save any emissions for the particular value-chain member). Again, choices should be based on what will deliver the lowest-carbon outcome at the system level.

05
Key enablers and accelerators

5.1 Introduction

PAS 2080 Clause 4 outlines the decarbonisation principles that underpin carbon integration into decision-making. Section 5 of the Guidance Document builds on these principles, focusing on the mechanisms that will accelerate the delivery of low-carbon outcomes across the built environment, i.e. the 'key enablers and accelerators' without which decarbonisation will continue to be sluggish.

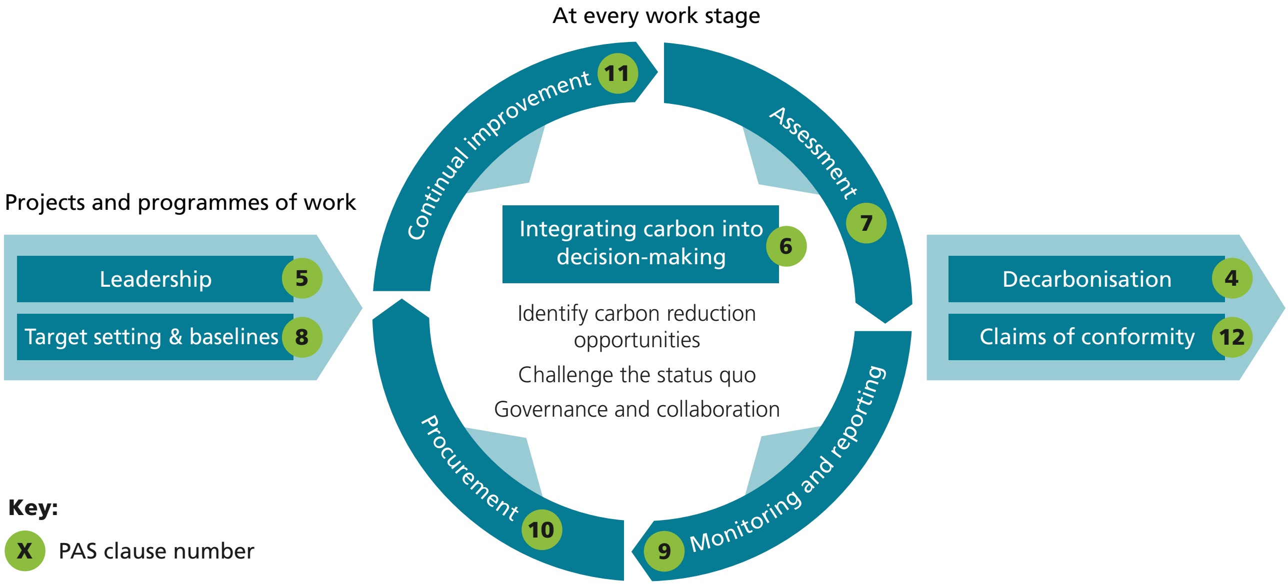
The first part of this section describes the maturity of organisations that are embarking on whole-life carbon management for transitioning to a net-zero carbon future.

Following this, guidance is provided on the leadership and value-chain collaboration required to accelerate progress, the need for consistency and transparency in the approach taken and the role of innovation in systems thinking, procuring and risk-sharing for a step change in decarbonisation efforts.

The Construction Leadership Council (CLC) and Green Construction Board (GCB) report assessing progress in the seven years since the Infrastructure Carbon Review (ICR) points out that systems thinking has been the missing link to meaningful decarbonisation. Section 4 described the need for upfront consideration during the early Need and Optioneering stages, including target-setting and baselining, to address the 'influence' of carbon opportunities (beyond the project boundary) and avoid unintended consequences across the system.

Decarbonisation enablers are relatively new concepts for the built environment industry and are continuously maturing and evolving. There is no complete and accurate guidance for their implementation, but they should be progressively developed. Continual improvement is necessary across all of them.

The following provides an explanation of each enabler, including industry examples for clarity. Fig 5.1 (see page 72) illustrates how these enablers map against the PAS 2080 clauses.



PAS clause	Enabler/accelerator in Guidance Document
Leadership (5)	Leadership (5.3.1)
	Systems thinking (5.3.3)
	Risk-based approaches (5.3.5)
Integration into decision-making (6)	Collaboration (5.3.2)
	Systems thinking (5.3.3)
	Risk-based approaches (5.3.5)
	Tools and data/consistency (5.3.6)
Assessment (7)	Tools and data/consistency (5.3.6)
Baseline and targets (8)	Systems thinking (5.3.3)
Monitoring and reporting (9)	Tools and data/consistency (5.3.6)
Procurement (10)	Procurement (5.3.4)
	Risk-based approaches (5.3.5)

Fig 5.1: Mapping enablers against the carbon management process

5.2 Maturity

Since the initial publication of PAS 2080, the CLC's and GCB's seven-years-on review recognised that different organisations in the value chain were at different levels of maturity for decarbonisation. Carbon maturity is defined as an assessment of a company's or organisation's level of competency in understanding and managing carbon emissions reduction.

Rather than a self-assessment exercise, maturity should focus on two main ideas: encouraging others in the value chain to follow the carbon management principles; and accelerating progress by focusing on the main enablers for the industry.

Carbon maturity requires ambition and involves innovation, risk-sharing and new procurement mechanisms, as well as new business models applied across the built environment. The PAS 2080 update recognises that everyone in the value chain will be gradually improving their carbon management maturity by demonstrating continual improvement – from large organisations down to smaller and more niche members of the value chain (e.g. SMEs) that can also bring significant decarbonisation benefits to projects and programmes of work.

There are many aspects to improving carbon maturity, from carbon data and improved data baselines to transformative behavioural changes and new ways of thinking (see Fig 5.2, page 74). The key enablers and accelerators to decarbonisation in the built environment described in this section must be embraced by all members of the value chain.

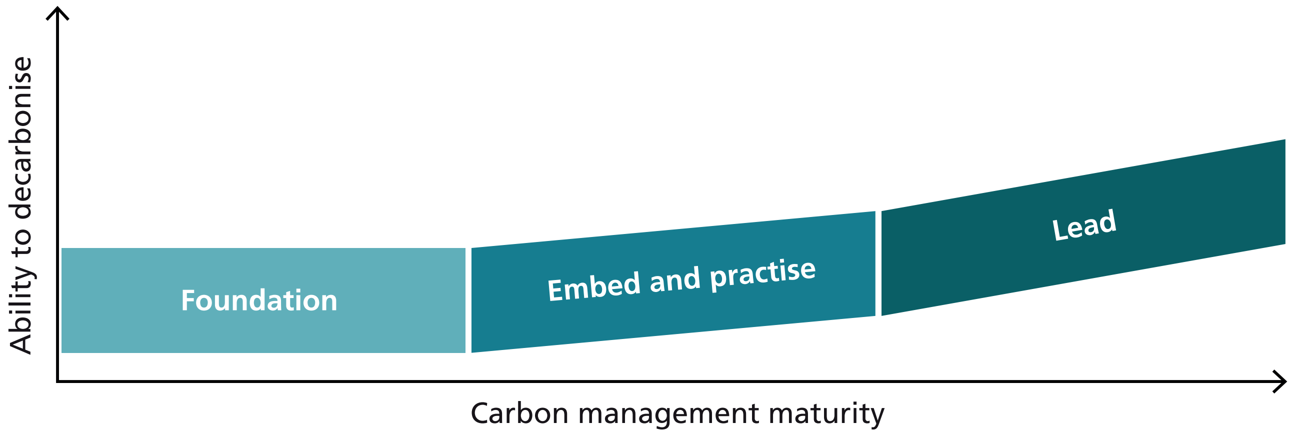
Fig 5.2 sets out three levels of maturity: *foundation*; *embed and practise*; and *lead*. These are aligned to the three levels originally set out in the ICR. As organisations progress in carbon maturity, their ability to control and influence the decarbonisation of projects and programmes increases.

At the *foundation* level, organisations have engaged their leadership, raised awareness and are championing carbon management among their practitioners. They are engaging with and requesting carbon data from their value chain. They understand the importance of setting baselines and targets, are assessing the carbon impacts of their projects and programmes of work, and are taking action to decarbonise solutions. They are building a culture of innovation to enable low-carbon solutions.

Organisations at the *embed and practise* level of maturity have set a vision and strategy for decarbonisation that is aligned to the net-zero transition. They understand the whole-life carbon emissions of projects and programmes that are within their control and influence. They are developing their capability for low-carbon solutions and are proactively encouraging or developing innovative approaches, technologies and products that result in whole-life carbon reduction across the value chain. They are implementing a process of continual improvement.

Leading organisations have embedded a culture of decarbonisation, which is a priority in all areas of planning, decision-making, procurement, governance and implementation of programmes and projects in the built environment. Target-setting, carbon assessment and carbon reduction are aligned with net-zero transition at the system level. Innovation is at the heart of the organisation. They have achieved strong collaboration across the value chain, with appropriate sharing of risk for carbon reduction, and continual improvement is evident.

Organisations at the lead level, and some at embed and practise level, will have achieved certification to PAS 2080 and are advocating for others in their value chain and across industry to do the same.



Foundation

- Initiate and adopt climate change (carbon and resilience) awareness campaign across the organisation
- Allocate carbon champion
- Put carbon on the agenda
- Assess carbon of projects and programmes of work
- Request capital and operational carbon data in purchased materials and services
- Identify actions for improving their decarbonisation impact

Embed and practise

- Vision and strategy for net-zero carbon transition published
- Developing capability and the right skills for decarbonisation solutions across all businesses
- Incentivise decarbonisation through procurement
- Understand the whole-life carbon in their control and influence
- Identify and avoid unintended whole-life carbon consequences
- Map their dependencies, synergies and collaboration potential for decarbonisation
- Proactively encourage services and products that result in whole-life carbon reduction
- Develop a continual decarbonisation improvement strategy

Lead

Decarbonising embedded in decision-making:

- Governance that helps unlock decarbonisation and implementation
- A culture of collaboration at industry and project levels
- A well-developed innovation implementation plan
- A decarbonisation-prioritised project and investment pipeline
- Mature procurement incentivisation of whole-life decarbonisation
- Risk-sharing for carbon reduction
- Baselines, target-setting and assessment methodologies aligned with systemic net-zero transition
- An established continual decarbinisation improvement process

Fig 5.2: Carbon maturity progression

5.3 Key enablers and accelerators for carbon management

5.3.1 Leadership (governance, organisational change)

Leadership should provide the vision and direction to drive carbon reductions across all levels of an organisation and ensure the right capability exists across the value chain. The commitment to decarbonisation should cascade from the board to the manager and practitioners at project or programme level, and is expected from all levels of the value chain (PAS Clause 5).

5.3.1.1 Vision and strategy

Each value-chain member should develop a clear vision and goals for reducing carbon in all of their activities (striving to be the leader in the market). New Zealand water utility company Watercare's 40:20:20 vision (see Section 6, page 88) is an example of the organisational change that was driven by these goals. Setting an organisational policy and strategy for carbon management with clear roles and responsibilities will help to align commercial/business goals with decarbonisation (Clause 5.1).

Asset owners/managers

Asset owners/managers must set specific carbon targets for projects and programmes of work and communicate roles, responsibilities and requirements to the value chain (Clauses 6-11). These individual targets should align with their network and system decarbonisation strategy. They should also inform the prioritisation of their capital and operational delivery pipeline, integrating decarbonisation in the commercial and delivery considerations of the organisation. The targets should be documented and used for claims of conformity (Clause 12). Asset owners should encourage the value chain by using relevant KPIs and financial incentives to recognise and reward opportunities for whole-life carbon reduction in their projects.

This approach is being trialled on projects that are being funded through UK, Welsh and Scottish Growth Deal finance. Both Ambition North Wales (a partnership between six local authorities, two universities and two further-education institutions responsible for delivery of the North Wales Growth Deal) and the Scottish Government have developed targets for carbon reduction and a robust methodology to ensure consistency of GHG quantification across the projects in their portfolios. The methodologies complement the HM Treasury business case process: ask projects to develop an understanding of the impacts beyond the project boundary and, critically, aim to ensure funding supports delivery of national and local carbon budgets and targets.

Other value-chain members

Similarly, all other value-chain members should promote a carbon reduction culture across their organisations to encourage collaboration with other value-chain members. This would support asset owner/managers' carbon goals, help to implement their requirements and constructively challenge the status quo to deliver low-carbon solutions at a systems level. They should also set a clear vision and guidance on requirements to their own supply chain to prioritise whole-life carbon reductions.

An example of how constructors can commit to net-zero emissions across their value chain is Skanska UK. Skanska estimated its supply-chain emissions using data collected from subcontractors and material suppliers. The data was then used to set an informed net-zero target (net zero by 2045).

The methodology has been made public on Skanska's website, which ensures transparency and accountability, supports consistency and facilitates knowledge-sharing across the industry.

Other examples where members further down the value chain (i.e. material suppliers) can take action in setting a clear vision for decarbonisation are the Green Construction Board's Low Carbon Concrete Routemap (LCCR) and the Climate Group's SteelZero project. Both initiatives are a collaboration of suppliers, contractors and consultants. Under the SteelZero initiative, members must commit to only procure, specify or stock 100% net-zero steel by 2050.

5.3.1.2 Building capability (empowering and upskilling)

Leaders at all levels (Clause 5), as well as practitioners, must continually communicate the importance of carbon management and empower members of their organisation and the value chain to take action on carbon reduction, encouraging them to influence others. Some methods of enabling and improving an organisation's carbon management capability include:

- Initially assigning responsibilities to members of the organisation to develop and implement the carbon management process, and eventually making carbon management normal practice for everyone in the organisation
- Knowledge-sharing and training/upskilling of climate change and carbon management principles. This could be achieved through outcome-based training initiatives and certifications relevant to the sector, discipline or skill set they are addressing – for example, at Transport for London (TfL), a Carbon Management Competency Scheme is being rolled out, enabling all staff to be more aware of their own expertise, democratising 'green skills' and improving staff mobility
- Rewarding efforts to drive down carbon emissions

5.3.1.3 Governance

Effective carbon management requires governance that ensures carbon reduction is prioritised in decision-making. The following should be an integral part of the organisation and project delivery:

- Clear communication of carbon priorities to the relevant disciplines and members of the value chain
- Robust processes for identifying decarbonisation opportunities
- Clear roles and responsibilities of those tasked with the review, prioritisation and implementation of such opportunities
- Enabling delivery teams to challenge existing technical and commercial standards/specifications and processes (where applicable) that could hinder implementation of whole-life decarbonisation and objective application of the carbon reduction hierarchy
- Encouraging the generation of ideas and prioritising innovation so it can be developed to maturity for implementation, accounting for the upfront capital and resource investment required and the need for different procurement incentives and risk allocation (see also subsection 5.3.5, page 82)

The decarbonisation governance should tie in with existing processes that are overarching across all directorates of the organisation, including commercial and quality strategies. TfL has aimed to incorporate carbon management and reduction at the heart of its decision-making: carbon has been integrated within its projects' risk-management processes, with risks being assigned a cost, schedule and carbon impact. Such integration of carbon into existing processes helps project managers to better understand their role in carbon management.

The governance structure set by an asset owner/manager must allow sufficient flexibility to encourage designers, constructors and product/material suppliers to demonstrate their capabilities and proactively put forward innovative ideas.

For the High Speed 2 (HS2) rail project to deliver on its strategic carbon reduction objectives, a transformative shift was required in how the business and its wider value chain thought, behaved and acted on carbon. The objectives included net zero by 2025 for its corporate activities and a target of 2035 for net-zero emissions from construction and operation. This required the creation of large-scale shared ownership of carbon reduction and elevating its status to that of cost, schedule and safety.

Every part of the business was included in a project to develop individual local carbon action plans, from HR to finance and procurement, engineering and delivery. Each team is responsible for driving and delivering its local plans, creating an ownership model for carbon that has shifted from dedicated environmental teams, with a holistic view gained on achieving net zero.

5.3.2 Collaboration

Meaningful decarbonisation is an enormous task for the built environment and society. It cannot be delivered by one organisation in isolation, monopolised for commercial advantage by individuals, or delegated down the value chain.

Fig 1 of the updated PAS 2080 reinforces the need for collaboration between members of the value chain to influence carbon reduction in the network/system of which they are part. Collaborations between different asset owners/managers can influence decarbonisation outcomes across the system, allowing for system-level carbon reduction considerations.

5.3.2.1 Industry-level collaboration

Traditionally, professional institutions, such as the ICE, the Institution of Structural Engineers (IStructE) and the Royal Institution of Chartered Surveyors, support their membership through offering professional qualifications, developing guidance, publishing papers, providing training, industry initiatives and so on. But there is also an increasing focus on accelerating decarbonisation through wider industry collaboration.

The World Green Building Council (WorldGBC) collaborated with the technical authors of PAS 2080 in aligning the buildings and infrastructure systems thinking for the Beyond Buildings positioning paper, making the case for an integrated approach to climate action.

In turn, its UK subsidiary (UKGBC) continued the national industry effort of updating the Net Zero Whole Life Carbon Roadmap for the Built Environment and made the commitment to regularly update it, including user emissions that were previously excluded.

Another example of an industry body facilitating collaboration across the building industry is the Royal Institute of British Architects' 2030 Climate Challenge. This initiative provides a set of phased targets for operational and embodied carbon through to 2030, based on the recommendations of the Green Construction Board and other industry bodies. The targets allow members of the value chain to benchmark performance, with the reassurance that projects are being delivered in line with a standard that allows for a realistic chance of net-zero carbon for all UK building stock by 2050.

The GCB brings together both government and industry representation with initiatives such as the creation of PAS 2080 and, now, its substantial revision. The GCB built on previous individual efforts from the Mineral Products Association (MPA), which developed a strategic roadmap for concrete to be net zero by 2050, by initiating the Low Carbon Concrete Routemap. This was largely achieved through collaboration between independent experts from across the value chain involved in specifying, designing, constructing and supplying materials for buildings and infrastructure.

The Routemap was launched jointly with the ICE in April 2022 and kickstarted the formation of the Concrete Decarbonisation Taskforce (CDT). Embracing the urgency to follow the commitments made by all of those involved, the CDT will prioritise, coordinate and lead in the areas recommended by the LCCR. The CDT is already supporting several workstreams initiated by the LCCR, including:

- Reviewing the existing BS 8500 Concrete guidance and specifications
- Introducing a new Flex Standard on concrete technology and decarbonisation – working with BSI, technical authoring started in February 2023 with a two-year programme to publication
- Addressing the issue of global supply of important materials, including the review of GGBS (ground-granulated blast-furnace slag) availability and global market analysis now and in the future, led by the IStructE
- Identifying additional funding for promoting new and important workstreams, such as concrete benchmarking

Another cross-sector, multi-organisation effort focuses on steel, the world's most widely used material and the biggest emitter of carbon globally. The SteelZero project, convened by the Climate Group and ResponsibleSteel, brings organisations together and requires signatories to agree to procure 50% low-emission steel by 2030 and 100% net-zero steel by 2050. Thus, it drives market demand for low-emission steel and speeds up the transition to a net-zero steel industry.

The collective power of client organisations, such as the Infrastructure Client Group in the UK, will be crucial in creating the right market conditions for increasing the speed of innovation and scaling up the uptake of decarbonisation opportunities, particularly where economies of scale and cost advantage are not present in the market.

Lastly, a key benefit for the sector from industry collaboration will be the sharing of carbon and performance data and benchmarks across the industry, as well as the removal of obstacles associated with commercial constraints, so that all value-chain members can benefit and quickly build their carbon maturity.

5.3.2.2 Collaboration at a project level

For a project or programme of work, the asset owner/manager should create a collaborative environment so that every member of the value chain can interrogate/challenge the scope and standards, and pursue innovative ideas for decarbonisation. This will also ensure consistency in the carbon management process. For example, Tarmac has run a series of engagement events with suppliers to develop practical and deliverable low-carbon solutions for its projects. This working group has been named the Decarbonisation Club, with collaboration actively encouraged throughout the value chain, notably including tier 3 suppliers and below (who contribute a significant portion of emissions).

The asset owner should encourage early engagement with designers, constructors and material/product suppliers, as well as with industry-wide initiatives (see subsection 5.3.2.1) so that knowledge, methodologies or new technologies for identifying decarbonisation solutions can be shared from the outset.

An example of this approach is the National Highways M42 J6 project, for which Skanska has developed and is trialling an alternative lower-carbon material for haul roads. Alkali-activated cementitious materials (AACMs), coupled with basalt reinforcement, are a significantly lower-carbon alternative to traditional reinforced concrete. Collaboration and expertise were required across the value chain – including National Highways, Skanska, the National Composites Centre (NCC) and supply-chain partners Basalt Technologies and Tarmac – to get the trial off the ground. It is estimated that the low-carbon concrete has a carbon footprint up to 80% lower than a standard CEM I concrete.

5.3.3 Systems thinking

Systems thinking has been the missing link to meaningful decarbonisation that is aligned with the net-zero carbon obligation.

As Section 4.1 explained, climate change and decarbonisation commitments are set at national level (for most nations), with some indication of apportionment at sector or geographical level. The majority of the built environment assets are already built into existing networks and systems that are highly carbon-emitting in their operation and use. Therefore, every new construction or retrofit must be considered as a capital carbon investment that enables a much bigger operational- and user-carbon reduction across the network and system of which it is a part, throughout its whole life. If not, every new capital project, even one deemed to be low-carbon, is simply adding to the problem.

The asset owner/manager, through collaboration with other stakeholders, operators of a system and value-chain members, where necessary, must look beyond the project boundary for associated emissions increases and reductions when assessing whole-life carbon at the strategic-need stage to avoid unintended consequences. The GHG assessment for HS2 is an example of how impacts beyond the project boundary are considered – specifically, how the introduction of HS2 Phase 1 will change the way people and freight will move around parts of England.

Guidance on how an asset owner/manager could approach systems thinking is provided below:

- **Step 1:** Define the required outcomes for the network and, where practicable, the wider system in collaboration with others with control and/or influence across the system.
- **Step 2:** Use the carbon reduction hierarchy (Clause 4) to assess high-level carbon-mitigation opportunities across the options to deliver this outcome, considering impacts at the system level. Building nothing may not always be optimal at a system level. For example, if a system consumes energy of high-carbon intensity, building a wind farm would lower the operational carbon of the system and result in net carbon benefits over building nothing.
- **Step 3:** Define a robust system boundary for assessing impacts, and communicate this to the value chain.
- **Step 4:** Once the system boundary has been set, define the system-level carbon reduction targets.

This novel approach is becoming part of decision-making. A research project, developed between the University of Sheffield and University College London, has modelled the whole-life carbon impact of different retrofit scenarios for a range of UK dwellings, considering the operational savings, as well as the embodied carbon impact of these retrofit measures. These scenarios are then reviewed against the Climate Change Committee’s carbon budgets. Several of the retrofit scenarios would not deliver system-level decarbonisation in line with the UK’s carbon budgets, providing an extremely valuable indication of the preferred retrofit options at scale that are compatible with the national net-zero transition.

The Environment Agency (EA) is also developing a systems-thinking approach to decarbonisation, improving its carbon management by factoring in the avoided emissions from reducing flood risk into the carbon assessment of a scheme. This approach was used on the Low Crosby Flood Risk Management scheme (see Section 6, page 104), whereby a systems-level approach was developed with local landowners to remove hard-engineering flood defences and reinstate a natural flood plain. The solution increases flood resilience, avoiding carbon from the construction of a hard flood-wall equivalent. It also naturalises this part of the flood plain, with the potential for carbon sequestration through the creation of biodiverse habitats that can thrive in the specific site conditions.

Anglian Water has also explored system-level decarbonisation. In one example, this involved working with regional stakeholders to unlock a nature-based solution for wastewater treatment, in the form of a wetland. In another example, waste heat from the sewer and treatment network is recovered to heat two of the UK's largest greenhouses, delivering an operational carbon footprint that is approximately 75% lower than a traditional hard-engineering equivalent.

5.3.4 Procurement

Procurement is the process of purchasing goods or services at every stage in the life of a project or programme of works. It needs to incentivise whole-life decarbonisation and penalise failure to make meaningful interventions. It must also avoid the risk of unintended consequences from setting relative carbon reduction targets against hypothetical baselines.

Procurement should aim to target and incentivise absolute whole-life carbon reduction. This should be in both the control and influence of the value chain, without relying on market offsetting.

A baseline is necessary in procurement for measurement of carbon performance. It must be meaningful and able to accommodate uncertainty and lack of detail in defining it. Procurement must discourage re-baselining throughout the project development, unless there is a substantial scope change. Since National Grid has been developing a greater consideration of carbon in its tendering process (see Section 6, page 109), it has found a strong correlation between cost and carbon reduction across its projects, achieved through establishing a baseline at contract award. It has also built decarbonisation commitments into contracts, with the specific terms and conditions developed in collaboration with its principal contractors.

Decarbonisation objectives should avoid conflict between carbon reduction and the traditional contractual requirements of cost and programme. Carbon reduction should not be treated as another KPI with lesser or equal footing against other commercial criteria. Instead, it should be the overarching obligation without which the project risks failing to achieve its objectives and, thus, not reflecting the climate emergency or urgency for decarbonisation.

Several projects are starting to trial this approach. The HS2 Phase 1 contracts were the first on a major project to include a contractual obligation for a 50% carbon reduction against a business-as-usual baseline. Also, the contract for the Cross Tay Link Road in Scotland has been awarded with a KPI to reduce carbon by more than 30% from the tender-award baseline. In both cases, failure to meet these targets will result in penalties and may affect any opportunities to work with the client again.

Understanding the levers that can be used for decarbonisation in procurement is important. Assigning a monetary value to carbon is often the way to create incentives, but this value must reflect the true cost of climate inaction – that is, the cost of providing increased resilience for unmitigated climate change impact. There is no universally agreed value for carbon tax in construction. In the UK, the Green Book[4] recommends values in the order of £245/tCO_2e on average, rising to £378/tCO_2e in 2050. A wide range of values exists nationally and internationally.

Challenging scope and technical specifications and standards for maximising decarbonisation should also be encouraged by procurement – as should efforts for collaboration.

5.3.5 Risk-based approaches

We cannot achieve decarbonisation by planning, designing, constructing and operating the built environment in the way it has always been done (as in the quote attributed to Einstein: "Insanity is doing the same thing over and over and expecting different results").

As an industry, we should regularly examine and adopt more risk-based approaches and challenge existing practices. Innovating, challenging the standards and changing traditional practices are necessary, but the risk is higher of not meeting performance requirements or simply reducing the existing performance when repurposing existing assets. Improving risk understanding and putting systems in place to manage risk appropriately across the value chain is essential.

5.3.5.1 Evolution from traditional delivery

Traditional engineering standards are often prescriptive and may encourage conservative approaches that are likely to result in high-carbon impacts. The impact of traditional requirements on whole-life cost and carbon should be considered. This requires a complete change of project delivery models, including the definition and monitoring of performance against safety and serviceability. Encouraging design for whole-life value and challenging conservative standards could result in carbon savings across the operational life of an asset/building and the system of which it is a part.

4 Valuation of energy use and greenhouse gas emissions (publishing.service.gov.uk); Para 3.34 and Box 3.7

A risk-based approach to design and construction could overcome this. Such methodologies already exist, but are not often adopted. As an example, in response to recognising the challenge and risk of re-using concrete structures, the Concrete Centre published guidance on fire performance assessments for structures intended for re-use.

5.3.5.2 Risk and innovation

Adoption of innovation in design and construction is very slow, largely owing to the increased risk and uncertainty that innovation brings.

A change in the understanding and definition of risk and the approach to risk-sharing and management across the value chain, mainly through procurement mechanisms, will be important for accelerating decarbonisation. By promoting delivery models that share risk and reward for low-carbon solutions, the risks associated with the implementation of innovative ideas will be balanced and mitigated within projects and programmes of work.

A risk-sharing approach between the regulator and Yorkshire Water for the Clifton Wetlands wastewater treatment project was used to achieve optimal performance of the wetlands as it matures, in terms of cost and carbon (see Section 6, page 111). Also, an innovative approach to the identification of risks to the Digley Reservoir (see Section 6, page 112) was undertaken by Mott MacDonald Bentley (MMB) and Yorkshire Water through new monitoring technology, which reduced carbon-intensive capital maintenance works.

5.3.5.3 Systems-level risks

Management of risk should be supported by systems thinking and benefit management assessment to allow a better understanding of uncertainties and trade-offs. Table A.2 in Annex A of PAS 2080 presents examples of cross-sectoral, system-level whole-life carbon implications.

5.3.6 Tools and data/consistency

Digital tools can ensure consistency, automate repetitive tasks in quantification and reporting, act as dashboards for ease of optioneering, and facilitate benchmarking and data manipulation. These are all essential ingredients in the carbon management process.

The tools must be appropriate for the granularity and level of accuracy required at the relevant stage of project development and must be able to inform decision-making through compatibility with tools and processes applied during project development.

Although Scope 1, 2 and 3 reporting frameworks and associated tools are well established, they are unable to inform decision-making processes to facilitate reductions in the capital or operational carbon of a project or programme of works. They lack the level of granularity required to optimise the construction or performance of an asset. Similarly, established lifecycle assessment standards, methodologies and tools are useful for reporting whole-life carbon construction and operation modules, but are poor for providing an understanding of whole-life carbon implications at network and system levels.

Transparency and consistency in assumptions, emissions factors and gap analyses across a project's lifecycle are critical to ensuring an accurate comparison against baselines for achieving targets. Tools should also provide the means for capturing data that can be fed back into future projects to drive continuous improvement.

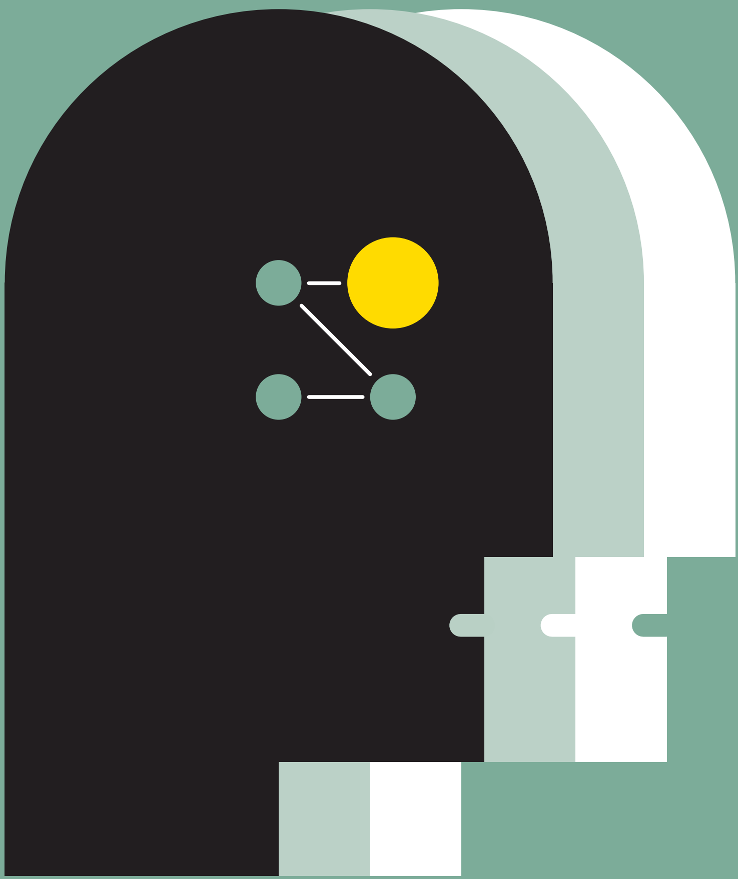
Practitioners should ensure that the tools adopted are consistent with the requirements of the project and are in accordance with Clause 7 of PAS 2080. This includes consideration of the study boundary and data quality. Examples of tools that can be used include:

- **Systems-level tools** The NATURE Tool (see Section 6, page 114), initiated by engineering consultancy WSP, can be used to assess the impacts of a proposed project on natural capital across the ecosystem and identifies health-benefit opportunities. It can also demonstrate whether net gains from the environment are likely to be achieved to help inform early-stage decision-making.
- **Material-specific tools** The CARES Cloud platform (see Section 6, page 113) publishes third party-verified, product-conformity and global warming-potential data from producers of reinforcement-bar and structural steels, available to the value chain to enhance data consistency.
- **Baseline tools** Used to provide high-level benchmarking at early work stages for optioneering. These tools can use graphics to visualise performance and identify carbon hotspots to guide reduction efforts. They can be aligned with existing cost-estimating tools and have the functionality to be updated to provide a more detailed quantification as improved data becomes available at later work stages.
- **BIM software** If the underlying emissions data is incorporated into digital design models for different products and materials, BIM (building information modelling) software can be used for GHG assessments and to rapidly identify carbon hotspots, test different designs and appraise alternative material options. Such tools are unlikely to be appropriate for early optioneering and are more suited to detailed stages of design and construction.
- **Construction-specific tools** Once a project is suitably detailed (for example, having a bill of quantities developed), these tools can be used to produce bottom-up assessments, which enable carbon requirements to be embedded into procurement requirements for product/material suppliers and for the tracking of carbon performance across construction.

- **In-house tools** Organisations can develop in-house tools tailored to meet specific design and reporting requirements (e.g. templates) and business processes. All Environment Agency projects subject to the Construction Design and Management Regulations must complete a whole-life carbon assessment using the EA's Eric tool (see Section 6, page 115) and carbon impact tools, which facilitate top-down assessments at early project work stages and bottom-up assessments at more detailed project work stages.
- **Sector-specific tools** These can aid consistency in assessment, knowledge transfer and peer comparison and improvement. Examples include the UK Water Industry Research Carbon Accounting Workbook and the Rail Carbon Tool. Grimshaw Architects' Energy Cost Metric tool provided a new way to objectively evaluate the whole-life energy savings and associated cost for different design strategies to establish the best value for the Civil Engineering Building project at the University of Cambridge.

It is important that tools are adaptable to the continual improvement process, including having the means to update emissions factors (from product, material and process) to reflect improvements, as well as to adapt assumptions/reference designs when more data (e.g. as-built information) becomes available.

06
Case studies



LEADERSHIP CASE STUDIES

01
LEADERSHIP CASE STUDY

Commitment to decarbonisation across the full supply chain

Actor: **Skanska UK**
Project: **Skanska UK Net Zero 2045**

In 2019, Skanska UK made a public commitment to achieve net-zero carbon emissions by 2045, aiming to achieve carbon neutrality across its operations without resorting to carbon offsetting schemes. This is supported by phased decarbonisation targets:

- An absolute reduction of 50% by 2030 (from a 2010 baseline)
- A carbon intensity reduction to 130 tonnes per £1m invested by 2030 (a reduction of more than half, compared with 2010)

Critically, this target encompasses Skanska's full supply chain. Skanska estimated its supply-chain emissions using data collected from subcontractors and material suppliers. Emissions from fuel use, electricity use, materials and waste were calculated using industry-recognised carbon factors.

This was carried out for every year since 2010. Skanska repeats this exercise annually and the methodology has been made public on its website. This ensures transparency, supports consistency and facilitates knowledge-sharing across the industry. The methodology includes an approach to gap-filling, with estimates being used, as opposed to emissions not being reported. This drives a continual-improvement approach, with each iteration improving on previous estimates.

Skanska found that the estimated emissions from its supply chain were 10 times higher than previously reported direct emissions. In 2018, Skanska's direct emissions were 35,000 tCO_2e. This compares with its supply-chain emissions of 378,000 tCO_2e. By including emissions from its whole supply chain, Skanska is able to develop a more informed route map to net zero, while highlighting the challenge facing the industry.

02
LEADERSHIP CASE STUDY

Shared ownership of decarbonisation

Actor: **Watercare Services Ltd (New Zealand's largest water utility company)**
Project: **Watercare 40:20:20 vision**

Auckland's water and wastewater service provider Watercare has created a carbon-centric approach to investment decisions under its strategic Enterprise Model for infrastructure delivery. The company will spend NZ$18.5bn (£9.6bn) upgrading and building new infrastructure over the next 20 years, as Auckland's population of 1.7 million is forecast to grow by more than half a million people. The Watercare 40:20:20 vision outlines three complementary targets for the company and its supply chain:

- 40% reduction in carbon emissions from construction by 2024
- 20% reduction in cost of construction by 2024
- 20% year-on-year improvement in wellbeing, health and safety

The Enterprise Model was created to transform the infrastructure delivery approach, which required a behavioural step change within Watercare and its supply chain to meet this vision. Driven by a collective ownership of the full works programme by Watercare and its partners, the model financially incentivises its partners to work towards the vision.

This incentive programme helps to bring the entire enterprise partnership together. They will succeed or fail as one because the scale of reward relates to the effectiveness of the collective enterprise. Constructors have a genuine interest in the performance of carbon-saving measures in feasibility and design, while designers are seeking repeatable lessons learnt and innovations through construction. Throughout the value proposition, leveraging technology and carbon leadership from supply-chain partners is a prime objective.

Key steps in the Watercare carbon reduction programme include:

- Baselining the present state: creating a carbon baseline to provide a starting block and a set of metrics to apportion targets, measure progress and develop knowledge, so that the enterprise can become more adept at assessing trade-offs and making investment calls.

- Starting early: using higher-level carbon assessments and immediate action in lieu of more granular detail and inertia. It is accepted that capability will be continually developed over time as the enterprise matures, but immediate action is prioritised.
- Getting everyone on board: establishing a collaborative culture at the outset was crucial, and partner engagement was assessed on alignment with the 40:20:20 vision. This is enhanced through the incentives programme. The benefits of this open collaboration include an improved ability to leverage the collective knowledge of the supply chain to achieve significant long-term carbon reductions.
- Embedding carbon outcomes as 'business as usual': instead of relying on sustainability experts, carbon savings need to become everybody's responsibility. To ensure everyone takes ownership of their role in achieving carbon savings, a conscious effort is needed to embed carbon assessments in every project's business case and approval process. Everybody involved – from those working onsite, to decision-makers and the board – needs to be familiar with these goals.
- Establishing routines: Watercare developed structured collaborative workshops with the enterprise partners at the most influential feasibility phases, to help guide the outcomes in line with the carbon reduction hierarchy in PAS 2080. These are dynamic environments that encourage challenging the status quo before core topics are closed out. Success is derived from the collective input of stakeholders – planners, designers, constructors, operators and customers. Carbon reduction can then be considered collaboratively at every step of the delivery process.

Watercare has adopted the Moata Carbon Portal assessment tool (developed by Mott MacDonald UK and then calibrated for the New Zealand infrastructure environment) to act as a single source of truth and as a dynamic comparative assessment tool to reconcile alternatives and ideas in near-real time.

Applying the collaborative Enterprise Model approach to the Hunua 4 watermain extension project, Watercare evaluated five options – and selected the one that reduced carbon by 38% and forecast a capital-cost reduction of 15% against the project baseline.

The focus on reducing the carbon footprint from both construction and operations is transforming infrastructure delivery and helping Watercare and New Zealand to achieve their emissions targets.

03
LEADERSHIP CASE STUDY

Delivering Growth Deal investment in line with national and regional carbon budgets: Wales

Actor: **Ambition North Wales**
Project: **Reducing carbon emissions and improving biodiversity in Growth Deal projects**

Ambition North Wales is a partnership between six local authorities, two universities and two further-education institutions, which are responsible for delivery of the North Wales Growth Deal. The UK and Welsh governments have each invested £120m (£240m total), and Ambition North Wales is tasked with delivering a total investment package of £1bn in the region over the next 10-15 years.

Projects are being developed across key growth areas: agri-food and tourism, high-value manufacturing, digital connectivity, land and property, and low-carbon energy. The goal is to build a more vibrant, sustainable and resilient economy in North Wales. Within the boundary of a project, Ambition North Wales understands the investment will have a carbon impact that could affect regional and national targets. To limit this, it has set targets for project teams (and their value chains) for: net-zero operational carbon; 40% less embodied carbon from the project's preferred option baseline at outline business case (OBC); and a 10% net gain for biodiversity.

To support project teams, and to ensure a consistent approach across all projects, Ambition North Wales has developed an assessment methodology for project teams to follow. Its purpose is to give step-by-step guidance for each Growth Deal project to set an assessment boundary, quantify a baseline and reduce overall impact. It is structured according to HM Treasury business-case development stages and complements the Green Book economic appraisal approach.

At each business-case stage, carbon and biodiversity assessments will be undertaken. In the early stages, these assessments are more qualitative, becoming more rigorous and quantitative as the project design takes shape. Importantly, they ask projects to develop an understanding of the impacts beyond the project boundary – with a formal project baseline being completed by the OBC.

The application of the methodology is still in its infancy and is currently being rolled out across the full portfolio of projects. Therefore, its effectiveness in delivering portfolio-wide carbon reduction is still to be tested. However, the approach taken demonstrates excellent leadership from Ambition North Wales in application of core decarbonisation principles.

04
LEADERSHIP CASE STUDY

Delivering Growth Deal investment in line with national and regional carbon budgets: Scotland

Actor: **Scottish Government**
Project: **Scottish Government City Deals**

The Scottish Government has committed £1.9bn to 12 City Region and Growth Deals encompassing the whole of Scotland. The intention of these deals is to empower regional partners to support long-term, sustainable economic growth across a range of themes, including innovation, tourism and culture, housing and transport. They comprise 200 mostly capital projects, delivered with local authorities and other regional partners, including higher and further education, enterprise agencies and the voluntary and private sectors. Co-funding is provided by regional partners and the UK Government, bringing total investment across Scotland to £5bn.

The deals provided the ideal mechanism to develop new carbon management requirements to ensure that all projects were designed, constructed and operated in accordance with Scotland's Climate Change Plan.

To ensure alignment with national net-zero targets and whole-life carbon business-case requirements in the UK Treasury's Green Book, the Scottish Government developed a new carbon management system. This includes a step-by-step guide enabling all deal-funded projects to first understand – and then take action to minimise – their whole-life carbon emissions. Central to this approach was the implementation of PAS 2080 across all projects, ensuring that whole-life carbon was considered from the earliest project stage.

A key concept within the PAS 2080 framework is the distinction between 'control' and 'influence'. This has been expanded in the Scottish Deals guidance to allow the rapid categorisation of projects according to their compatibility with Scotland's Climate Change Plan. This proportionate combination of qualitative and quantitative carbon management has been well received by all stakeholders across the UK and is being recognised as an emerging form of 'net-zero test'.

Recognising the variability in whole-life carbon management services across all sectors, the Scottish Government's Deals approach includes ongoing training and support for all stakeholders to ensure the successful uptake of PAS 2080 and its core principles. By using PAS 2080, it is proving possible to show that new infrastructure can be developed while simultaneously addressing the climate emergency.

05
LEADERSHIP CASE STUDY

Increasing awareness of carbon management on projects

Actor: **Transport for London (TfL)**
Project: **Carbon Management Training Suite and integrating carbon as a project risk**

TfL is exploring different ways to build expertise on decarbonisation, carbon management and the integration of carbon into decision-making. As part of this initiative, it is rolling out a Carbon Management Training Suite: an internal set of training modules and accreditation of carbon management competency, taking project staff from 'awareness' up to 'expert'. An expert-level practitioner with experience will be able to create internal carbon standards, manage carbon at a system level and produce carbon assessments independently.

The suite is available to all staff – engineers; project managers; sponsors; safety, health and environment (SHE) business partners; and risk managers – and will enable wider awareness of expertise, democratise 'green skills' and improve staff mobility.

Alongside internal training programmes, TfL has been trialling a range of decarbonisation initiatives on projects. One involved the Piccadilly Line upgrade, a multibillion-pound programme supporting the introduction of new rolling stock to the London Underground service. At project inception, the lack of carbon management was highlighted as a programme risk. To address this issue, carbon has been integrated within the programme risks and the project's risk-management process, with risks being assigned a cost, schedule and carbon impact.

More widely, the TfL decarbonisation initiative involves:

- Projects identifying carbon hotspots from whole-life carbon assessments
- Workshops to discuss quantified carbon reduction opportunities and threats in response to their hotspots and the carbon impacts of existing risks in project registers
- The carbon impacts of the risks being quantified and entered in the project's risk register. These are reviewed continually at workshops, alongside cost and schedule risks

Integrating carbon opportunities and threats into project risk-management systems has resulted in greater awareness of carbon management, helping project managers to better understand their role in reducing carbon and relating this to cost and schedule.

06
LEADERSHIP CASE STUDY

Organisational change on a large infrastructure project

Actors: **High Speed Rail 2 (HS2 Ltd) and Arup**
Project: **High Speed 2**

HS2, the UK's new high-speed railway, is under construction. It has more than 350 active sites between the West Midlands and London. HS2's Environmental Sustainability Vision includes:

- Using zero-carbon electricity generation to power trains
- Carbon emissions from construction and operation to be eliminated or offset from 2035
- From 2025, HS2 Ltd will offset the residual emissions from its corporate activities

To achieve the Environmental Sustainability Vision efficiently, and to deliver its Net Zero Carbon Plan objectives effectively, HS2 Ltd recognised the need for a transformative shift in how the business and its wider value chain thought, behaved and acted on carbon. This meant creating large-scale shared ownership of carbon reduction and elevating its status to that of cost, schedule and safety.

To turn ambition into action, HS2 Ltd and Arup supported teams across all areas of the business to develop carbon action plans outlining how their part of the business would contribute to the delivery of the Net Zero Carbon Plan objectives. Every part of the business is included, from HR, finance and procurement to engineering and delivery teams. Each team is responsible for driving and delivering their local plans.

Leadership and team briefings, in-depth exploratory interviews and action-planning workshops empowered people to put forward their ideas on what the net-zero carbon objectives meant to their team and individually. HS2 Ltd also set up the governance and leadership to hold each other to account on delivery, with plans endorsed at executive level and a dedicated cross-disciplinary net-zero carbon steering group established.

Central to the action-planning approach was organisational change. Team plans identified the organisational, social and technical systems that were acting as blockers or enablers to systemic carbon reduction. The approach resulted in comprehensive team plans that explored not just the technical solutions to carbon reduction, but how to set up effectively as an organisation to mobilise people and drive action at scale.

COLLABORATION CASE STUDIES

01
COLLABORATION CASE STUDY

Industry collaboration develops net-zero route map for built environment

Actor: **UK Green Building Council (UKGBC)**
Project: **UKGBC net-zero roadmap**

The UKGBC was launched in 2007 by the construction and property industry to offer sector leadership, to campaign for a sustainable built environment and to provide a framework for industry collaboration. More than 750 organisations from all parts of the built environment value chain are UKGBC members. In 2021, UKGBC developed the Net Zero Whole Life Carbon Roadmap.

The purpose of the roadmap was to: build consensus on a pathway towards net zero among business and industry bodies; identify key interventions and critical interdependencies; develop sectoral carbon targets (and the actors, owners and processes needed to achieve these targets); identify policy recommendations for supporting, incentivising and regulating carbon reduction measures; and encourage consistency between sectors.

UKGBC appointed Arup and Dr Jannik Giesekam, from the Centre for Research into Energy Demand Solutions, to deliver the whole-life carbon analysis as technical partners. The roadmap was developed by a steering group and four task groups, which focused on new-build, domestic retrofit, non-domestic retrofit and infrastructure. All of the groups comprised representatives from commercial organisations, professional institutions and other key sector bodies.

Through workshops, the task groups developed the carbon trajectory and proposals for policy and industry, working with technical partners. A formal consultation was undertaken on the draft proposals, alongside engagement with government, local authorities, industry stakeholders and the Climate Change Committee.

The roadmap elements include a carbon footprint for the UK built environment, a net-zero trajectory to 2050, and policy recommendations with industry action plans to deliver the 2050 scenario. These are available online in four reports.

02
COLLABORATION CASE STUDY

Industry collaboration develops concrete and cement net-zero roadmap

Actors: **Mineral Products Association (MPA), Institution of Civil Engineers (ICE) and Green Construction Board (GCB)**
Projects: **MPA UK Concrete and Cement Industry Roadmap to Beyond Net Zero and ICE/GCB Low Carbon Concrete Routemap**

The MPA is the industry trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and silica sand industries. In 2020, in collaboration with all members across the UK concrete and cement industry, it published its Roadmap to Beyond Net Zero. This explored how different 'technology levers' could contribute to the decarbonisation of the concrete and cement industry by 2050 through technical innovation in material manufacturing and process innovation via the application and scale-up of carbon capture, usage and storage (CCUS) technologies.

The MPA has built on this collaborative roadmap to successfully apply for government funding for innovation projects that demonstrate the sector-wide commitment to achieving net zero. The funding has enabled the production and testing of low-carbon cements and concretes, and the development of a net-zero fuel mix of hydrogen, biomass and electrification for cement production. This is an example of how 'roadmap in action' projects enable accelerated deployment of new technologies.

The ICE's and GCB's Low Carbon Concrete Routemap, meanwhile, sets out its proposals across seven strands. The first focuses on how to benchmark the carbon in concrete. Strands 2, 3 and 4 relate to the use of concrete, while strands 5, 6 and 7 relate to the production of concrete. Each strand is accompanied by a case study that provides a tangible example of best practice.

The routemap ends with a set of 'next steps' with a specific timeline. It has been endorsed by major actors in the industry and across the value chain, including the Construction Leadership Council, IStructE and the MPA.

03
COLLABORATION CASE STUDY

SteelZero collaboration drives market demand for low-emission construction steels

Actor: **CARES**
Project: **SteelZero**

The SteelZero project is a global, multi-stakeholder initiative that brings together leading infrastructure organisations to speed up the transition to a net-zero steel industry. Convened by the Climate Group and ResponsibleSteel, its construction and property working group is a collaboration between steel-makers, contractors and clients to drive market demand for low-emission steel.

CARES (Certification Authority for Reinforcing Steels) is an associate member and participant in the working group, as well as being an approved certification body for ResponsibleSteel. It offers a bridge between clients, contractors and producers. SteelZero requires signatories to agree to procure, specify or stock 50% low-emission steel by 2030 and 100% net-zero steel by 2050. It also encourages interim targets to 2030. The low-emission steel definition aligns to Version 2.0 of the ResponsibleSteel International Standard. The SteelZero framework provides a consistent approach to targeting, definitions and opportunities to share how the construction value chain can work together to share relevant information.

CARES is supporting the SteelZero initiative through its decarbonisation work within its sustainable constructional steels (SCS) scheme, which includes mandatory lifecycle assessment, resulting in an EN 15804-compliant, third-party verified environmental product declaration (EPD) for constructional steel products. Global warming potential per tonne of steel is published within the EPD and is publicly available to support this process, including in a digital format through the CARES Cloud digital chain.

Using the SteelZero framework, clients and contractors can adopt reduction targets, ask steel suppliers for relevant data and procure low-emission steels. This supports the steel industry business case to invest in decarbonisation and accelerates the production of lower-emission steels.

04
COLLABORATION CASE STUDY

A collaborative industry-level initiative to facilitate outcome-oriented design

Actor: **Royal Institute of British Architects (RIBA)**
Project: **RIBA 2030 Climate Challenge**

RIBA has developed a 2030 Climate Challenge that includes a set of voluntary performance targets for operational energy use, water use and embodied carbon. These targets were developed in consultation with other professional UK construction bodies, including the Green Construction Board. The targets aim to support the industry in the delivery of a net-zero building sector by 2050 through a quantifiable reduction trajectory through to 2030.

The Climate Challenge was launched in 2019 and was re-issued as version 2 in 2021 to reflect the passage of time, as well as increased embodied carbon data and industry knowledge. Following collaboration with LETI (Low Energy Transformation Initiative), the Whole Life Carbon Network, IStructE and the latest jointly authored guidance, the updated embodied carbon targets in version 2 reflect the carbon definition and alignment work.

RIBA acknowledges that further refinement of the targets will be required as more detailed data and further industry research is developed. However, the institute understands that urgent action is required and it is more important to commit to imperfect targets than to none at all.

The 2030 Climate Challenge is open to all RIBA chartered practices. Signatories commit to attempting to meet the targets on all of their new and major refurbishment projects and to submitting anonymised data to RIBA on these projects. There is no penalty or consequence for projects that miss the voluntary performance targets; instead, the approach is to use the 2030 Climate Challenge to build capacity for, and understanding and awareness of, the interim steps required to deliver a net-zero 2050 building sector.

05
COLLABORATION CASE STUDY

How collaboration between tier 3 and 4 suppliers can help to deliver decarbonisation targets

Actor: **Tarmac**
Project: **Supplier Sustainability Week and Decarbonisation Club**

To reach its net-zero commitment before 2050 and achieve a 25% absolute reduction in Scope 1 and 2 emissions by 2030, Tarmac has worked collaboratively with its supply chain to drive decarbonisation and the wider sustainability agenda.

In 2021, the company held its first Supplier Sustainability Week, attended by more than 800 suppliers, with a clear focus on encouraging collaboration, supporting suppliers to embrace change, and identifying opportunities to reduce carbon collectively. During the event, Tarmac welcomed 21 presenters, produced 10 hours of content and delivered 595 hours (about three and a half weeks) of learning.

During this inaugural week, the Tarmac Decarbonisation Club was created, which now comprises 16 suppliers that contribute towards 30% of Tarmac's Scope 3 emissions. This forum is an example of progressive procurement that is focused on developing practical and deliverable solutions for Tarmac and supply-chain partners to implement across construction and infrastructure projects.

To date, 120 recommendations have been generated and 60% of these ideas use technology that is either currently available or will be within the next two years. The recommendations have been mapped on a marginal abatement cost (MAC) curve and judged against three main criteria – cost, timescales to implement and potential carbon savings – to help Tarmac and its partners to understand projects that can deliver sustainable change.

06
COLLABORATION CASE STUDY

Constructors collaborate with material suppliers and asset owners to replace carbon-intensive materials

Actors: **Skanska, National Highways, supply-chain partners Basalt Technologies and Tarmac, and the National Composites Centre (NCC)**
Project: **M42 J6**

Alkali-activated cementitious materials (AACMs), coupled with basalt reinforcement, present a significantly lower-carbon alternative to traditional reinforced concrete. In developing this solution, Skanska worked with National Highways to trial the material on a temporary haul road for National Highways' M42 Junction 6 project.

Collaboration and expertise were required across the value chain, which included National Highways, Skanska, the NCC and supply-chain partners Basalt Technologies and Tarmac. The trial is an industry first, with significant opportunity for carbon reduction when implemented at larger scale. Skanska and the NCC are working with National Highways and other clients, such as HS2, to further develop and scale the technology for market adoption.

Using AACMs decreases carbon in conventional concrete mixes, while basalt rebar is non-corrosive, lighter than traditional steel-reinforcement and has a lower carbon footprint – estimated at up to 80% lower than a standard CEM I concrete. Basalt consumes 62% less CO_2e than steel during manufacture.

Four reinforced concrete slabs were cast at the M42 Junction 6 site, as part of a temporary haul road that will be used by heavy construction vehicles. The performance of these slabs is being monitored in situ. Simultaneously, full-scale slabs have been sent to a specialist laboratory for bending and shear testing.

The conclusions and insights drawn from this trial will inform the future use of low-carbon alternatives for durable construction and the proposed revision to Eurocode 2: Design of concrete structures (EN 1992).

07
COLLABORATION CASE STUDY

How constructors can collaborate with their value chain to deliver cost and carbon savings with innovative solutions

Actors: **Skanska, Costain and Strabag joint venture (SCS JV)**
Project: **HS2, Euston Area**

Traditionally, piles are trimmed or broken down using percussive breaking or a cropping method. This is time-consuming, costly and results in damage to the projecting reinforcement, as well as having significant health and environmental impacts. On the HS2 Euston Area works, the Skanska, Costain and Strabag joint venture (SCS JV) team decided that the traditional method was unacceptable and sought a better solution.

A team from piling specialist Cementation Skanska, SCS JV works superintendent Lee Piper and subcontractor Hercules Site Services devised a method of pile reduction that requires little or no physical breaking. The zero-trim technique uses a vacuum excavator, which eliminates the need for pile-cropping. The vacuum excavator is used to extract the contaminated concrete during the casting of the pile, before the concrete has cured, thereby removing the need for future cropping.

On the Euston Area works, this approach saved 60,000 working hours and 840 tCO_2e, in addition to a number of environmental benefits, such as no noise from drilling and breaking. The zero-trim technique is being used on HS2 sites near Euston, and will extend to other sites across London where the SCS JV is working. Discussions are also taking place with other HS2 contractors to determine whether it can be used further across the route.

SYSTEMS-THINKING CASE STUDIES

01
SYSTEMS-THINKING CASE STUDY

Assessing emissions beyond the project boundary

Actor: **High Speed 2 (HS2 Ltd)**
Project: **HS2**

HS2, the UK's new high-speed railway, is under construction, with more than 350 active sites between the West Midlands and London. HS2 will release space on the current rail network for more local, regional and freight services – creating opportunities for modal shift and supporting the decarbonisation of the wider transport system.

Recognising HS2 as an integral part of this wider transport system, the greenhouse gas (GHG) assessment published as part of the hybrid bills to Parliament considered impacts beyond the project boundary (module D). Specifically, it considered how the introduction of HS2 changes the way people and freight move around the UK – and the associated likely GHG emission impacts. The GHG assessment considers carbon burdens (e.g. journeys to access HS2 services) and carbon benefits (e.g. transfer of passenger and freight journeys from road and air to rail).

This approach provides stakeholders and decision-makers with a more holistic view of the likely GHG emission impacts of HS2. It also enables identification of the interfaces with third parties, providing insights with respect to stakeholder control and influence over GHG emissions, ultimately informing carbon management and stakeholder-engagement strategies to drive and deliver carbon reduction.

02
SYSTEMS-THINKING CASE STUDY

Systems thinking for buildings retrofit at scale

Actors: **University of Sheffield and University College London**
Project: **Building retrofit at scale case study**[5]

In 2021, buildings contributed nearly 20% of UK carbon emissions, the majority of which was from residential. The advanced age of the stock means that a successful national transition to net zero relies on an extensive energy retrofit programme, both on the energy supply and demand sides.

The scale of the task is enormous. England's housing stock consists of just under 23 million dwellings across a range of typologies – detached, terraced, apartments and so on – of which more than half may have an energy rating of D or worse.

Assessing the carbon impact of residential retrofit means dealing with a wide variation in the characterisation of existing building stock, with data availability ranging from building-level 3D stock models to national estimates aggregated by building type.

The University of Sheffield, in collaboration with University College London, estimated the operational energy baseline for UK building stock in England and modelled a range of retrofit interventions using the Government's National Household Model. Combining the energy modelling with the embodied carbon benchmarks of eligible building fabric and system interventions allows the whole-life carbon emissions of retrofit measures to be compared to the Climate Change Committee (CCC)'s 'carbon budget' estimate for the sector (see Fig 6.1, next page).

The analysis shows that retrofitting in England would require a mass deployment of heat pumps to achieve emissions less than the available carbon budget for the sector. In this scenario, where heat pumps (ground or air source) are rolled out, the operational energy is more than halved, but it results in twice the load being placed on the national grid. Even in this scenario, the operational energy of the building sector does not reach net-zero operational emissions, with some residual emissions remaining due to the grid not fully decarbonising and the use of fossil fuels in buildings that are not suitable for heat pumps.

5 Li, X et al (2022) Net zero by 2050: investigating carbon-budget compliant retrofit measures for the English housing stock, Renewable and Sustainable Energy Reviews 161, 112384, 10.1016/j.rser.2022.112384

The study concentrated on the whole-life carbon of the buildings and the interventions. The retrofit solutions that are compatible with the CCC carbon budgets rely not only on an ambitious national grid decarbonisation scenario, but also almost doubling of the grid electricity supply. The capital and operational carbon implications of the energy infrastructure for the generation and distribution of this doubling in demand must be added to the carbon equation and still be delivered within the specified carbon budgets.

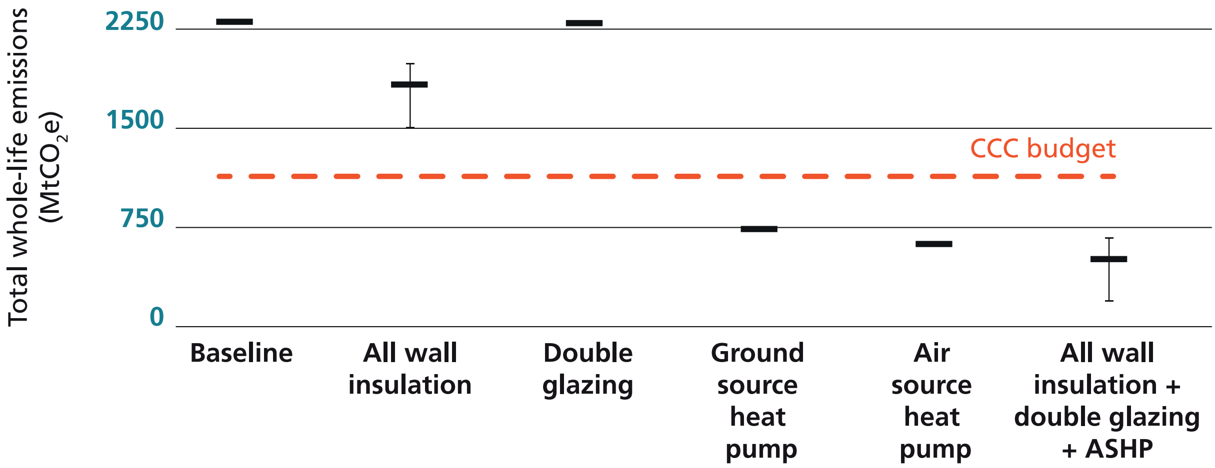


Fig 6.1: Total whole-life carbon emissions of various retrofit measures to 2050 – error bars show the variable impact of material choice when considering fabric insulation

03
SYSTEMS-THINKING CASE STUDY

Systems-thinking approach to alleviation scheme design delivers lower-carbon outcomes and an enhanced natural environment

Actors: **Jacobs and Environment Agency**
Project: **Low Crosby Flood Risk Management scheme**

The village of Low Crosby in Cumbria is subject to flood risk, primarily from the River Eden. In December 2015, approximately 60 properties were flooded during Storm Desmond. To reduce the risk of future flooding to residential properties, critical infrastructure and local businesses, a climate-resilient flood alleviation solution was required.

The Environment Agency (asset owner/manager) and Jacobs (designer) collaborated to assess and manage whole-life carbon throughout the Need and Optioneering project stages, with an ambition to reduce whole-life emissions. Working with natural processes, rather than implementing a hard-engineered solution, a 'build less' approach was adopted, which satisfied the whole-life project objectives and performance requirements.

The solution was to remove a 3km embankment on the opposite bank of the River Eden. This removed a local restriction to floodplain conveyance, resulting in significantly reduced water levels at Low Crosby. The embankment provided protection to high-grade arable farmland within the River Eden floodplain. Extensive landowner engagement took place to return approximately 185 hectares of previously agricultural land back to natural floodplain.

Returning the floodplain provides protection to, and enhances, the natural environment, with the possibility of creating longer-term, higher-value habitats. Other long-term natural capital benefits include carbon sequestration of about 30,000 tCO_2e over a 100-year assessment period.

As well as achieving primary objectives related to flood-risk management, the solution offered the lowest whole-life carbon when compared with the other 'do something' options.

The avoidance of a hard-engineered flood wall significantly reduced the potential whole-life carbon emissions of the scheme by approximately 1,900 tCO_2e. The 'build less' approach further minimised emissions by keeping 100% of existing embankment material in situ.

The Environment Agency's Carbon Impacts Tool was used to calculate an overall value of carbon avoided from reducing flooding risks, against emissions from constructing and maintaining an alternative solution. The estimated net carbon value for Low Crosby is 1,300 tCO_2e over the 100-year assessment period. As with all carbon-sequestration estimates, soil-carbon absorption over time is site-specific, depending on the microclimatic conditions, topography orientation or soil type and condition.

The realised carbon sequestration over time should be verified through a bespoke programme of intrusive monitoring throughout the life of the project. The data from this monitoring would support the continuous improvement of the site management, as well as improving the sequestration database of the Environment Agency for the benefit of other assessments and interventions across its asset portfolio.

04
SYSTEMS-THINKING CASE STUDY

How infrastructure defines spatial development

Actors: **Local government urban planning (literature example)**
Project: **Barcelona urban carbon habits case study**

The comparison of the carbon of two cities is a classic systems-interdependency demonstrator. Both Barcelona and Atlanta have populations of about 5 million. Barcelona is shaped around an efficient public transport corridor, dictating a dense and efficient urban development and very controlled land-use change. This results in carbon per capita almost an order of magnitude lower than that of the sprawling suburbia in Atlanta, where car ownership is the only option (see Fig 6.2).

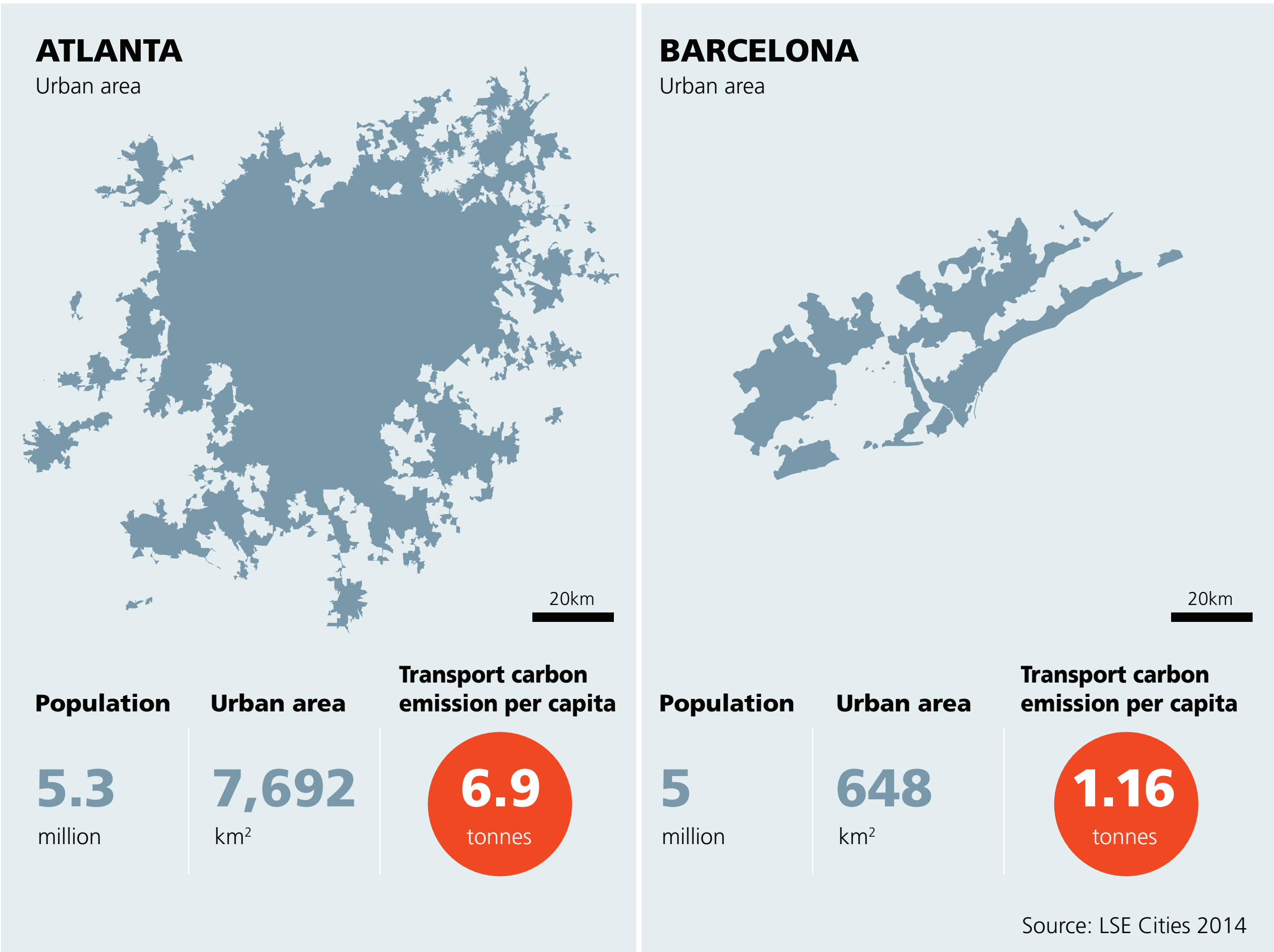


Fig 6.2: Decarbonising at system level

05
SYSTEMS-THINKING CASE STUDY

How an asset owner can collaborate with its stakeholders to decarbonise at a systems level

Actor: **Anglian Water**
Project: **PAS 2080 case study**

Anglian Water has an ambitious goal of achieving net-zero carbon by 2030 and reducing capital carbon by 70% from a 2010 baseline. Carbon and cost baselines are developed for all projects within a £3bn investment programme, and reduction against these baselines is targeted throughout the delivery process. Innovation and opportunities developed by supply-chain partners have ensured Anglian is keeping to the net-zero target and, in 2022, it achieved a 63% reduction in capital carbon.

However, Anglian recognises that a wider system view is needed to deliver and exceed the year-on-year targets, going beyond its regulatory boundary. For example, traditional wastewater treatment processes are generally carbon-intensive, requiring concrete tanks with high usage of electricity and chemicals. The company moved to work with regional stakeholders, including the North Norfolk Rivers Trust, to unlock nature-based solutions, constructing a treatment wetland at Ingoldisthorpe with a series of lagoons, which reduced capital carbon by 55% (from a 2010 baseline[6]).

Another example of this approach has been employed on a wastewater recovery scheme that recovers heat from the sewer and treatment network. Anglian partnered with Oasthouse Ventures to use warm water, which is a natural by-product of the sewage treatment process, to heat two of the UK's largest greenhouses in Norfolk and Suffolk. Closed-loop heat pumps are used to capture and transfer waste heat from nearby sewage treatment works to the greenhouses to accelerate the growth of the salad crops year-round. Through capturing this warmth, the crops grown in the glasshouses have an operational carbon footprint that is about 75% lower than normal.

A key element in the success of the glasshouse project was not only cross-sector collaboration between water and agricultural sectors, but also government support through the Renewable Heat Incentive scheme. Reviews are under way to agree the principles and methodology on how to report and share the carbon benefits of this type of systems-thinking collaborative project.

6 The reduction is calculated using historic carbon models that cover a range of different equipment assets (e.g. pumps) and process groups (e.g. pumping stations). These are back-to-back with cost models. For each five-year business plan, the carbon and cost baseline is calculated using existing data based on the assets being designed and built as per the 2005-2010 standard. The same models are used to calculate the actual solution and, hence, the reduction can be calculated.

PROCUREMENT CASE STUDIES

01
PROCUREMENT CASE STUDY

How can designers support asset owners to embed decarbonisation principles and requirements into procurement?

Actors: **Perth and Kinross Council and Sweco UK**
Project: **Cross Tay Link Road**

The Cross Tay Link Road in Scotland will link the A9 over the River Tay to the A93 and A94 north of Scone. This will alleviate traffic congestion in the city centre and Bridgend, creating capacity in the city's road network that will enable a shift to greener modes of travel, and facilitate economic development in Perth and the surrounding area.

From concept to specimen design through to tendering, Perth and Kinross Council (asset owner) and Sweco (designer) have collaborated to minimise the environmental impact of the scheme and maximise decarbonisation. In 2019, Perth and Kinross Council prepared a procurement strategy for the contract, developed from previous lessons learnt, early market engagement and advice from NEC specialists. This initial strategy was supported and enhanced through collaboration in the value chain, with Sweco supporting the development of the tender documents and including carbon in the weighted evaluation criteria[7].

Tendering companies had to provide proposals to demonstrate a minimum saving of 30% against the specimen design. The successful contractor's tendered carbon baseline replaced the client's original on the award of the contract. The contractor's baseline and reduction proposals had to follow a predefined carbon-quantification methodology and industry-standard carbon coefficients set out in the invitation to tender.

The contract for the project began in August 2021 and detailed design is under way. In the awarded contract, the proposed savings, which exceeded 30%, have become a contractual KPI with measures in place to ensure emissions are reported and minimised. Failure to meet these targets will result in a penalty.

7 Three environment questions were given a 15% weighting, one of which was 'carbon management'.
The overall contract award criteria was split into a quality/price weighting of 80% quality, 20% price.

02
PROCUREMENT CASE STUDY

How an asset owner can incorporate carbon management into tender contracts

Actor: **National Grid**
Project: **National Grid including carbon in tenders**

National Grid Electricity Transmission aims to reduce embodied carbon throughout the network-development process of its construction projects, from conceptual design to construction delivery. Investment engineers eliminate and reduce carbon in their designs and then incentivise the supply chain to reduce carbon further in the construction phase.

Between 2019 and 2021, a consideration of carbon was part of the criteria for 21 tenders, totalling more than £497m. It was established that most bids were awarded to the highest- or second-highest-performing carbon options. In addition, the lowest-carbon option cost was, on average, 31% less than the highest submission in any given event, meaning this can be a significant differentiator when selecting a contractor. Through this review, a carbon-to-cost ratio of 10:6 was established, where a 10% carbon reduction results in a cost reduction of up to 6%.

At the start of this initiative, the carbon assessments were carried out by National Grid's central sustainability team. To embed carbon literacy across the business, with a focus on the procurement team, it has introduced 'sustainability champions' that are trained by the sustainability team. This has resulted in a consistent approach to contractual frameworks, which include a common set of sustainability questions.

National Grid has learnt that clear accountability to review and, later, manage carbon commitments at each of the contractual and delivery process stages is critical to tender commitments being delivered. It also found that including carbon targets within the commercial terms and conditions, the works scope and specific KPIs resulted in greater success in commitments being achieved. These terms were developed collaboratively between National Grid and its principal contractors.

RISK-BASED APPROACHES CASE STUDIES

01

RISK-BASED APPROACHES CASE STUDY

Understanding fire risk in the re-use of concrete structures

Actors: **The Concrete Centre and Building Research Establishment (BRE)**
Project: **Fire performance: assessing concrete structures for re-use**

The re-use of a concrete structure is almost always the lowest capital-carbon option in construction. Re-use can feature significant modification, and the building may be used for a different purpose for which it was originally intended. This can necessitate a re-assessment of the building's structural capacity, including its fire resistance. This can present complications in undertaking a project where 'best practice' may not be well established or clear.

Recognising this challenge, The Concrete Centre, as part of the Mineral Products Association, in partnership with the Building Research Establishment (BRE), published guidance in January 2022 on assessing the fire performance of concrete structures for re-use. This allows actors to take a risk-based approach to re-use of concrete structures, giving them the necessary tools to fully consider an option that could substantially reduce a project's embodied carbon.

The publication – Fire performance: assessing concrete structures for re-use – is a practical guide to conducting a fire performance assessment for structures intended for re-use. The guidance covers the quantity, type and hierarchy of information needed to conduct the assessment, and discusses appropriate methods to calculate fire resistance. This ranges from more simplified methods using historical data tables and more advanced methods using numerical codes based on structural mechanics. It explains the scenarios in which either are most appropriate and discusses how to validate advanced models against existing or historical test evidence.

Lastly, it recommends several methods by which the fire resistance of a building can be further enhanced, such as cementitious sprays, intumescent coatings or board types.

02
RISK-BASED APPROACHES CASE STUDY

Sharing operational risks for innovative solutions that deliver lower cost and carbon outcomes

Actors: **Yorkshire Water, Environment Agency, Stantec, BarhaleDoosan and Ofwat**
Project: **Clifton Wastewater Treatment Works**

Clifton Wetlands is a new integrated constructed wetland (ICW) built at Yorkshire Water's Clifton Wastewater Treatment Works, near Doncaster in South Yorkshire. It uses a nature-based solution to replace conventional wastewater treatment processes with a more sustainable, low-carbon alternative.

A joint venture between Yorkshire Water, the Environment Agency, Stantec and BarhaleDoosan delivered the project. It is the first of its type in the UK to be granted an operating techniques agreement, using a risk-sharing approach between the regulator (Ofwat) and Yorkshire Water, to achieve optimal onsite performance as the wetland matures, with optimal performance achieved over time.

The approach to design and construction reduced the amount of concrete poured and reduced lorry movements. In addition, no waste was removed from the site, reducing disruption and carbon emissions. The passive operation and use of nature-based treatment eliminates the need for energy-heavy chemical treatment processes. Operationally, it lowers the amount of power needed (monitoring equipment is powered by a small solar array) and avoids reliance on the chemical supply chain. The ICW also slows the flow of water entering the River Don, helping to reduce flood risk and lessening the risks associated with climate change for local communities.

The risk-sharing approach between the regulator and Yorkshire Water for the initial period of operation while the scheme matures was critical to its delivery. The project was completed at 35% lower cost than building a conventional solution and the operational costs are 40% lower. The operational carbon saving is 79%, with an embodied carbon saving of 50%.

03
RISK-BASED APPROACHES CASE STUDY

Improving investigation techniques for asset deterioration to minimise risk and use-stage carbon

Actors: **Mott MacDonald Bentley and Yorkshire Water**
Project: **Digley Reservoir**

Mott MacDonald Bentley (MMB) was appointed by Yorkshire Water to assess the potential for seepage through the dam at Digley Reservoir, near Holmfirth in West Yorkshire.

Geotechnical investigation indicated water within the clay core and downstream shoulder, suggesting that seepage could be occurring. Conventional solutions may have ranged from localised grouting to the dam core, to replacement of the core with a slurry trench. Both solutions are heavily energy intensive and use cement-bentonite grout, with the largest extent of works representing an estimated 700 tCO_2e. Upon review of the initial investigation, MMB, Yorkshire Water and other design team members agreed that follow-on investigations should be undertaken.

MMB proposed the use of temperature-sensing fibre-optic probes. This represented one of the first applications of the technology within an earth-embankment dam, and the first in Yorkshire Water's dam portfolio. The technique allows for a substantial increase in the accuracy and density of data, estimation of seepage velocities and, therefore, identifying risk to internal erosion at the dam.

Following two years of data collection using this technique, plus historic and targeted intrusive investigations following review of the data, MMB concluded that there was evidence of seepage within the clay on a localised level, but not at a rate that would cause concerns with internal erosion. It was deemed that no capital works were necessary – a decision that may not have been possible without this new technology.

The fibre-optic system was later adapted to allow remote monitoring of the site as a cost-effective, long-term asset management tool. Should works be required in future, this system would allow near-real-time monitoring of the efficacy of the works.

TOOLS AND DATA/CONSISTENCY CASE STUDIES

01
TOOLS AND DATA/ CONSISTENCY CASE STUDY

How a Cloud platform for material data can help to support decarbonisation

Actor: **CARES**
Project: **CARES Cloud platform**

CARES is a certification body providing steel certification for the construction sector. Its CARES Cloud platform enables the exchange of accurate, third party-verified product conformity and global warming potential (GWP) data from reinforcement-bar and structural-steel producers and fabricators, contractors, consulting engineers and clients. This data can feed into design and fabrication schedules, be digitally transferred to designers and engineers and incorporated into building or infrastructure BIM (building information modelling) or similar digital records.

CARES publishes a 'sector average' GWP figure per tonne of reinforcing steel, which enables reasonably accurate estimates to be used at early RIBA stages (e.g. design). These estimates can be confirmed/adjusted at later RIBA stages when the reinforcement is procured and the actual steel producers are known.

This data is collected by each steel mill into a third-party verified lifecycle assessment calculator, tool and model, validated by CARES auditors and subject to further verification by BRE. The GWP is published in EN 15804-compliant environmental product declarations (EPDs) to ensure consistency. LCAs and EPDs are mandatory requirements of the CARES Sustainable Constructional Steels (SCS) certification scheme, which covers a significant percentage of reinforcement used in the UK, and some structural steels.

The CARES Cloud can also help to reduce emissions through specification of stronger-grade steels. Accurate tensile-strength data is held on the platform, which can be shared, subject to agreement between the steel producer and the client/ contractor. The designers can reduce the quantity needed for any given application to achieve the same strength characteristics and can, therefore, reduce upfront embodied emissions.

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Development of the NATURE Tool

Actors: **WSP (lead), Ecosystems Knowledge Network and Northumbria University**
Project: **NATURE Tool**

The NATURE Tool was developed by 30 organisations involved in the built environment sector. Its development was initiated and led by WSP after securing £130,000 in UK Government R&D funding. While the scope of the collaboration presented challenges in terms of coordination and managing expectations, it was also essential to involve as many partners as possible to ensure the tool could meet industry demand.

Free to use, the NATURE Tool predicts changes to natural capital (i.e. habitat or greenspace) following development or other greenspace interventions. The changes are assessed across 17 ecosystem services, as well as their physical and mental health benefits, expressed simply through percentage changes. This innovation allows users to quickly and systematically assess natural-capital impacts and demonstrate net gains for the environment, alongside biodiversity net gain.

The tool can be used to assess natural carbon storage in vegetation and soils, as well as abated carbon due to photovoltaic installations, alongside other ecosystem services. The only data requirements needed to run the tool are baseline habitat type, post-intervention habitat type and the level of public accessibility. The tool can help to inform decision-making throughout planning and development and lead to wider environmental outcomes from multifunctional green spaces.

The tool was released in July 2021 and WSP is continuously improving its functionality, the quantification of carbon impacts in monetary terms being one of its more recent features.

The NATURE Tool has the potential to become a UK industry standard when assessing project impacts on natural capital, including natural carbon storage.

03
TOOLS AND DATA/ CONSISTENCY CASE STUDY

Whole-life carbon management at every project stage

Actor: **Environment Agency**
Project: **Eric tool and carbon impact tool**

All Environment Agency (EA) projects subject to the Construction Design and Management (CDM) regulations must complete a whole-life carbon assessment. This starts at the earliest stages of a project's lifecycle and is used to help in optioneering and minimising the whole-life impact of the EA's activities. At every business-case stage, the following are required:

- The calculation of a carbon budget
- An assessment of the whole-life carbon and net whole-life carbon
- A description of what has been done to minimise carbon so far
- A look forward to potential carbon savings at the next stage

Carbon budgets (for capital carbon only) are calculated based on the asset types that are being built. They can be calculated either from the overall cost, asset cost or asset size, depending on the design stage of the project. These calculations use a baseline carbon footprint for the assets based on 2019-20 carbon intensity levels and apply a glide path of expected decarbonisation for the specific assets and the net-zero carbon 2030 target to the expected construction date. Thus, the further away the expected construction date, the lower the carbon budget is likely to be.

The assessments use the Eric tool and the carbon impact tool, both developed in-house by the EA. Eric has two components: the carbon modelling tool (CMT) and the carbon calculator (CC). The CMT is used as a 'top-down' assessment, looking at carbon per asset. It uses data from previous similar projects and is used in appraisal to quickly compare options and shortlist solutions. It is typically used in the earlier project stages, up to the strategic outline case. The CC provides a detailed 'bottom-up' assessment using project data. It is used in all later business cases for assessing the carbon footprint of the preferred option. Both the CMT and CC present a whole-life carbon assessment over a 100-year period. All projects are required to complete and maintain a carbon appendix, which records all of the carbon assessments, carbon budget calculations and actions taken to minimise carbon throughout the project's life.

The carbon impact tool assesses the carbon avoided due to reductions in flood frequency. The carbon avoided is subtracted from the whole-life carbon to give the net whole-life carbon (NWLC). This is then monetised and added to the benefit side of the cost benefit calculation used in the business case and for funding purposes.

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Development of carbon tool through collaboration between industry and academia

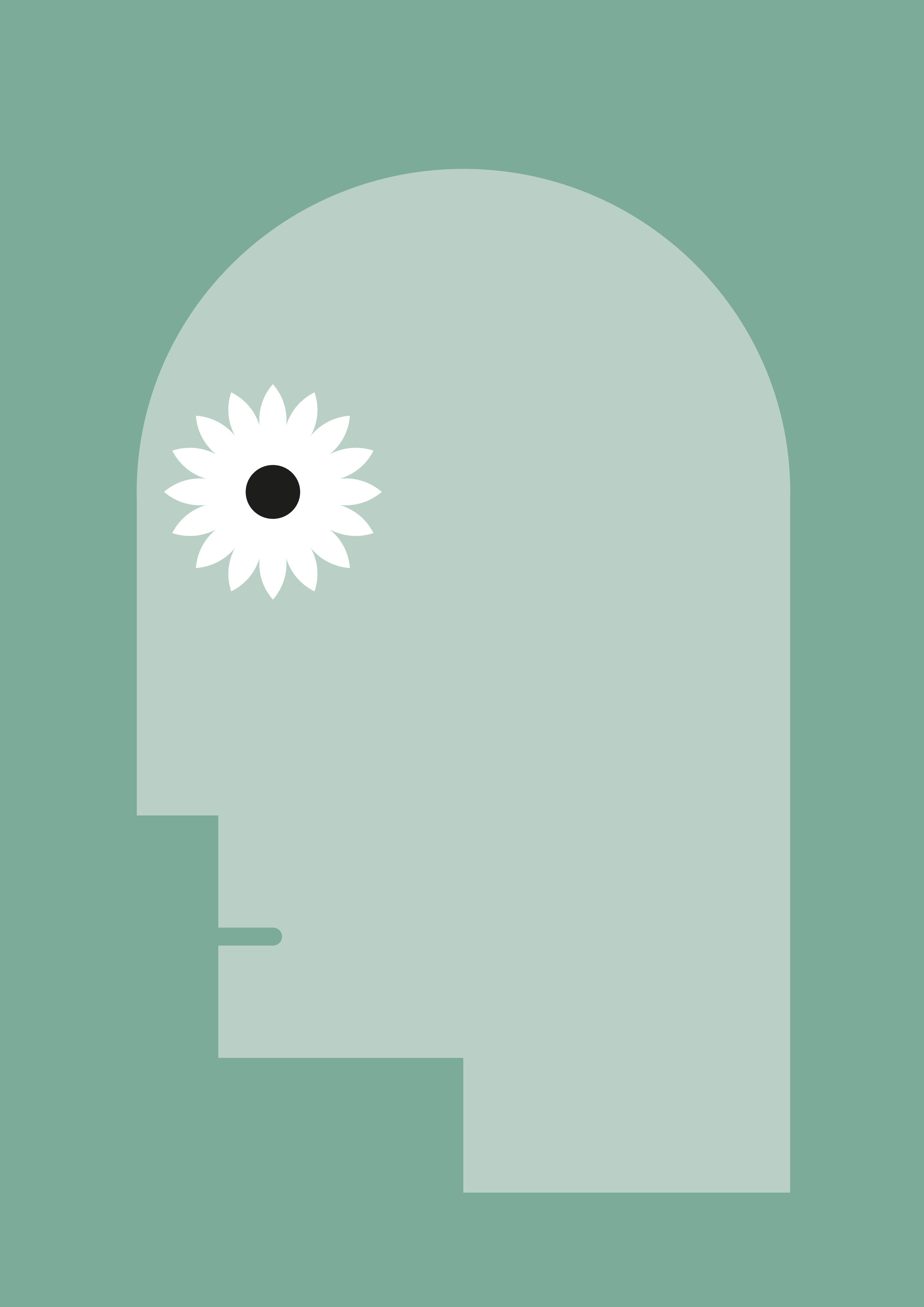
Actors: **Grimshaw, University of Cambridge, Max Fordham and Smith & Wallwork**
Project: **Energy Cost Metric tool – Civil Engineering Building in Cambridge**

Grimshaw's team worked with leading academics at the University of Cambridge to develop the Energy Cost Metric (ECM). By combining whole-life energy and costing assessments into a single analytical tool, the ECM provided a new way to objectively evaluate the whole-life energy savings and associated cost for different design strategies in a single equation to establish which provided the best value to the university.

Its use during the design phase influenced the decision to specify a ground-source heat pump (GSHP) with heat recovery over gas boilers. Subsequently, the university's Estates Department incorporated the ECM into its guidance for new buildings.

The Department of Engineering has recently published a paper[8] outlining the ECM's development and application during the project-design phase, to support the construction industry's efforts to minimise whole-life energy and carbon within a cost-conscious framework. Selecting the GSHP over the other heating, ventilation and air conditioning solutions resulted in significant carbon savings.

8 MacKay D et al (2020) Energy Cost Metric, Energy Design Guide for the Civil Engineering Building in West Cambridge. Part 1: Early stage design decisions (ENG-TR.001) https://doi.org/10.17863/CAM.52920



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