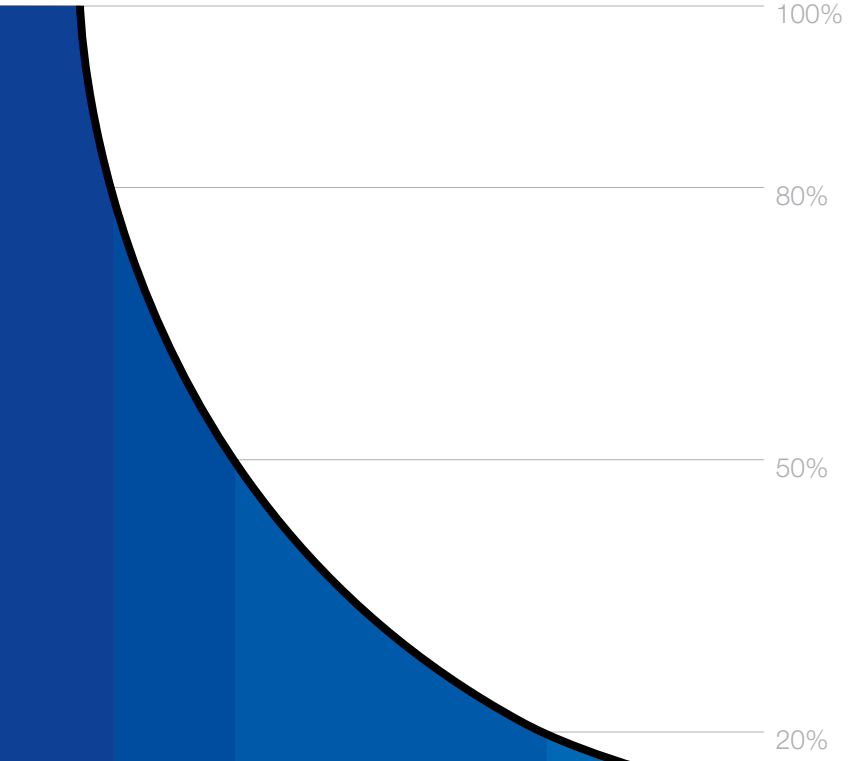
PAS 2080:2016

Carbon Management in Infrastructure

Construction Leadership Council

The **Green Construction Board**



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Carbon management in infrastructure –

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Reduce carbon, reduce cost and stay on top of it!

Construction Leadership Council

The **Green Construction Board**

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Foreword

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This PAS was developed from a preliminary draft prepared by a Technical Authoring Team from Mott Macdonald and Arup, who have continued to support the development of the specification as members of the Steering Group.

Particular thanks are extended to the Carbon Trust for their pre-review contribution to the draft PAS and acknowledgement is also given to the following organizations that were involved in the development of this PAS as members of the Steering Group:

- Anglian Water Services Limited
- Arup Group Limited
- Balfour Beatty plc
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- Construction Products Association
- Costain Group plc
- Department for Business, Innovation and Skills (BIS)
- HM Treasury
- High Speed Two (HS2) Limited
- J.N. Bentley Limited
- London Underground
- Mott McDonald
- MWH Global
- National Grid
- Responsible-Solutions
- SKANSKA UK plc
- Tata Steel
- Transport for London

Comments from other parties were also sought by BSI. The expert contributions from all the organizations and individuals consulted in the development this PAS, are gratefully acknowledged.

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Use of this document

Presentational conventions

The provisions of this PAS are presented in roman (i.e. upright) type. Its methods are expressed as a set of instructions, a description, or in sentences in which the principal auxiliary verb is "shall".

The blue bordered boxes in clauses **5** through to **10**, each provides a short summary of the intention for its relevant clause but does not include specific requirements.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a PAS cannot confer immunity from legal obligations.

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Executive Summary

Working together, infrastructure organizations have the power to use PAS 2080 to transform the benefits that a national economy gains from its infrastructure systems and to provide a sustainable legacy. If all parties involved across the value chain work collaboratively, towards a common goal to reduce carbon, the following outcomes can be achieved:

- Reduced carbon, reduced cost infrastructure;
- More collaborative ways of working will promote innovation, delivering benefit to society and communities served by economic infrastructure;
- Effective carbon management in infrastructure will make an important contribution to tackling climate change and leave a positive legacy for future generations;
- Delivering more sustainable solutions, at lower cost, will enhance the reputation of the infrastructure industry, generating pride for those who work in it and attracting new people and skills;

The challenges set out in PAS 2080 will create a platform for innovation to thrive, leading to more vibrant and rewarding workplaces.

The Infrastructure Carbon Review recognized the opportunity and PAS 2080 will help the infrastructure value chain turn this into reality.

Targeted at leaders and practitioner-level individuals in different value chain organizations (asset owners/managers, designers, constructors and product/material suppliers) responsible for delivering infrastructure, PAS 2080 provides a common framework for all infrastructure sectors and value chain members, on how to manage whole life carbon when delivering infrastructure assets and programmes of work. Use of the PAS will promote reduced carbon, reduced cost infrastructure delivery, more collaborative ways of working and a culture of challenge in the infrastructure value chain through which innovation can be fostered.

- This PAS includes requirements for all value chain members to show the right leadership and to establish effective governance systems for reducing whole life carbon through the use of a carbon management process. The individual value chain requirements in the carbon management process are structured around the following components:
- setting appropriate carbon reduction targets;
- determining baselines against which to assess carbon reduction performance;
- establishing metrics (e.g. Key Performance Indicators) for credible carbon emissions quantification and reporting;
- selecting carbon emissions quantification methodologies (to include defining boundaries and cut off rules);
- reporting at appropriate stages in the infrastructure work stages to enable visibility of performance; and
- continual improvement of carbon management and performance.

All value chain members can claim conformity to PAS 2080 by demonstrating that relevant requirements set out in the different PAS clauses have been met. This will illustrate that the right organizational capability, for working collaboratively under a carbon management process to deliver low carbon assets and programmes of work, is actively in place.

The PAS is supplemented by the "Guidance Document for PAS2080" which provides practical advice on how to implement the different PAS requirements and addresses current good practice through worked examples and case studies.

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0 Introduction

0.1 Infrastructure and greenhouse gas emissions

The Infrastructure Carbon Review (ICR)[1] showed that infrastructure is associated with over half of UK Greenhouse Gas (GHG) emissions:

- 30% of which are directly attributed to the construction, operation and maintenance of infrastructure assets (emissions that infrastructure directly controls); and
- 70% of which are attributed to the users of infrastructure (emissions over which infrastructure has influence)

Figure 1 illustrates the importance of infrastructure in relation to the overall challenge of reducing national carbon emissions targets.

Reducing carbon emissions associated with infrastructure is fundamental to addressing the global challenge of climate change.

PAS 2080 is applicable to anyone involved in the delivery of infrastructure, including asset owners/managers, designers, constructors and product/material suppliers.

Complying with the requirements of PAS 2080 will help all value chain members understand and manage carbon associated with the development of infrastructure from its inception to the end of its life and is equally applicable to individual assets or to programmes.

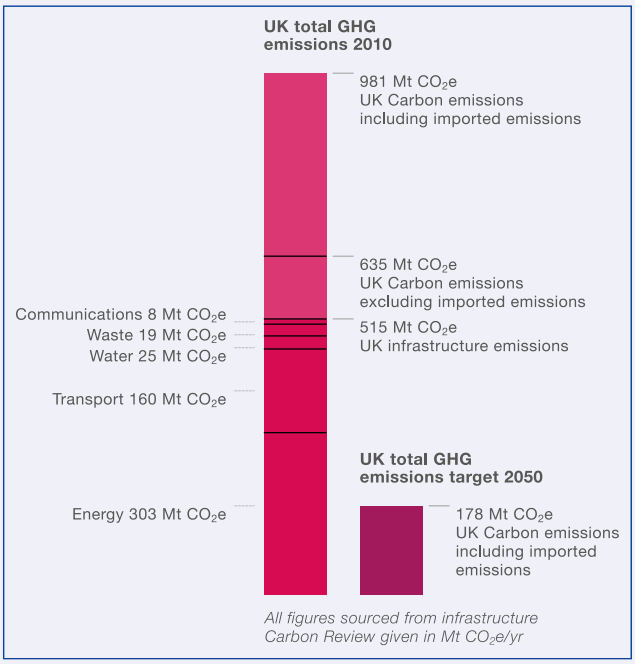
In this regard PAS 2080 is a specification for whole life carbon management and is not a detailed quantification protocol. As such it avoids the duplication of existing quantification protocols.

NOTE 1 *The word 'carbon' used in this document is used as shorthand for GHG emissions as defined in Clause* ***3.18****.*

NOTE 2 *Figure 1 GHG emissions outside the UK infrastructure sector include: transport related emissions from imported products; emissions from agriculture, land use change and industrial process emissions outside infrastructure. Readers should refer to the Infrastructure Carbon Review Technical Report for details of the GHG emissions attributed to the different infrastructure sectors.*

PAS 2080 should be read in conjunction with the "Guidance Document for using PAS 2080" [2] which is designed to help practitioners implement the requirements of the PAS with the aid of real case studies and worked examples.

Figure 1 – Infrastructure is responsible for over half of the UK's consumption GHG emissions



0.2 Whole life carbon and cost reduction

PAS 2080 sets out the general principles and components of a carbon management process, to promote carbon and cost reduction in infrastructure delivery on a whole life basis. The individual clauses of the PAS are arranged in accordance with the components illustrated in **Figure 2** .

1) 2013 by HM Treasury, BIS and the Green Construction Board
2) Published by the Green Construction Board, see www.greenconstructionboard.org.

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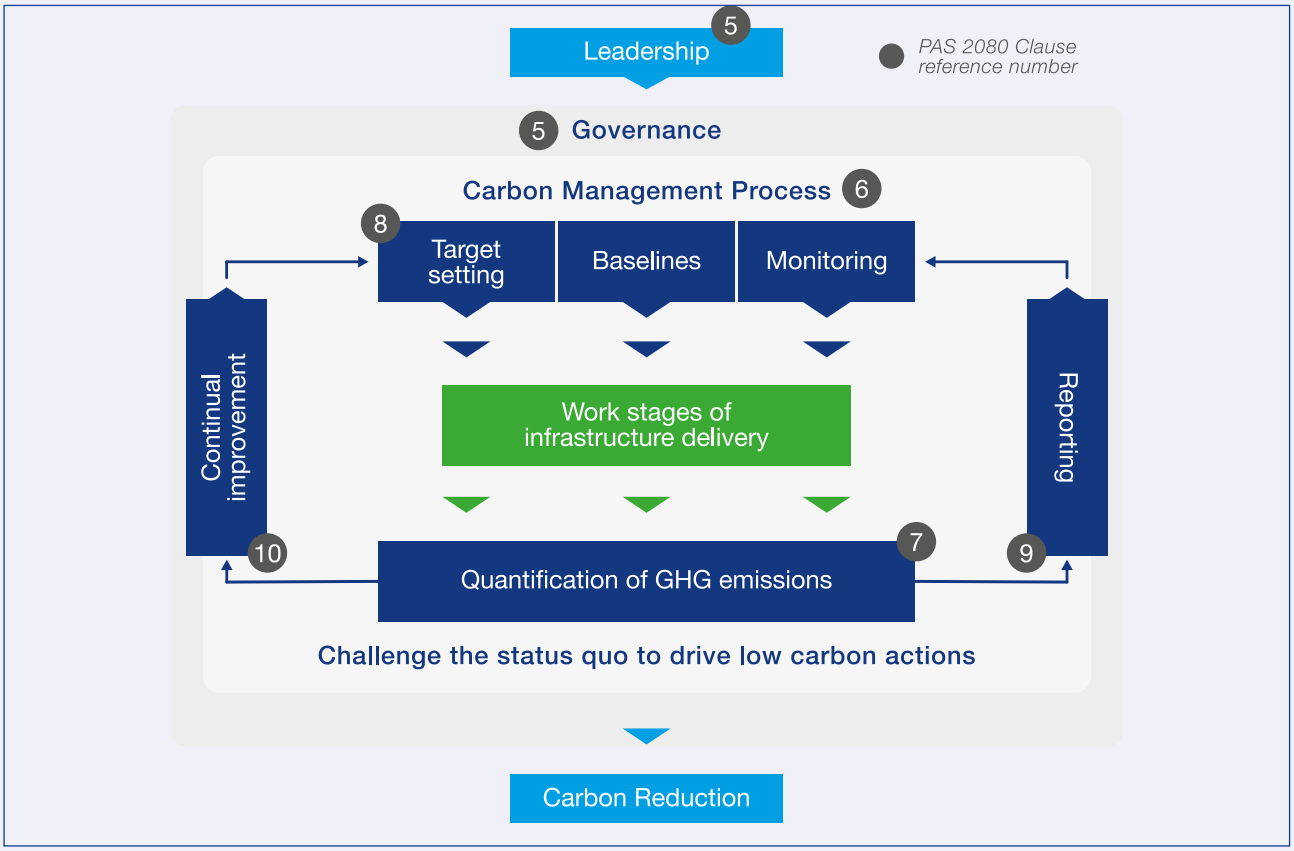
Figure 2 – Process map summarising the key components of the PAS 2080 carbon management process and their respective clause numbers in this document



***NOTE** to **Figure 2**: Clauses **1** to **4** are excluded from Figure 2 as they do not set out any requirements which directly relate to the carbon management process.*

Achieving carbon reductions in infrastructure depends on robust leadership and governance and the integration of the key carbon management process components (i.e. baseline and target setting, monitoring, quantification, reporting and continuous improvement) into existing infrastructure delivery processes. Developing and implementing a carbon management process within infrastructure delivery processes will help join up the value chain, create a strong innovation culture, challenge the current status quo and thereby maximise reductions in both carbon and cost.

0.3 The aim of PAS 2080

The aim for PAS 2080 is that it should set out a carbon management process for use in infrastructure delivery that can be undertaken collaboratively, applied by all parties across the value chain and against which compliance can be either:

- monitored and self-validated by the applying entity; or
- assessed and validated uniformly by other parties or by independent certification bodies accredited to undertake certification services against PAS 2080, with the primary objective of reducing carbon emissions from infrastructure in a manner that also reduces cost.

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1 Scope

This PAS specifies requirements for the management of whole life carbon in infrastructure – defined as the transport, energy, water, waste and communications, sectors – both in the provision of new infrastructure assets and programmes of work and the refurbishment of existing infrastructure.

The scope of the PAS is summarised in **Table 1**.[3]

Table 1 – The scope of PAS 2080

PAS 2080 is about:	PAS 2080 is not about:
Carbon management (as part of wider climate change mitigation).	Wider environmental or sustainability issues[3].
Consistency in the use of data, reporting, quantification, benchmarking, target setting, continuous improvement, leadership, inclusion in BIM, etc.	Prescriptive approaches to quantifying GHG emissions, including the use of specific data or methods.
Management of capital and operational carbon under direct control of the value chain, and user carbon over which the value chain has influence.	Management of user carbon which relies on government policy or action, or where other parties are better placed to manage.
Promoting whole life cost reductions through whole life carbon reduction	Whole life cost management

Because of the evidence included in the Infrastructure Carbon Review that reduced carbon infrastructure is related to reduced cost, PAS 2080 has been developed to:

- Provide a specification for infrastructure carbon management which is compatible with international and sectoral norms, relevant existing standards and guidance, with the view of reducing whole life carbon in infrastructure delivery and;
- Bringing consistency to the practice of carbon management;
- Encouraging wider uptake and action on carbon management;
- Helping the infrastructure value chain to become more efficient – to reduce carbon and cost in infrastructure delivery;
- Improving the accuracy, transparency, consistency, relevance and completeness of carbon management and GHG emissions quantification;
- Improving the knowledge and understanding of carbon management by infrastructure practitioners throughout the value chain; and
- Supporting evidence-based decision making and identification of opportunities for carbon reduction.

Although asset owners/managers have the primary responsibility for delivering and managing infrastructure assets, all value chain members share responsibility for the management of the associated carbon emissions. Asset owners/managers can only realise the intended reductions within a fully integrated value chain involving designers, constructors and product/material suppliers.

To reflect this the PAS is applicable to all value chain members involved in the delivery of infrastructure, including asset owners/managers, designers, constructors and product/material suppliers. There are national and sectoral policies covering infrastructure carbon management, however these are mainly the responsibility of Governments and Regulators and are not in the PAS scope. **Figure 3** illustrates the value chain members involved in infrastructure management for whom this PAS is applicable.

[3] While this standard is not about environmental or sustainability issues generally, it is important that such issues are taken into full account both in the provision of new infrastructure assets and programmes of work and the refurbishment of existing infrastructure assets.

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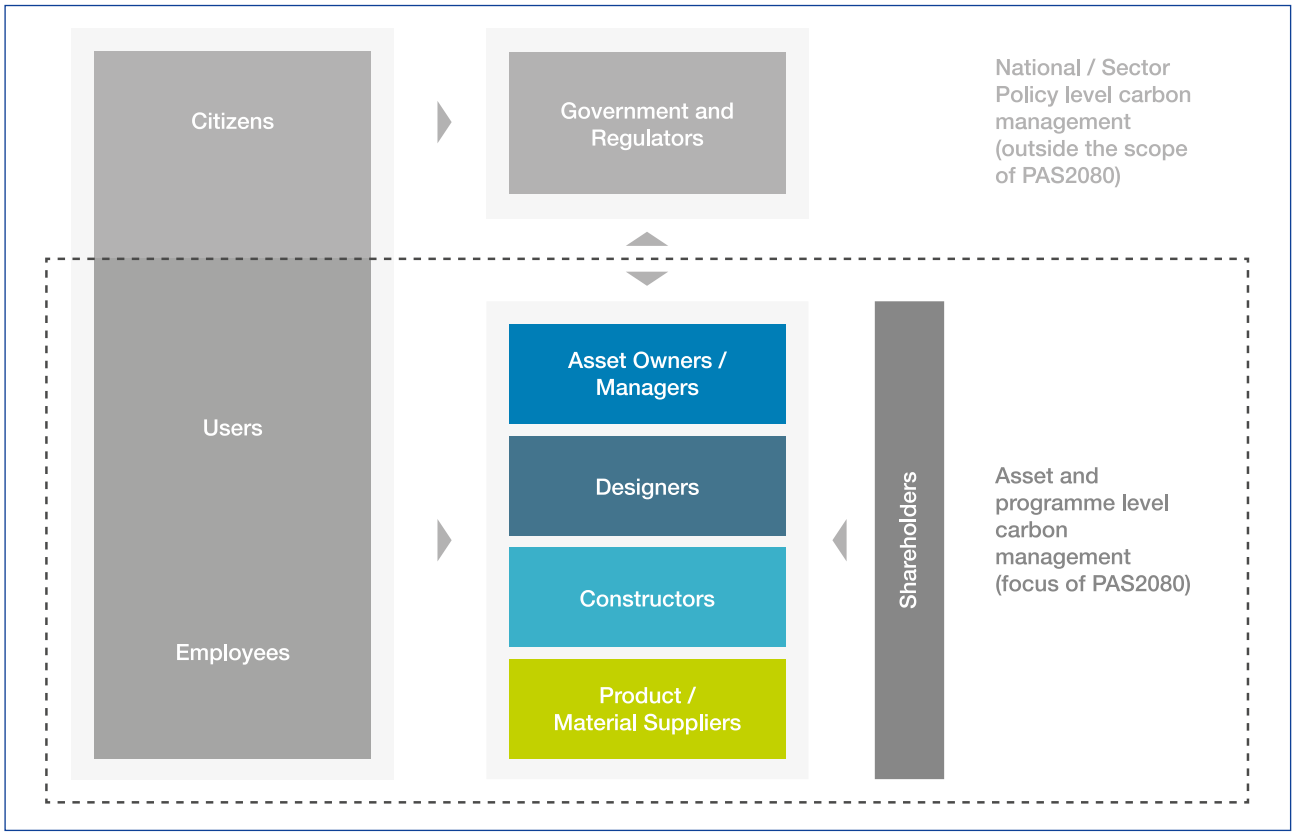
Figure 3 – Infrastructure value chain members responsible for carbon management. The focus of PAS 2080 is on value chain members responsible for asset and programme level carbon management



To help each value chain member to contribute effectively, the responsibilities set out in each clause of this PAS are arranged under the following headings:

- Requirements for all value chain members;
- Asset owner/manager requirements;
- Designer requirements;
- Constructor requirements; and
- Product/material supplier requirements.

In order to successfully claim compliance with the requirements of this PAS, each value chain member is required to declare the role(s) they undertake (from the above list). They can then demonstrate conformity with the clauses under the "requirements for all value chain members" heading and those under other headings pertaining to their role(s).

NOTE *All value chain members will be able to claim conformity with PAS 2080 as: PAS 2080 Asset Owner/Manager; PAS 2080 Designer; PAS 2080 Constructor; and PAS 2080 Product/Material Supplier (refer to Clause* ***12****).*

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To achieve compliance, value chain members must be able to demonstrate relevant organizational capability appropriate to the point(s) of infrastructure delivery at which they are involved.

To maximise carbon and cost reduction, it is recognised that the asset owner/manager has primary responsibility for integrating the work of all value chain members under a common carbon management process that is specifically developed for delivering assets and programmes of work.

The PAS is targeted at both leaders and practitioner-level individuals who are responsible for the day-to-day aspects of infrastructure delivery and carbon management. Practitioner roles range from strategic planning, procurement, design to construction and operations.

NOTE *Further details on the specific practitioner-level roles in each value chain organization that are intended to implement PAS2080 are included in the "Guidance Document for PAS2080".*

This PAS includes requirements for developing a carbon management process built around the following components:

1) Quantification of GHG emissions;
2) Target setting, baseline setting and monitoring;
3) Reporting; and
4) Continual improvement.

Annex C includes reference to a range of external documents from which value chain members seeking to comply with PAS2080 will be able to select approaches and methodologies to assist them.

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2 Normative references

Normative references identify documents external to the specification from which they are cross referenced, the applications of which are requirements of that specification. Users of PAS 2080 might therefore expect to find several documents normatively referenced here.

However, in view of the breadth of target subjects existing in the infrastructure sector, the approach taken in PAS 2080 deliberately avoids normative reference to such external documents so as to provide asset owners/managers with the flexibility to select the external methodologies most appropriate for their particular sphere of activity. Consequently, the PAS does specify requirements for transparency and disclosure and the provision of evidence that the selections made are justified.

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3 Terms and definitions

For the purposes of this PAS, the following terms and definitions apply.

3.1 activity data

data based on a unit quantity of input or output of the studied system or a process within it

NOTE *Activity data may be a physical quantity such as mass (kg), a unit of cost (£) or a unit of energy (kWh), etc.*

3.2 asset

physical entity forming part of infrastructure that has potential or actual value to an organization and its stakeholders

[adapted from BS ISO 55000: 2014]

3.3 asset owner/manager

organization that manages and is responsible for providing, operating and maintaining infrastructure assets

NOTE *Typically the asset owner/manager is the asset owner, but on occasion an asset owner/manager might also be the organization charged with operating infrastructure, a project sponsor, a service provider, the entity undertaking project works, or the organization charged with providing services from infrastructure.*

3.4 baseline

scenario for what carbon emissions would have been in the absence of planned measures aiming to reduce emissions

[adapted from Greenhouse Gas Protocol: 2009]

3.5 carbon management

assessment, removal and reduction of GHG emissions during the delivery of new, or the management of existing, infrastructure assets and programmes

3.6 carbon reduction

process of minimising GHG emissions in the development of new infrastructure assets and programmes of work or the refurbishment of existing assets

NOTE *the outcome of carbon reduction process would be a quantified reduction in existing sources of GHG emissions or the avoidance of GHG emissions associated with new or existing infrastructure.*

3.7 carbon dioxide equivalent (CO_2e)

unit for comparing the radiative forcing of a greenhouse gas to carbon dioxide

[BS ISO 14064-1: 2006; PAS 2050: 2011]

NOTE *The carbon dioxide equivalent is calculated using the mass of a given GHG multiplied by its global warming potential (see 3.16).*

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3.8 capital carbon

GHG emissions associated with the creation, refurbishment and end of life treatment of an asset

NOTE *The term capital carbon is being adopted in the infrastructure sector as it accords with the concept of capital cost. The related term 'embodied carbon' will continue to be used at a product or material level whereas capital carbon will have greater relevance at an asset level.*

3.9 constructor

entity that undertakes work to construct, build, maintain or disassemble an infrastructure asset

NOTE *A constructor may be a product/material supplier.*

3.10 control

where asset owner/managers have the ability to manage, through direct requirement of infrastructure design and operational approach, specific objectives for capital and operational carbon emissions

3.11 designer

entity that creates, prepares or specifies the design of an asset that is to be constructed or maintained

NOTE *A designer may be an asset owner/manager, consultant, constructor, or product/material supplier.*

3.12 infrastructure

transport, energy, water, waste and communications sectors, as defined in the UK National Infrastructure Plan 2014

3.13 emissions factor

amount of greenhouse gases emitted, expressed as CO_2e and relative to a unit of activity

[PAS 2050: 2011; ISO 55000: 2013; ISO 14064: 2012; ISO 14033: 2013]

3.14 direct influence

where asset owners/managers have the ability to use enablers to encourage users to make low carbon decisions

3.15 functional unit

quantified performance of a product or system for use as a reference unit

[BS EN ISO 14044: 2006, 3.20]

NOTE *The functional unit takes into account a function, a quantity, a duration, and a quality of the infrastructure asset or programme of work being assessed. Refer to Clause **7.1.2** and the Guidance Document for PAS2080 for further explanation and examples of functional units.*

3.16 global warming potential (GWP)

factor describing the radiative forcing impact of one mass-based unit of a given greenhouse gas relative to an equivalent unit of CO_2 over a given period of time

[BS ISO 14064-1: 2006]

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3.17 greenhouse gases (GHGs)

gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds

NOTE 1 *Throughout PAS 2080 the term 'carbon' is often used (e.g. Capital Carbon, User Carbon, Operational Carbon). This is applied as short-hand for GHGs as defined by the UNFCC Kyoto Protocol six main greenhouse gases.*

NOTE 2 *The UNFCC Kyoto Protocol six main greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perluorocarbons (PCFs) and sulphur hexafluoride (SF_6).*

[BS ISO 14064-1: 2006]

3.18 greenhouse gas (GHG) emissions

total mass of GHGs released to the atmosphere over a specific period of time

[BS ISO 14064-1: 2006]

3.19 organization

company, corporation, firm, enterprise, authority or institution, or part or combination thereof, public or private, that has its own function and administration

[adapted from ISO 14064-1: 2012]

3.20 operational carbon

GHG emissions associated with the operation of infrastructure required to enable it to operate and deliver its service

NOTE *This is primarily defined as stages B6, B7 and B8, but on occasion might also include modules B2, B3, B4 and B5 depending on organisational setting. Refer to* ***Figure 7***

3.21 practitioner

individual responsible for different aspects of infrastructure delivery and carbon management including, strategic planning, procurement, programme manager, operator, designer/technical advisor, construction manager, material/product developer, environment or sustainability manager, etc.

NOTE *Each value chain member will have different practitioner roles. For more details on practitioner roles, refer to the "Guidance Document for PAS 2080".*

3.22 programme

defined set of works related to the construction, maintenance or operation of an infrastructure asset or assets

3.23 product/material supplier

organization which extracts, manufactures or produces materials or products for incorporation into works to construct, build or maintain an asset

3.24 sector

collection of organizations involved in the delivery and operation of infrastructure assets for the purpose of providing an infrastructure service (e.g. energy, water, telecommunications)

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3.25 system boundary

set of criteria specifying the life cycle, spatial and temporal extent of a GHG quantification or management system

[adapted from BS EN ISO 14040: 2006, 3.32]

3.26 specific data

data representative of a product, product group or construction service provided by one supplier

[from BS EN ISO 15804: 2012]

3.27 target

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

NOTE *A target should be specific and appropriate to an asset or programme of works, it must be measurable, and it must be time bound.*

3.28 user carbon

GHG emissions associated with Users' utilisation of infrastructure and the service it provides during operation

NOTE 1 *This is equivalent to the operation work stage, as show in* ***Figure 4.***

NOTE 2 *Although user carbon is not directly controlled by infrastructure asset owners/managers, they may have a direct influence on user carbon emissions.*

NOTE 3 Annex A *lists the User GHG emissions in each infrastructure sector.*

3.29 value chain

organizations and stakeholders involved in creating and managing infrastructure assets. These include asset owners/managers, designers, constructors and product/material suppliers

NOTE *Government and users of infrastructure can also influence infrastructure asset management however they are not the primary focus of PAS2080 (refer to* ***Figure 3*** *)*

3.30 whole life cycle carbon emissions

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

NOTE *This includes all GHG emissions and removals associated with the processes within the boundary of the life cycle of infrastructure assets. To avoid undue repetition, reference to removals is not commonly included in the text, but it is intended that assessment should include removals wherever they occur.*

[adapted from PAS 2050: 2011]

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4 General Principles

4.1 Context

The principles set out in **4.2** to **4.6** are fundamental principles underpinning the carbon management process presented in PAS 2080. Their application ensures that practitioners undertaking carbon management activities are able to demonstrate that a true and fair approach has been adopted.

4.2 Relevance

Data and assessment methods relevant to the defined boundary of carbon management and assessment are to be selected, documented and used.

[adapted from PAS 2050: 2011]

4.3 Completeness

All life cycle carbon emissions arising within the defined infrastructure system boundary which provide a material contribution to the management and assessment of carbon emissions are to be included.

[adapted from PAS 2050: 2011]

***NOTE** Clause **7.1.3.2** sets out criteria which identify how to identify emissions which are deemed to be material.*

4.4 Consistency

Consistent methodologies and data sources for carbon management and assessment are to be used to allow comparisons of emissions over time. Any changes to methodologies, assumptions or data sources are to be transparently documented.

[adapted from GHG Protocol: 2009]

4.5 Accuracy

The quantification of carbon emissions is to neither over nor under estimate actual emissions, as far as can be judged, and uncertainties are to be reduced as far as reasonably practicable. A sufficient level of accuracy is to be achieved to enable users to make decisions with reasonable assurance as to the integrity of the reported information.

[adapted from GHG Protocol: 2009]

4.6 Transparency

Where the outputs of a carbon management approach carried out in accordance with this PAS are to be disclosed to a third party, information shall be made available on the methodology and data sources used and any relevant assumptions to allow such a third party to make associated decisions with confidence.

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5 Leadership and Governance

Leadership is recognised as a key enabler of carbon management in infrastructure. It provides the vision to drive the organization's carbon management process, and motivates the necessary behaviours and actions from the value chain. Leadership is expected from all levels of the value chain and it is essential that value chain members take responsibility for implementing the PAS 2080 leadership and governance requirements. Asset owners/managers must encourage their value chain to challenge the existing 'business as usual' approach to leadership of infrastructure delivery, to reduce carbon and cost in assets and programmes of work.

5.1 Requirements for all value chain members

Leaders in each value chain member organization shall implement the following, in the areas under their control:

a) Set an organizational policy and strategy for carbon management and align these with business goals;

b) Support the development and implementation of a carbon management process within their organization to support low carbon infrastructure delivery;

c) Communicate consistently and regularly to staff at all levels within their own organization on the importance of carbon management;

d) Communicate consistently with other value chain members to develop collaborative relationships with the goal of reducing carbon emissions;

e) Challenge targets (which their own organizations have set /or which have been set for them) where they consider there is potential for greater carbon reduction;

f) Ensure that training programmes are in place to fill gaps in knowledge and skills;

g) Ensure that adequate human resources are available for the development and implementation of the carbon management process;

h) Ensure that the requirements of the carbon management process are compatible and integrated with existing business processes (e.g. asset management, procurement, health and safety, cost management, quality, delivery programme, sustainability, environmental management, etc.);

i) Demonstrate a commitment to continuous improvement through the sharing of current good practice;

j) Promote a culture that rewards the challenging of the status quo when it comes to carbon management during infrastructure delivery;

k) Implement governance structures where:

- Carbon management underpins the delivery of an asset or programme of work (as per the requirements of the carbon management process components Clauses **6** to **10**);
- Roles and responsibilities for carbon management are established to promote the desired carbon management values and behaviours;
- The implementation of low carbon solutions in their own operations (Clause **6.1.4**) are fully supported;
- Feedback from value chain members is used to improve business processes to drive low carbon solutions;
- All decision making that has a material effect on carbon management within the organization and through the value chain, receives appropriate senior management support and approval;
- Procedures are established and maintained for document retention and record keeping, in support of carbon management.

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5.2 Asset owner/manager requirements

In addition to Clause **5.1** asset owners/managers' leadership shall:

a) Clearly document and communicate the desired carbon management outcomes to their value chain;

b) Encourage value chain members to challenge the status quo to drive low carbon solutions;

c) Consider appropriate mechanisms to recognise, and where possible reward, performance in the value chain to drive low carbon solutions (e.g. can include relevant KPIs, financial incentives, etc.);

d) Be accountable for delivery of carbon emissions reductions in assets and programmes of work.

5.3 Designer requirements

In addition to Clause **5.1** designers' leadership shall:

a) Put systems in place to ensure collaboration with constructors and product/material suppliers to examine the feasibility of low carbon solutions (including material and product supply options, design solutions, and construction techniques);

b) Put systems in place to ensure they challenge the asset owners/managers' asset standards, or equivalent, to drive low carbon solutions.

5.4 Constructor requirements

In addition to Clause **5.1** constructors' leadership shall:

a) Promote early involvement in the delivery of infrastructure and put systems in place to ensure collaboration with asset owners/managers, designers and material / product suppliers;

b) Challenge their product/material suppliers to provide low carbon solutions.

5.5 Product/material suppliers

In addition to Clause **5.1** product/material leadership suppliers shall:

a) Promote low carbon solutions to all value chain members during early infrastructure work stages;

b) Promote carbon management within their supply chain;

c) Proactively communicate carbon information to other value chain members.

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6 The carbon management process

A carbon management process which is integrated into infrastructure delivery processes will drive the value chain to collaborate and create a culture of innovation. This supports reductions in carbon and cost during infrastructure delivery by driving the use of low carbon solutions.

6.1 Requirements for all value chain members

6.1.1 Carbon management process

All value chain members shall:

a) Implement an organizational carbon management process to help them meet their requirements (Clauses **5** to **10**) when delivering assets and/or programmes of work. The components of the organizational carbon management process shall follow those described in Clause **6.2.1** in a manner that will enable integration of their process with the carbon management process deployed by other value chain members;

b) Assign roles and responsibilities to people within their organization in support of their carbon management process; and

c) Engage with other value chain members during the delivery of assets and programmes of work when working under the asset owner/manager's carbon management process (Clause **6.2.1**) as applied to infrastructure delivery (refer to **Annex B** for an example of such engagement).

NOTE *An organizational carbon management process is a process that will enable a value chain member to establish their own organization capability for the delivery of low carbon assets and programmes of work aligning with the asset owner/manager's carbon management process as defined in Clause* ***6.2****.*

6.1.2 Meeting carbon reduction targets

During the delivery of assets and programmes of work, all value chain members shall:

a) Take early action to reduce carbon emissions, where the reduction opportunity is greatest (see **Figure 4)**;

b) Demonstrate they have investigated alternative solutions for carbon reduction at relevant work stages;

c) Follow the carbon reduction hierarchy (Clause **6.1.4**) and select the best collective approach for meeting or exceeding the targets by engaging with other members of the value chain;

d) Communicate and share the proposed carbon reduction actions they have identified with other value chain members;

e) Encourage other value chain members to choose products/materials and adopt approaches which provide the lowest whole life carbon solution; and

f) Adopt an approach to carbon management that defines and implements measures that achieve whole life carbon reductions against a baseline.

NOTE *Without regular and in-depth engagement with other value chain members, unintentional decisions on options/products/materials can be made which lead to short term carbon reductions but over a whole life perspective can lead to greater carbon emissions. For example, more frequent replacement/refurbishment requirements due to reduced durability or more substantial replacement costs due to greater difficulty in expanding service capacity.*

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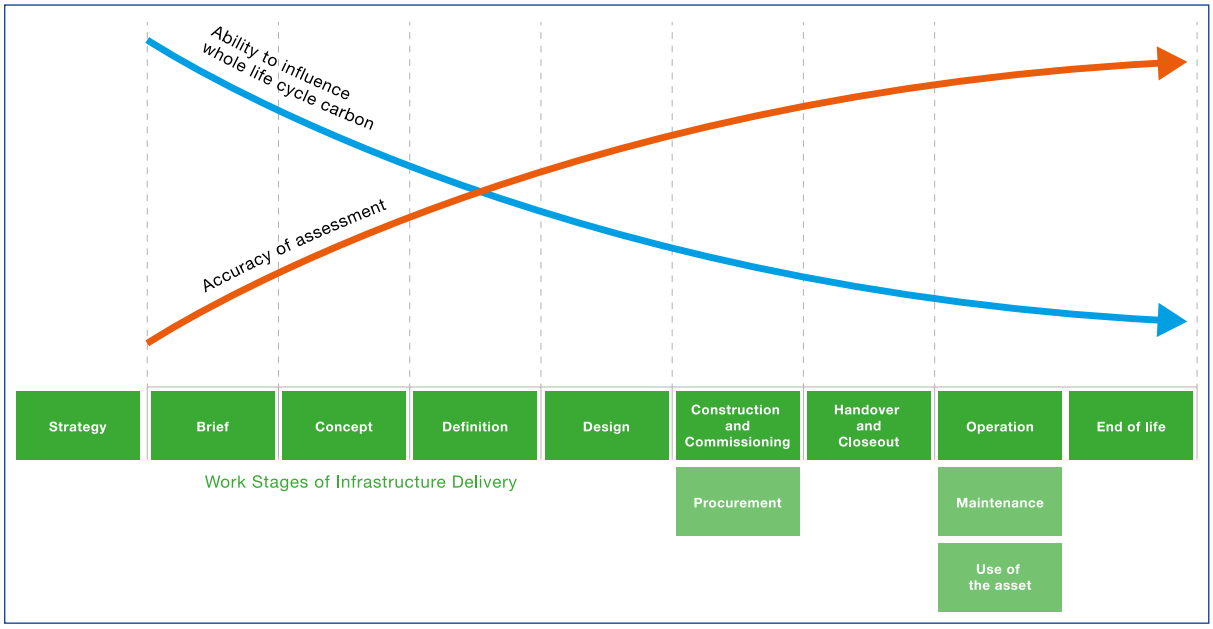
Figure 4 – Conceptual diagram to showing ability to influence carbon reduction across the different work stages of infrastructure delivery



NOTE 1 Figure 4 *is a conceptual representation of how ability to influence whole life cycle carbon and accuracy of assessment develop across the infrastructure delivery work stages. The figure highlights that action to reduce carbon needs to be taken early in the work stages before accurate information may be available. This figure has been adapted from Chart 1.C. in the Infrastructure Carbon Review.*

NOTE 2 Figure 4 *introduces the infrastructure delivery work stages from Brief through to Operation as presented in PAS 1192:2. For the purposes of the requirements of this PAS and carbon management in infrastructure an additional 'End of life' work stage has been included.*

NOTE *Value chain members should recognise that one of the main challenges for managing and reducing carbon during infrastructure delivery is that the scope for reducing whole life cycle carbon emissions is greater during the initial work stages (stages Brief to Definition) than in the later work stages (stages Design to End of life). On the other hand, the degree of knowledge of the types of assets required to deliver the desired outcomes is smaller at these initial work stages and increases over time. Accuracy requirements for the assessment (or quantification) of whole life cycle carbon emissions would also vary in different work stages (e.g. for data and modelling assumptions that are needed for assessing whole life carbon emissions). The degree of accuracy becomes important only when it affects decisions in each work stage to select the lowest whole life carbon option. Refer to Clause* ***7*** *for quantification specific requirements.*

6.1.3 Carbon emission priorities

All value chain members shall manage whole life carbon as set out in **Figure 7** and place priority on managing carbon emissions that are under their control and on carbon emissions over which they have a direct influence.

In defining the scope of activities for which the value chain member has control, direct influence and influence, all value chain members shall consider how whole life carbon is managed in sector-specific infrastructure assets and programmes of work and the delivery infrastructure services.

NOTE *The "Guidance Document for PAS2080" provides further explanation and examples of control and direct influence.*

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6.1.4 Carbon emissions reduction hierarchy

All value chain members shall engage with other value chain members as early as possible in any collaborative working to identify whole life low carbon solutions, including the selection of relevant low carbon materials and products, innovative design solutions and construction methods. Value chain members shall follow the following carbon emissions reduction hierarchy (in the order of priority shown) when identifying potential opportunities to reduce carbon:

a) Build nothing: they shall evaluate the basic need for an asset and/or programme of works and shall explore alternative approaches to achieve outcomes set by the asset owner/manager;

b) Build less: they shall evaluate the potential for re-using and/or refurbishing existing assets to reduce the extent of new construction required;

c) Build clever: they shall consider the use of low carbon solutions (including technologies materials and products) to minimise resource consumption during the construction, operation and user's use stages of the asset or programme of work;

d) Build efficiently: they shall use techniques (e.g. construction, operational) that reduce resource consumption during the construction and operation phases of an asset or programme of work; or

where this carbon emissions reduction hierarchy is not applied the value chain member shall provide documented justification for not doing so.

6.2 Asset owner/manager requirements

6.2.1 Carbon management process

In addition to Clause **6.1** asset owners/managers shall:

a) Develop a carbon management process that incorporates the following components:
   1) Quantification of GHG emissions
   2) Target setting, baselines and monitoring
   3) Reporting
   4) Continual improvement;

b) Unambiguously identify the assets or programmes of work to which the carbon management process is to be applied;

c) Allocate and communicate unambiguous responsibilities for each aspect of the carbon management process to value chain members involved in the delivery of identified assets or programmes of work;

d) Develop a collaborative environment for all value chain members involved in the implementation of the carbon management process during the delivery of assets and programmes of work.

NOTE *Standards such as BS 11000 Collaborative Business Relationships provide further detail on how to develop and implement collaborative environments which will benefit all aspects of infrastructure delivery. Asset owners/managers can use such a framework to define roles, responsibilities and processes which include all value chain members.*

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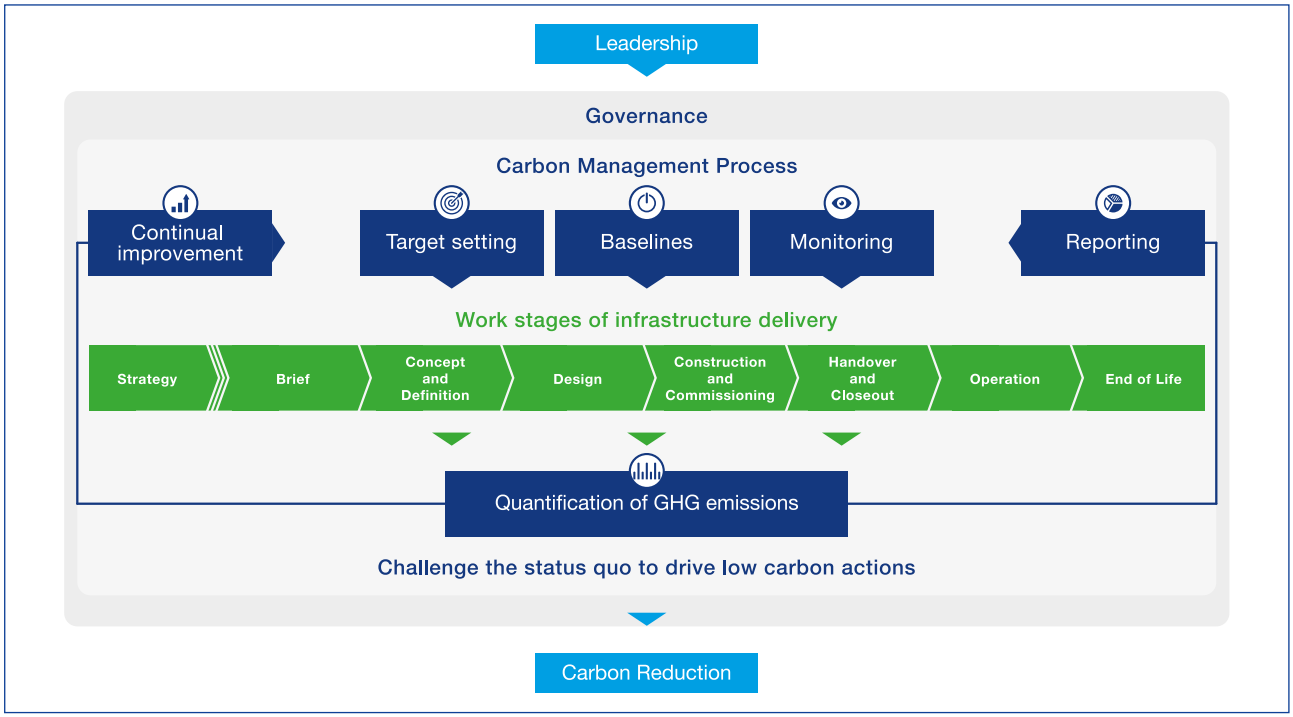
Figure 5 – Carbon management process



6.2.2 Work stages of infrastructure delivery

Asset owners/managers shall apply the carbon management process to the work stages of infrastructure delivery as defined by:

- Strategy
- Brief
- Concept
- Definition
- Design
- Construction and commissioning
- Handover and closeout
- Operation
- End of life

As illustrated in **Figure 5.**

Asset owner/managers shall define the components of the carbon management process during the initial Strategy phase. The latter shall be driven by the organization's leadership and governance (Clause **5**).

NOTE *The work stages set out above have been adopted from PAS 1192-2:2013 for information management in construction. PAS 1192-2 refers to the work stages as 'information processes'. This framework is adopted because it represents current good practice in infrastructure information management (including information to inform carbon management), over the asset life cycle.*

6.3 Designer requirements

In addition to Clause **6.1** designers shall:

a) Unambiguously identify the part of their organization, as demonstrated through work on selected assets and/or programmes of work, to define the scope of activity to which the carbon management process is to be applied;

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b) Share details of their own carbon management process (Clause **6.1.1**) with the asset owner/manager and other relevant value chain members.

c) Where the designer believes that improvements can be made to the asset owners/managers approach to carbon management, designers shall propose such improvements to the asset owners/manager and encourage their use in the delivery of assets and programme of work;

d) Where carbon management improvement proposals are made by designers, they shall be documented in evidence of their submission to the asset owner/manager, supported by the anticipated benefits to the carbon management process and record of the outcome'

6.4 Constructor requirements

In addition to Clause **6.1** constructors shall:

a) Unambiguously identify the part of their organization, as demonstrated through work on selected assets and/ or programmes of work, to demonstrate the scope of activity to which the carbon management process is to be applied.

b) Share details of their own carbon management process (Clause **6.1.1**) with the asset owner/manager and other relevant value chain members.

c) Where the constructor believes that improvements can be made to the asset owners/managers approach to carbon management, constructors shall propose such improvements to the asset owners/manager and encourage their use in the delivery of assets and programme of work.

d) Where carbon management improvement proposals are made by constructors, they shall be documented in evidence of their submission to the asset owner/manager, supported by the anticipated benefits to the carbon management process and record of the outcome'

6.5 Product/material supplier requirements

In addition to Clause **6.1**. product/material suppliers shall:

a) Unambiguously identify the part of their organization, as demonstrated through work on selected assets and/ or programmes of work, to demonstrate the scope of activity to which the carbon management process is to be applied.

b) Share details of their own carbon management process (Clause **6.1.1**) with the asset owner/manager and other relevant value chain members.

c) Where the product/material supplier believes that improvements can be made to the asset owners/managers approach to carbon management, product/material suppliers shall propose such improvements to the asset owners/manager and encourage their use in the delivery of assets and programme of work.

d) Where carbon management improvement proposals are made by product/ material suppliers, they shall be documented in evidence of their submission to the asset owner/manager, supported by the anticipated benefits to the carbon management process and record of the outcome'

***NOTE** THE CARBON MANAGEMENT PROCESS: Throughout this PAS and the guidance document that supports it, the various components of the Carbon Management Process are flagged by a set of icons intended to assist component recognition, as follows:*

Continued Improvement

Target setting

Baselines

Monitoring

Reporting

Quantification of emissions

Throughout this document, 'component icons' are each hyper linked to the next instance of use.

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7 Quantification of GHG emissions

The quantification of GHG emissions allows carbon hotspots to be identified and informs carbon reduction strategies. A robust methodology gives confidence that all value chain members are following consistent practice. This, in combination with the principle of transparency, will enable results to be compared or for variations to be accounted for by highlighting differences in methodologies.

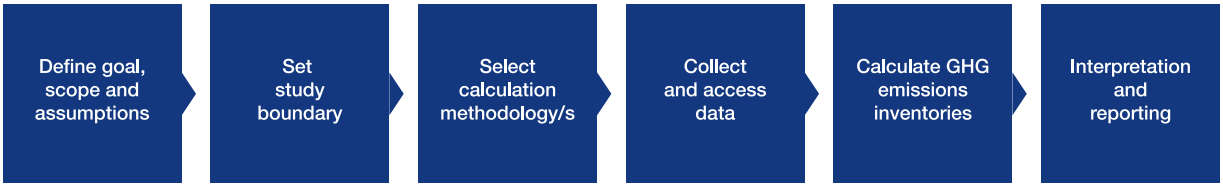
7.1 Requirements for all value chain members

All value chain members shall:

a) Put systems in place within their organizations to ensure they are capable of quantifying GHG emissions for assets and programme of works based on the steps shown in **Figure 6**;

b) Challenge other value chain members to strengthen the robustness of GHG emission quantification studies undertaken to achieve greater consistency and accuracy. Challenge includes providing advice on the ambition of study objectives, the quantification methodology applied, tool options, and data quality.

Figure 6 – Principal steps of GHG emissions quantification



7.1.1 Define study goal and scope

The practitioner shall define and document the goal and scope of the GHG quantification to ensure that it is consistent with the intended audience and the intended use of results. The study goal and scope shall describe:

a) The goal of the GHG emissions quantification;

b) The system that is the subject of a quantification;

c) The function of the system (i.e. its performance characteristics);

d) The functional unit (see Clause **7.1.2** where relevant);

e) The system boundary (see Clause **7.1.3**);

f) Allocation procedures (where relevant);

g) The quantification methodology to be applied (see Clause **7.1.4**);

h) How GHG emissions information will be interpreted and used in decision-making;

i) Data quality requirements appropriate to the study goal and the life cycle stage at which an assessment has been made (see Clause **7.1.5.3**);

j) Assumptions, limitations and constraints;

k) The study review process, ensuring it is appropriate and proportionate to the intended use of the assessment and size of the asset or programme of works.

7.1.2 Function and functional equivalence of studied systems

Where relevant to the GHG emissions quantification, the practitioner shall use a functional unit that describes the performance characteristics of the system. The functional unit shall:

a) Be relevant to the asset or programme of works being studied and take account of function, a quantity, a duration, and a quality of the infrastructure asset or programme of work being assessed;

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b) Allow the performance characteristics of the studied system to be compared.

NOTE 1 *A functional unit can assist in defining baselines and comparing options for infrastructure delivery. For example, when comparing the GHG emissions outcomes of two separate assessments where the studied systems serve the same purpose, then functional unit can aid in decision making, particularly when study boundaries, input inventories, and other relevant aspects are not always directly equivalent. Organizations may choose to quantify the performance of options using more than one functional unit.*

NOTE 2 *NThe inherent nature of infrastructure means that on occasion it may provide additional functions beyond those originally envisioned by the asset owner/manager and as defined by the functional unit. Where relevant the associated benefits or loads – on a GHG emissions basis – of this additional functionality might be included in a quantification study. Where a practitioner chooses to include so called additional infrastructure benefits or loads, they should be reported in module D (**Figure 7**).*

7.1.3 Study boundaries

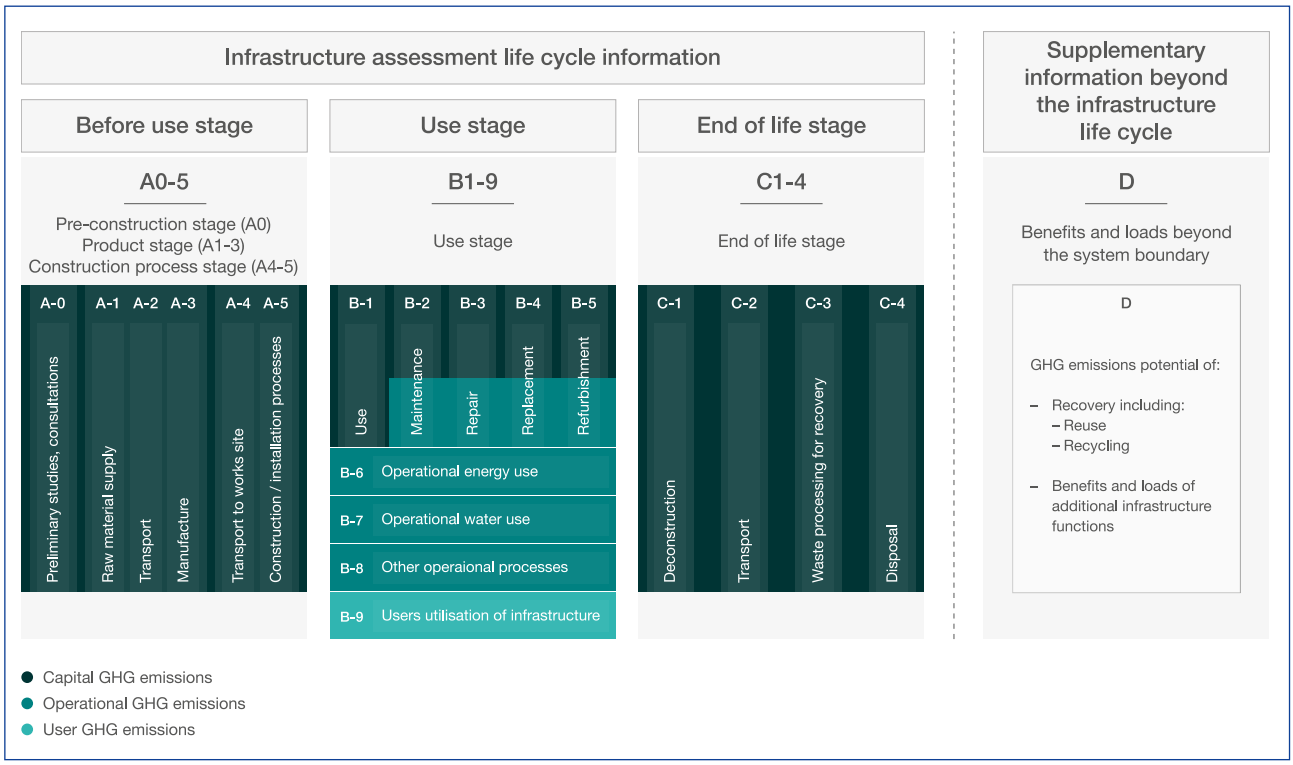
7.1.3.1 Boundary application principles

The practitioner shall apply system boundaries, use data that is consistent with, and report, using the modular approach presented in **Figure 7.**

A GHG emissions quantification shall cover all life cycle modules including A, B and C with module D seen as optional (Clause **7.1.3.3** and **Annex A**).

NOTE *A whole life cycle based approach to GHG emissions quantification avoids un-intended consequences, helping to ensure a balanced perspective by showing the gross size/scale of emissions and when they occur. In this way informed decisions can be made supporting optimum low carbon outcomes.*

Figure 7 – Modular approach showing the life cycle stages and individual modules for infrastructure GHG emissions quantification



NOTE 1 Figure 7 *provides a framework for the quantification of GHG emissions for an infrastructure asset or programme of works and corresponds to the modular structure for information reporting used for Environmental Product Declarations (EPD) for construction products, processes and services following a structure consistent with the principles set out in BS EN 15978:2011 and BS EN 15804:2012.*

NOTE 2 Figure 7 *is taken from BS EN 15978:2011 and has been adapted for PAS 2080 and infrastructure.*

NOTE 3 Figure 7 *is to be read in conjunction with Annex A and the Guidance Document to PAS 2080 which provides descriptions and worked examples of the modular life cycle boundaries.*

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7.1.3.2 Inclusions

The practitioner shall:

a) Apply a study boundary that reflects the system under study including:
   - The physical scope of the activities taking place (physical characteristics);
   - The life cycle stages relevant to the goal of the assessment;

b) Ensure that all activities controlled by the asset owner/manager are included in the system boundary;

c) Ensure that all activities over which the asset owner/manager has influence are included in the system boundary;

d) Clearly document the study system boundary.

NOTE *The principal elements of a system boundary are defined by the different infrastructure life cycle stages shown in* ***Figure 7.***

7.1.3.3 Cut off rules

The practitioner shall:

a) Include in the system boundary all the activities leading to GHG emissions relevant to the system being assessed as outlined in Clause **7.1.3**;

b) exclude only activities that do not significantly change the result of the quantification, using sensitivity analysis to demonstrate that such exclusions are not significant.

c) Apply the following provisions to any exclusion of inputs or outputs to the study system:
   - All inputs and outputs to any process for which data are available are always included;
   - Data gaps may be filled by conservative assumptions using generic data (subject to data quality requirements, Clause **7.1.5.3**);
   - The total excluded input or output flows per module shall be a maximum of 5% of energy usage and mass;

   Expert judgement by the practitioner shall be used to determine compliance with these criteria;

d) Justify and document any exclusions applied to the study system including any assumptions and criteria used to decide them.

7.1.3.4 Study period

The practitioner shall carry out the quantification on the basis of a chosen reference study period:

a) The default value for the reference study period shall be the required service life of the infrastructure asset;

b) Where infrastructure industry standards on deriving the required service life exist, these shall have priority in informing the choice of the value used by the study.

NOTE 1 *The reference study period may differ from the required service life. This may be the case for example if an elemental component of infrastructure is being studied which has a shorter life (i.e. a reference study period is 30 years) than a broader infrastructure asset or system into which it is being incorporated (i.e. the asset has a required service life of 120 years).*

NOTE 2 *.Guidance given in standards ISO 15686-1, -2, -7 and -8 may be useful in assigning appropriate reference study periods and required service life values.*

7.1.4 GHG emissions quantification methodology

The practitioner shall:

a) Select and use GHG emission quantification methodologies that assess and reasonably minimize uncertainty and yield accurate, consistent and reproducible results;

b) Where it is available, and there is confidence in its accuracy, use directly measured data.

NOTE *Quantification methodologies can be commonly classified into the following types:*

1. Calculation based;

2. Measurement based;

3. A combination of calculation and measurement based.

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7.1.5 Collect and access study inventory data

7.1.5.1 Data collection

The practitioner shall use study data in the quantification of GHG emissions that are consistent with the stated study goal, scope, and study boundaries. The practitioner shall record whether actual or forecast data are used in the quantification.

NOTE 1 *To undertake a GHG emissions quantification for an asset or programme of works, data for the study system will be required. This will include data on the activities occurring and GHG emissions factors for these activities. Depending on the work stage at which a quantification is made, either part or all of the quantification may be based on data which is predictive in nature (i.e. something that is forecast or planned to occur), or is based on actual activity data (e.g. recorded amounts of consumption).*

7.1.5.2 GHG emission factor data

The practitioner shall present emission factors in carbon dioxide equivalents (CO_2e) which cover all relevant GHGs within the system.

NOTE 1 GHG *emission factors are a value for 'GHG emissions per unit of activity'. GHG emission factors may be representative of a single process or multiple processes spanning multiple life cycle stages.*

NOTE 2 *It may be necessary to apply multiple GHG emission factors for the same activity when assessing infrastructure assets over long study periods. This may be appropriate when future GHG emissions for that activity are expected to reduce. Examples where this might be appropriate include:*

– *Accounting for the GHG emission reduction of an energy grid and the outcome of this on any demand side functions (i.e. highway lighting, electric trains, water pump energy loads, etc.).*

– *The shift in fuel mix of a vehicle fleet or construction plant over time.*

7.1.5.3 Data quality rules

The practitioner shall:

a) Use the most representative, accurate and plausible data in the study;

b) First define, and then apply, data quality requirements in terms of the following criteria:
   - Age (age of data, and the period over which they have been collected);
   - Geography (the region or country from where the data have originated);
   - Technology (whether the data are specific to a particular technology or mix of many);
   - Methodology (the approach applied to gather or calculate the data);
   - Competency (proficiency of entity that developed the data).

7.1.5.4 Types of data for GHG emissions quantification

The practitioner shall:

a) Use activity data that are specific to the system under study to quantify the GHG emissions of an asset or programme of work;

b) Combine activity data with GHG emission factors to determine the GHG emissions associated with the asset or programme of works;

c) Use **Table 2** to guide the selection of data and its appropriateness for use in infrastructure GHG emissions quantification across work stages.

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Table 2 – Types of data for GHG emissions quantification

Preferred data	Selected work stages				
	Strategy, Brief and Concept	Design	Construction and commissioning	Operation	End of life
Generic: data typical of the type of component, product and/or material to be used	X	X	O	O	O
Specific: data specific to a manufacturers particular component, product and/or material	O	X	X	X	X
Average: data averaged across different manufacturers or production sites /lines for the same product and/or material	X	X	X	X	X
Collective: data created according to BS EN 15804 representing a category of products	O	X	X	X	X
Measured: data gathered from direct measurement for a component, product and/or material			X	X	X
Other	O	O	O	O	O
NOTE *Cross (X) represents the preferred use of data; Circle (O) represents alternative sources if available.*					

NOTE 1 *Derived from BS EN 15978:2011 and adapted for PAS 2080.*

7.1.6 Study uncertainty

The practitioner shall:

a) Evaluate the uncertainty of any GHG emissions study findings taking account of the methodology applied (i.e. Clause **7.1.4**);

b) Consider whether the level of uncertainty might significantly affect the outcome of the study and if so, take additional steps to either reduce uncertainty or increase confidence in results.

NOTE 1 *Uncertainty may arise from the quality of data, emission factors, selection of study period and the scope and boundaries selected.*

NOTE 2 *It is unlikely that all sources of uncertainty can be eliminated from a quantification, and the approach to minimising uncertainty should be proportionate to the analysis being undertaken. The uncertainty may be reduced by, for example, testing the upper and lower limits of certain input parameters, testing for inclusions and exclusions or modifying the study period, and noting whether this would change the outcome of any decision which may be made, or how results may be interpreted when reported.*

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7.1.7 Quantification of GHG emissions

The practitioner shall:

a) Apply the following logic in the quantification of GHG emissions and removal:

b) Sum individual calculations to form a GHG emissions inventory for the quantification as a whole; and where relevant, determine GHG emissions on the basis of functional unit, and against baseline or target value.

NOTE *Emission factors may already be expressed in CO_2 equivalents. In these cases, it should be understood which global warming potentials were applied. Care should be taken to make sure that factors are as consistent as possible and where differences exist they should be documented.*

7.1.8 GHG emission quantification tools

Where value chain members use GHG emission calculators/tools, they shall be consistent with the requirements of Clause **7**.

NOTE *The "Guidance Document for PAS2080" sets out considerations for selecting and using software tools in GHG emissions quantification.*

7.2 Asset owner/manager requirements

The asset owner/manager shall:

a) Put systems and processes in place for the GHG emissions quantification of assets and programmes of work;

b) Identify which value chain member is responsible for GHG emissions quantification at each work stage of infrastructure delivery;

c) Set out the requirements of each value chain member and the roles and responsibilities they must fulfil as part of supporting the GHG emissions quantification process shown in **Figure 6**;

d) Set out the objective of the GHG emissions quantification including identifying the intended audience and what results will be used for;

e) Set out the overarching principles for the GHG emissions quantification relating to study goal and scope, study boundaries, inclusions, quantification methodology, study uncertainty, data quality, and quantification tools as required by Clause **7.1**;

f) Set out the frequency of GHG emissions quantifications during the delivery of assets and programmes of work, to ensure that GHG quantification sufficiently informs decision-making in reducing whole life carbon emissions.

7.3 Designer requirements

Designers shall:

a) Quantify GHG emissions of design options using an approach that is consistent with the requirements of Clauses **7.1** and **7.2b)** through to **7.2 f)** (inclusive) as defined by the asset owner/manager;

b) Where opportunity for improvement to the asset owner/manager's approach to GHG emissions quantification is identified, to recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work.

c) Where GHG emissions improvement proposals are made by designers, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the quantification and record of the outcome.

d) Report GHG emissions of design options to other value chain members showing where the greatest emissions occur;

e) Where appropriate agree the use of software tools for the quantification of GHG emissions.

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7.4 Constructor requirements

Constructors shall:

a) Quantify the GHG emissions of construction work activities using an approach that is consistent with the requirements of Clauses **7.1** and **7.2 b)** through to **7.2 f)** (inclusive) as defined by the asset owner/manager;

b) Where opportunity for improvement to the asset owner/manager's approach to GHG emissions quantification is identified, to recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work.

c) Where GHG emissions improvement proposals are made by constructors, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the quantification and record of the outcome

d) Report GHG emissions of construction works to other value chain members showing where the greatest emissions occur;

e) Quantify and report as-built capital carbon emissions to help improve baseline data;

f) Work with product and material suppliers to collect and use inventory data (Clause **7.1.5)** to inform GHG emissions quantification studies.

7.5 Product/material supplier requirements

Product/material suppliers shall:

a) Use the framework presented in **Figure 7**, to quantify the GHG emissions of their activities and subsequent products/materials (including their direct operations and those of their supply chain) for inclusion in GHG quantification studies by other value chain members;

b) Establish systems to gather specific inventory data from their operations, relevant to the supply of their products/materials and their GHG emissions;

c) When requested support the GHG emissions quantification of their products/materials with third party accreditation;

d) Periodically review GHG emissions quantification methodologies they apply to ensure they reflect current good practice;

e) Proactively share GHG emissions quantification information of their products/materials with the asset owner/manager.

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8 Target setting, Baselines and Monitoring

Setting carbon reduction targets provides clear direction and communicates intent for carbon reduction. Targets should be set against clear baselines so that performance against them can be determined. This should be underpinned by robust monitoring at frequent intervals during infrastructure delivery to highlight progress of carbon reductions against set targets.

8.1 Requirements for all value chain members

8.1.1 Carbon reduction targets

All value chain members shall:

a) Adopt the carbon reduction targets set by the asset owner/manager as a minimum (Clause **8.2.1**);

b) Communicate and share carbon targets with other value chain members.

8.1.2 Baselines

All value chain members shall:

a) Collect data relevant to their activities and roles within infrastructure delivery for asset and/or programmes of works carbon baselines;

b) Take into account limitations in the accuracy of baselines when making comparisons against their activities during infrastructure delivery and transparently report these against any claims of reductions achieved.

8.2 Asset owner/manager requirements

8.2.1 Carbon reduction targets

In addition to Clause **8.1** the asset owner/manager shall set carbon reduction targets (i.e. capital, operational and/or whole life carbon) that:

a) Relate to a defined outcome (based on the functional unit set for the asset or programme of works defined in Clause **7.1.2**);

b) Will be achieved within a fixed timescale by which the desired outcome is achieved;

c) Where appropriate, align with sector-level or wider national/international carbon reduction targets.

NOTE *Targets may be set to apply to the whole asset or programmes of work, or parts therein. Where targets are set for individual elements of work or for specific work stages, the asset owner/manager should, in line with Clause **8.1.1**, communicate these specific targets to the relevant parts of the value chain.*

8.2.2 Baselines

In addition to Clause **8.1** asset owners/managers shall set baselines which:

a) Create a reference level against which future performance can be compared with respect to the desired outcome;

b) Assist with finding carbon emissions hotspots, on which to focus efforts to reduce emissions;

c) Transparently state any assumptions used to fill data gaps and the limitations this may have on the relevance of the baseline;

d) Follow the principles of GHG emissions quantification (Clause **7**);

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e) Follow a process of continual improvement to ensure future baselines reflect current good practice in GHG emissions quantification.

NOTE *There may be limitations when setting baselines for the first time where there is not enough existing data within an organization, or relevant secondary data to produce baselines which follow the principles for GHG emissions quantification (Clause **7**). In such instances the best available data is chosen to allow the most valid comparisons against the design. It is critical however that mechanisms are put in place that require the collection of relevant data from the value chain during infrastructure delivery so improved baselines can be created for future assets and programmes of works.*

8.2.3 Monitoring

In addition to Clause **8.1** asset owners/managers shall:

a) Develop appropriate KPIs to monitor carbon emissions, which are:
   - Developed with the same functional unit as used in baseline and target setting;
   - Incorporated into a governance system which makes the collection and reporting of KPI data a pro-active process;
   - Not overly burdensome to particular value chain members, with data gathering and reporting requirements shared across the value chain;

b) Set and communicate to all value chain members the monitoring regime and frequency of reporting during the delivery of assets or programmes of work;

c) As a minimum, monitor carbon emissions during all infrastructure work stages or at key points where decisions are made that influence whole life carbon reduction;

d) Report and review KPIs regularly to identify any further actions required to meet targets.

NOTE *Asset owners/managers can decide the frequency of quantification and monitoring of GHG emissions against the baseline. This will depend on the nature of the asset or programme of work being delivered. For example, for an asset with significant construction duration (e.g.>2 years) asset owners/managers may choose to quantify and monitor progress of capital carbon during construction in order to ensure a capital carbon target is being met.*

8.3 Designer requirements

8.3.1 Carbon reduction targets

In addition to Clause **8.1** designers shall:

a) Where opportunity for improvement to the asset owner/manager's approach to setting carbon reduction targets is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work.

b) Where carbon reduction target improvement proposals are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the carbon reduction target and record of the outcome.

8.3.2 Baselines

In addition to Clause **8.1** designers shall:

a) Help setting baselines, where requested by the asset owner/manager, by providing relevant activity data to support their development;

b) Where opportunity for improvement to the asset owner/manager's approach to setting baselines is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work;

c) Where baseline improvement proposals are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the quantification and record of the outcome;

d) Collect relevant data during the design of assets or programmes of work and communicate such data to the asset owner/manager so it can be used in future baselines.

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8.3.3 Monitoring

In addition to Clause **8.1** designers shall:

a) Monitor the predicted carbon emissions of the elements of design for which they are responsible at appropriate, agreed infrastructure work stages and report these against the asset owner/manager's carbon reduction targets at the required frequency;

b) Where opportunity for improvement to the asset owner/manager's approach to monitoring is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work;

c) Where monitoring improvement proposals are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the quantification and record of the outcome;

d) Identify carbon hotspots in the design of the asset or programme of work and report these to the asset owner/manager and other value chain members on regular intervals.

8.4 Constructor requirements

8.4.1 Carbon reduction targets

In addition to Clause **8.1** constructors shall:

a) Where opportunity for improvement to the asset owner/manager's approach to setting carbon reduction targets is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work.

b) Where carbon reduction target improvement proposals are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the carbon reduction target and record of the outcome

8.4.2 Baselines

In addition to Clause **8.1** constructors shall:

a) Assist asset owners/managers set baselines, where requested by the asset owner/manager, by providing relevant activity data to support their development;

b) Where opportunity for improvement to the asset owner/manager's approach to setting baselines is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work;

c) Where baseline improvement proposals are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the quantification and record of the outcome;

d) Collect relevant data during the construction of assets or programmes of works and communicate these to the asset owner/manager so these can be used in future baselines.

8.4.3 Monitoring

In addition to Clause **8.1** constructors shall:

a) Monitor carbon emissions of construction and where appropriate commissioning activities, during the relevant infrastructure work stage for the purpose of affecting performance against the carbon realigning target;

b) Where opportunity for improvement to the asset owner/manager's approach to monitoring is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work;

c) Where monitoring improvement proposals are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the quantification and record of the outcome;

d) Identify and report where the greatest carbon emissions have occurred and where future reductions can be made.

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8.5 Product/material supplier requirements

8.5.1 Carbon reduction targets

In addition to Clause **8.1** product/material suppliers shall:

a) Where opportunity for improvement to the asset owner/manager's approach to setting carbon reduction targets is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work.

b) Where carbon reduction target improvement proposals are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the carbon reduction target and record of the outcome

8.5.2 Baselines

In addition to Clause **8.1** product/material suppliers shall:

a) Assist asset owners/managers set baselines, where requested by the asset owner/manager, by providing relevant activity data to support their development.

b) Where opportunity for improvement to the asset owner/manager's approach to setting baselines is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work;

c) Where baseline improvement proposals are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the quantification and record of the outcome;

d) Ensure that, when claims are made that a product or material will reduce carbon compared to another product or material, these claims align with the baselines specified by the asset owner/manager.

8.5.3 Monitoring

In addition to Clause **8.1** product/material suppliers shall:

a) Put systems in place in their own organization to monitor carbon emissions of their own product/material development processes

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9 Reporting

Reports should make carbon reduction performance visible at different infrastructure work stages and inform decision-making in managing whole life carbon. This should be done with sufficient frequency to enable progress monitoring against targets and continuous improvement over the duration of the project or programme.

9.1 Requirements for all value chain members

There are no common requirements to all value chain members.

9.2 Asset owner/manager requirements

Asset owners/managers shall:

a) Report whole life carbon emissions during the delivery of assets or programmes of work, relevant to the objective of the carbon emissions quantification;

b) Set out and communicate to all value chain members the reporting requirements for the infrastructure asset or programme of work, using the modular structure for information reporting (**Figure 7**);

c) Set out the requirements of each value chain member and the roles and responsibilities they must fulfil as part of the asset and programme of work reporting process;

d) Set out the frequency of reporting during the delivery of assets and programmes of work;

e) Disseminate the reporting requirements to all value chain members;

f) Report results of carbon emissions quantification to relevant stakeholders at a frequency sufficient to allow carbon reductions to be implemented and inform the continual improvement process (see Clause **10**).

NOTE 1 *The Guidance Document provides details of the appropriate content of reports prepared in accordance with the PAS*

NOTE 2 *'relevant stakeholders' refers to those involved in the delivery or maintenance of infrastructure assets who have an interest in or influence on GHG emissions falling within the boundary defined for the assessment or carbon management process.*

9.3 Designer requirements

Designers shall:

a) Report, carbon emissions according to requirements and frequency defined by the asset owner/manager during the delivery of assets or programmes of work;

b) Where opportunity for improvement to the asset owner/manager's approach to reporting is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work;

c) Where reporting improvement proposals are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the quantification and record of the outcome.

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9.4 Constructor requirements

Constructors shall:

a) Report, carbon emissions according to the requirements and frequency defined by the asset owner/manager during the delivery of assets or programmes of work.

b) Where opportunity for improvement to the asset owner/manager's approach to reporting is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work;

c) Where reporting improvement proposals are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the quantification and record of the outcome.

9.5 Product/material supplier requirements

Product/material suppliers shall:

a) Report, carbon emissions according to the requirements and frequency defined by the asset owner/manager during the delivery of assets or programmes of work;

b) Where opportunity for improvement to the asset owner/manager's approach to reporting is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work;

c) Where reporting improvement proposals are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the quantification and record of the outcome.

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10 Continual Improvement

Continual improvement is a core part of the carbon management process and allows lessons learned from applying the carbon management process components to improve the delivery of future assets and programmes of work. Continual improvement also allows organizations to embark on the low carbon journey without having comprehensive carbon data or low carbon solutions at the outset and allows them to gradually improve their carbon management maturity.

10.1 Requirements for all value chain members

All value chain members shall:

a) Establish a process of continual improvement and embed in the relevant carbon management process components (Clause **6.2.1**);

b) Seek the input of all value chain members to the process of continual improvement of their own activities during infrastructure delivery;

c) Capture carbon emissions information and share with other value chain members in order to facilitate benchmarking and continual improvement in future carbon management between organizations within infrastructure sectors;

d) Capture carbon reduction solutions and share learning with other value chain members to inform future current good practice

NOTE 1 *Organizations within the infrastructure value chain may already use approaches to continual improvement at an asset or programme level (e.g. ISO 14001 or ISO 9001). These are generally based on a 'process approach' using the Plan Do Check Act (PDCA) method. This Clause is designed to be compatible with these existing approaches to continual improvement.*

NOTE 2 *Where existing management systems are in place, it may be appropriate for the carbon management process to form part of an existing system or to align closely with it (e.g. as part of an ISO14001-compliant Environmental Management System).*

10.2 Asset owner/manager requirements

10.2.1 Continual improvement of Baselines and Quantification

In addition to Clause **10.1** asset owners/managers shall:

a) Adapt their GHG quantification methodology, as data availability improves, to minimise uncertainty and produce accurate, consistent and reproducible quantification results (Clause **7.1.4**)

b) Build up an inventory of the most relevant data to use when developing baselines and quantify carbon emissions at different infrastructure work stages.

c) Update the asset or programme of work baselines at appropriate points during infrastructure delivery to ensure that carbon reductions cannot be claimed when they are based on outdated and/or inappropriate baselines.

10.2.2 Continual improvement of Targets

Asset owner/managers shall periodically review their targets to ensure they are challenging and promote innovate lower carbon solutions whilst still aligned to their defined outcomes.

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10.3 Designer requirements for continual improvement of Baselines and Quantification

In addition to Clause **10.1** designers shall:

a) Provide input to the processes of continual improvement of the carbon management process for the delivery of assets and programmes of work.

b) Where opportunity for improvement to the asset owner/manager's approach to continual improvement of baselines and quantification is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work;

c) Where proposals for improvement to the asset owner/ manager's approach to continual improvement are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the continual improvement of baselines and quantification and record of the outcome.

10.4 Constructor requirements for continual improvement of Baselines and Quantification

In addition to Clause **10.1** constructors shall:

a) Provide input to the processes of continual improvement of the carbon management process for the delivery of assets and programmes of work;

b) Where opportunity for improvement to the asset owner/manager's approach to continual improvement of baselines and quantification is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work;

c) Where proposals for improvement to the asset owner/ manager's approach to continual improvement are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the continual improvement of baselines and quantification and record of the outcome.

10.5 Product/material supplier requirements for continual improvement of Baselines and Quantification

In addition to Clause **10.1** product/material suppliers shall:

a) Provide input to the processes of continual improvement of the carbon management process for the delivery of assets and programmes of work.

b) Where opportunity for improvement to the asset owner/manager's approach to continual improvement of baselines and quantification is identified, recommend and where accepted, assist in its implementation in the delivery of assets and programmes of work;

c) Where proposals for improvement to the asset owner/ manager's approach to continual improvement are made, they shall be documented in evidence of their submission to the asset owner/ manager, supported by identification of the anticipated benefits to the continual improvement of baselines and quantification and record of the outcome.

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11 Assessment of carbon reductions

11.1 Requirements for all value chain members

All value chain members shall:

a) Assess and record any carbon emission reductions planned and/or achieved for the asset and/or programme of work at the earliest opportunity

b) Demonstrate how the carbon emissions reduction hierarchy (Clause **6.1.4**) has been considered and document relevant evidence to substantiate any claimed reductions

c) Document at which work stages carbon reductions have been achieved and whether the reductions are forecast or have been delivered

d) Use the documented evidence to share current good practice at organizational and sector level

e) Put systems in place that ensure that any carbon reduction claims are consistent with the requirements of Clause **9** on reporting and Clause **12** on claims of conformity to PAS 2080

f) ensure that the quantification of any carbon emission reductions is not founded on changes to the GHG emissions quantification methodology used (Clause **7**)

NOTE *Where it is possible to demonstrate GHG emissions reduction through the use of low carbon materials or similar, then it is justifiable to make an emissions reduction claim based on using updated GHG emission factor data that is specific to the asset or programme of works under study. A claim will not be valid if the carbon reduction is based on switching to a different source of generic, average or collective data (see Clause **7.1.5.4**).*

11.2 Asset owner/manager requirements

No further requirements

11.3 Designer requirements

No further requirements

11.4 Constructor requirements

No further requirements

11.5 Product/material supplier requirements

No further requirements

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12 Claims of conformity

12.1 General

Where claims of conformity to PAS 2080 are made, the provisions in Clause **12.2** and Clause **12.3** shall apply. These provisions include identification of the type of certification/verification undertaken (Clause **12.2**) and requirements for how the claim shall be expressed (Clause **12.3**).

12.2 Basis of claim

12.2.1 General

The claim shall identify the type of conformity assessment undertaken as one of the following:

a) independent third-party certification in accordance with Clause **12.2.2**;

b) other-party validation in accordance with Clause **12.2.3;** or

c) self-validation in accordance with Clause **12.2.4**.

12.2.2 Independent third-party certification

Infrastructure asset owners/managers seeking to demonstrate that their carbon management process has been independently verified as being in accordance with this PAS shall undergo assessment by an independent third party certification body accredited to provide assessment and certification to this PAS.

12.2.3 Other-party validation

Organizations using an alternative method of validation involving parties other than those qualifying as accredited independent third-parties shall satisfy themselves that any such party is able to demonstrate compliance with recognised standards setting out requirements for bodies providing certification services.

NOTE 1 *Other-party validation bodies are those undertaking assessment services without having achieved accreditation from the authorized accreditation service (e.g. UKAS in the UK). Such bodies could include those which, although independent of the organization undertaking the assessment of GHG emissions, cannot demonstrate complete independence, e.g. a trade body providing assessment services for its members or a consultant employed for such a purpose).*

NOTE 2 *Examples of such recognised standards include BS EN ISO/IEC 17065.*

12.2.4 Self-validation

Organizations shall be able to demonstrate that their carbon management process has been established in accordance with this PAS, and make supporting documentation available on request.

NOTE 1 *The appropriate method for self-validation and for presentation of the results can be determined by reference to BS EN ISO 14064-3 and BS EN ISO 14021.*

NOTE 2 *Organizations for whom neither independent third-party certification nor other-party verification is a realistic option, may rely on self-verification. In so doing, organizations should be aware that independent verification could be required in the event of a challenge and that stakeholders could have less confidence in this option*

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12.3 Permitted forms of disclosure

12.3.1 Asset owners/managers

Claims of conformity shall use the appropriate form of disclosure, as follows:

a) For claims of conformity based on independent third-party certification in accordance with Clause **12.2.2**:

"Carbon management process for [insert unambiguous identification of asset or programme of work] implemented as Asset owner/manager by [insert unambiguous identification of the claimant] in accordance with PAS 2080, [insert unambiguous identification of the certification body] certified."

b) For claims of conformity based on other-party validation in accordance with Clause **12.2.3:**

"Carbon management process for [insert unambiguous identification of asset or programme of work] implemented as Asset owner/manager by [insert unambiguous identification of the claimant] in accordance with PAS 2080, [insert unambiguous identification of the validation body] validated."

c) For claims of conformity based on self-validation in accordance with Clause **12.2.4:**

"Carbon management process for [insert unambiguous identification of asset or programme of work] implemented as Asset owner/manager by [insert unambiguous identification of the claimant] in accordance with PAS 2080, self-validated"

12.3.2 Designers

Claims of conformity shall use the appropriate form of disclosure, as follows:

a) For claims of conformity based on independent third-party certification in accordance with Clause **12.2.2**:

"Carbon management process for work undertaken on [insert unambiguous identification of asset or programme of work] implemented as Designer by [insert unambiguous identification of the claimant] in accordance with PAS 2080, [insert unambiguous identification of the certification body] certified."

b) For claims of conformity based on other-party validation in accordance with Clause **12.2.3:**

"Carbon management process for work undertaken on [insert unambiguous identification of asset or programme of work] implemented as Designer by [insert unambiguous identification of the claimant] in accordance with PAS 2080, [insert unambiguous identification of the validation body] validated."

c) For claims of conformity based on self-validation in accordance with Clause **12.2.4:**

"Carbon management process for work undertaken on [insert unambiguous identification of asset or programme of work] implemented as Designer by [insert unambiguous identification of the claimant] in accordance with PAS 2080, self-validated."

12.3.3 Constructors

Claims of conformity shall use the appropriate form of disclosure, as follows:

a) For claims of conformity based on independent third-party certification in accordance with Clause **12.2.2**:

"Carbon management process for work undertaken on [insert unambiguous identification of asset or programme of work] implemented as Constructor by [insert unambiguous identification of the claimant] in accordance with PAS 2080, [insert unambiguous identification of the certification body] certified."

b) For claims of conformity based on other-party validation in accordance with Clause **12.2.3**:

"Carbon management process for work undertaken on [insert unambiguous identification of asset or programme of work] implemented as Constructor by [insert unambiguous identification of the claimant] in accordance with PAS 2080, [insert unambiguous identification of the validation body] validated."

c) For claims of conformity based on self-validation in accordance with Clause **12.2.4:**

"Carbon management process for work undertaken on [insert unambiguous identification of asset or programme of work] implemented as Constructor by [insert unambiguous identification of the claimant] in accordance with PAS 2080, self-validated."

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12.3.4 Product/material suppliers

Claims of conformity shall use the appropriate form of disclosure, as follows:

a) For claims of conformity based on independent third-party certification in accordance with Clause **12.2.2**:

"Carbon management process for work undertaken on [insert unambiguous identification of asset or programme of work] implemented as Product/material supplier by [insert unambiguous identification of the claimant] in accordance with PAS 2080, [insert unambiguous identification of the certification body] certified."

b) For claims of conformity based on other-party validation in accordance with Clause **12.2.3**:

"Carbon management process for work undertaken on [insert unambiguous identification of asset or programme of work] implemented as Product/material supplier by [insert unambiguous identification of the claimant] in accordance with PAS 2080, [insert unambiguous identification of the validation body] validated."

c) For claims of conformity based on self-validation in accordance with Clause **12.2.4:**

"Carbon management process for work undertaken on [insert unambiguous identification of asset or programme of work] implemented as Product/material supplier by [insert unambiguous identification of the claimant] in accordance with PAS 2080, self-validated."

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Annex A (Normative) Categories of carbon emissions in different infrastructure sectors

A1 Introduction

In this PAS, capital, operational and user carbon are assigned based on the principles of where they arise during the infrastructure life cycle; and on who exerts control/influence on the infrastructure as it is designed/built, operates and is used (**Figure 7**).

They have further been guided by the expenditure categories widely applied across infrastructure management including capital expenditure (CAPEX) and operational expenditure (OPEX). They are broadly consistent with this terminology, but may vary based on the precise interpretations that different organisations and sectors apply.

Practitioners shall work within the frameworks set out in this annex but may choose to deviate in their interpretations of which activities are allocated to which carbon emission modules. Where they do so justification must be made and supported with documentation of any assumptions and criteria used to guide the working approach.

A2 Capital carbon

PAS2080 defines capital carbon as GHG emissions that can be associated with the creation, refurbishment and end of life treatment of an asset.

This follows for all infrastructure sectors which have similar sources of capital carbon. This includes the emissions associated with the use of materials, such as concrete and steel, the use of construction plant, such as excavators or tunnel boring machines, and the transport of materials and plant to construction sites.

This will occur for all construction activities be they directed to new build, maintenance or refurbishment.

Capital carbon emissions also arise at end of life and are associated with demolition, waste processing and any final treatment/disposal. Carbon emissions from transportation which occurs as part of any of these activities is considered to be capital carbon.

A3 Operational carbon

PAS 2080 defines operational carbon as GHG emissions associated with the operation of an asset.

Given the different functions of separate infrastructure sectors, it follows that the origins of operational carbon emissions may vary between sectors. All sectors consume energy, either through direct fuel combustion or from supplied electricity or heat. Direct and indirect carbon emissions associated with this energy are considered as operational energy.

In the water or waste sector, operational carbon emissions may also occur through the use of particular products, technologies or certain chemicals during the use of the asset. In the energy/power sector, fugitive emissions from gas networks, and transmission losses are further examples. In the waste sector, fugitive emissions may occur during the waste treatment or final disposal processes and these are considered as operational carbon.

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A4 User carbon

PAS 2080 defines user carbon as GHG emissions associated with the users' utilisation of infrastructure (i.e. emissions arising from the user utilising infrastructure services).

An example of user carbon emissions can be provided for the roads and highways where emissions arising from vehicles utilising road infrastructure are categorised under user carbon emissions as they represent the user utilising the infrastructure service provided.

The boundary on where to draw this distinction between operational and user carbon is not always clear, for example in the waste sector emissions arising from final disposal of goods could be argued to be both operational or user emissions as the user is utilising the infrastructure but the waste operator is also operating the infrastructure. To differentiate between these, PAS 2080 has used the principle of control and influence. Therefore, asset owner/managers who have a significant level of influence to reduce user emissions through their organizational activities will be allocated the emissions (and hence they shall be termed operational emissions). For example, in the waste sector, the waste collection, disposal and treatment operators do have a level of control over how the waste is disposed of therefore the emissions arising from final disposal are categorised as the waste sectors operational emissions.

A5 Applying carbon emission categories

Table A 1 sets out for all infrastructure sectors the categories of capital, operational and user carbon. This framework shall be used for describing and reporting sources of carbon emissions. Practitioners may choose to deviate from the framework of definitions for capital, operational and user carbon. Where they do so justification must be made and supported with documentation, of any assumptions and criteria used to guide the working approach.

Emissions due to land use change are not included in **Table A 1**. Depending on whether changes in land use lead to emissions or removals, these could be classed as capital or operational carbon.

Operational and user carbon emissions occur only during the use stage of the infrastructure life cycle (**Figure 7**). The assignment of whether an emission is operational or user shall be established based on the principle of control and influence (Clause **3** Terms and definitions).

This is applied by considering which actors in the use stage of the infrastructure life cycle have the ability through their actions to control or directly influence carbon emissions.

If the infrastructure asset owner/manager is the main controlling and influencing, force then the carbon emission is assigned as operational carbon.

If the infrastructure user is the main controlling and influencing force then the carbon emission is assigned as user carbon.

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Table A 1 – Summary of infrastructure sector-specific descriptions of capital, operational and user carbon; this summary is high level and should be read in conjunction with Figure 7 and the specific descriptions documented in Annex A.

Infrastructure Sector	Capital carbon[4]	Operational carbon[5]	User carbon[6]
Energy	Infrastructure which generates, transmits, distributes and stores energy	Energy consumption of the infrastructure itself (auxiliary loads) All energy sector conversion, transmission and distribution losses Any emissions from chemicals used in processes	Emissions associated with the use of energy at the point of energy consumption
Water	Infrastructure including: • Water resources assets: – Rivers, reservoirs and dams • Portable water supply: – Distribution systems, pumping stations and treatment works • Collection and treatment of sewage: – Sewers, pumping stations and treatment works • Distribution: – Pipelines and pumping stations • Flood and coastal defences	Conveyance of water Direct treatment process emissions Energy use for the operation of water assets Chemicals for treatment of water	Energy use for the heating of water in buildings and conveyance of water inside buildings (NOTE: if the product sold is hot water, then energy use associated with the heating of water would instead be classed as operational carbon)
Transport	Infrastructure covering all road, rail, aviation, and marine /inland water modes	Energy for street and public realm lighting Energy for pumps, control and automation systems, signage, signalling etc. Other energy related emissions and operational processes necessary for the operation and management of transport assets Energy and fuel use by vehicles (road, aviation, water and rail) that are owned and operated by asset owners/managers and/or operators providing transport services on the infrastructure	Energy and fuel use by user owned vehicles (road, aviation, water and rail)

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Table A 1 – Summary of infrastructure sector-specific descriptions of capital, operational and user carbon; this summary is high level and should be read in conjunction with Figure 7 and the specific descriptions documented in Annex A. *(continued)*

Infrastructure Sector	Capital carbon[4]	Operational carbon[5]	User carbon[6]
Waste	Infrastructure used for processing, treatment, reuse, recycling and final disposal of waste	Energy used to power waste handling, processing and treatment equipment (to end-of-waste point) Direct emissions arising from any chemicals or other agents used to process and treat waste Transport of waste from point arising to point of recycling/reuse (i.e. to end-of-waste point), and final disposal Direct emissions arising from any process to treat and dispose of waste at point of final disposal	
Communications	Infrastructure for: Voice and data networks (fixed and mobile) Satellite networks TV and radio broadcast networks	Electricity consumption of the networks and data centres Energy and fuel use by vehicles (that are owned and operated by asset owners/managers and/or operators providing services on the infrastructure	End-user device electricity consumption (and any end-user data centres)

4) Refer to Figure 7 for details of capital carbon in the different life cycle modules (e.g. Before use stage: A0, A1, A2, A3, A4, A5; Use stage: B1, B2, B3, B4, B5; End of life stage: C1, C2, C3 and C4)

5) Refer to Figure 7 for details of operational carbon in the different life cycle modules (e.g. Use stage: B2, B3, B4, B5, B6, B7 and B8)

6) Refer to Figure 7 for details of user carbon in the different life cycle modules (e.g. Use stage: B9)

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A6 Carbon emissions over the infrastructure life cycle

Figure 7 illustrates the relationship of capital, operational and user carbon with the detailed life cycle modules. To bring further description to these life cycle modules the tables below provide a more detailed summary on each. Further more detailed guidance is provided in BS EN 15978:2011.

Practitioners may choose to deviate from the modular framework set out in this Annex with the exception that carbon emission benefits and loads as defined by module D shall not be aggregated with other life cycle stage modules. Where practitioners do deviate justification must be made and supported with documentation of any assumptions and criteria used to guide the working approach.

Table A 2 – Before use stage

Boundary stage	Description
Boundary of pre-construction stage (module A0)	Represents preliminary studies and works; for example strategy and brief development, architecture, design efforts, EIA and cost planning. Most if not all these functions will be largely office based functions contributions from across the value chain. In this case carbon emissions might normally be associated with energy use and transportation demands.
Boundary of product stage (modules A1 – A3)	Represents raw material extraction, precursor product processing, and final product manufacture, its energy use, and waste management within these processes. It will include any use of recycled or reuse materials and the process associated with making them ready for incorporation in infrastructure (but not processes that are part of the waste processing of the previous product system). Transportation will include all movement of materials and goods within the supply chain up to the point of final factory gate. Manufacture includes the final product used in the infrastructure but also any pre-product elements it might demand. Packaging and other material demands that may be necessary should also be included.
Boundary of construction process stage (module A4)	Represents transportation (including intermediate storage and distribution) of products/materials and construction equipment (e.g. an asphalt paving machine or a crane) to the infrastructure construction site from point of production (or point of storage in the case of plant and machinery) to site works. This category might also record any carbon emissions associated with environmental conditions required to keep materials in a required state. If waste occurs due to spillage or damage during transport then waste processing of this and provision of new material and subsequent carbon emissions would be recognised here.
Boundary of construction process stage (module A5)	Represents construction site works activities including: • temporary works, ground works, and landscaping • materials storage and any energy or otherwise need to maintain necessary environmental conditions • transport of materials and equipment on site • installation of materials and products into the infrastructure asset • emissions associated with site water demand • waste management activities (transport, processing, final disposal) associated with waste arising from the construction site • production, transportation, and waste management of materials/products lost during works.

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Table A 3 – Use stage

Boundary stage	Description
Boundary of use stage – installed products and materials (module B1)	Called 'Use' this represents the carbon emitted directly from the fabric of products and materials once they have been installed as part of infrastructure and it is in normal use.
Boundary of use stage (modules B2 – B5)	Represents the works activities and new materials for the maintenance, repair, replacement and refurbishment of the infrastructure during the use stage / operation of infrastructure. This is notionally described as capital carbon. However, depending on organisational interpretation, and the way that such activities are delivered through capital and/or operational expenditure budgets, they might alternatively be described as operational carbon emissions.
Boundary of use stage – operational energy (modules B6)	Represents the carbon emissions resulting from the energy used by infrastructure-integrated technical systems to enable it to deliver its service during operation. This might be to provide heating and cooling, ventilation, lighting, auxiliary energy for pumps, control and automation. Both direct and indirect energy sources might be used for such systems including the combustion of fuels in plant and equipment and the consumption of electricity from energy grids. In the case that hot water or steam is purchased to enable infrastructure operation, it should also be included in this module.
Boundary of use stage – operational water (modules B7)	This represents the carbon emissions resulting from the consumption of water required by infrastructure to enable it to operate and deliver its service. It will include all water used and its treatment (pre- and post-use) during the normal operation of the infrastructure. For transport this might include aspects such as water for washing and cleaning trains; or in the case of highways water used for cleaning road surfaces by street cleaning plant. Energy usage associated with providing water to and from infrastructure shall be included in the module B6.
Boundary of use stage – other operational processes (module B8)	Represents other process carbon emissions arising from infrastructure to enable it to operate and deliver its service including management of operational waste. An example is chemicals used in the treatment of water and wastewater or emissions arising from chemical reactions during the wastewater treatment process.
Boundary of use stage – user's utilisation (module B9)	Represents the activities associated with user's utilisation of the infrastructure during the use stage. This is defined by the principle of control and influence where by which the carbon emissions are B9 (user's utilisation) when they arise from an activity that the user has control over. An example is highway vehicle carbon emissions where the user makes the decision as to which type of vehicle they purchase (petrol, diesel, electric etc.), the route they travel, and the load they carry.

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Table A 4 – End of life stage

Boundary stage	Description
Boundary of end of life stage – deconstruction (module C1)	Represents the on-site activities of deconstructing, dismantling and demolishing the infrastructure. For example, emissions arising through the use of plant and transport on site.
Boundary of end of life stage – transport (module C2)	This represents all carbon emissions due to transport to disposal and/or until the end-of-waste state of waste materials arising.
Boundary of end of life stage – waste processing for recovery (modules C3)	Represents the activities associated with treatment and processing for recovery, reuse and recycling of waste materials arising from infrastructure. This includes use of all waste material outputs from dismantling, deconstruction or demolition of the infrastructure and covers all debris, all construction products, materials or construction elements, etc. arising from the infrastructure. All waste processing carbon emission shall be accounted for up until the material reaches the end-of-waste state as defined in BS EN 15978:2011.
Boundary of end of life stage – disposal (module C4)	The boundary includes the carbon emissions resulting from final disposal of demolition materials (neutralisation, incineration with or without utilisation of energy, landfilling with or without utilisation of landfill gases, etc.). Any carbon emission benefits from exported energy (i.e. through substitution) shall be reported into module D. This category also includes any possible post-transportation treatment that is necessary before final disposal.

Table A 5 – Supplementary information beyond the infrastructure life cycle

Boundary stage	Description
Boundary of benefits and loads beyond the infrastructure life cycle (module D)	Includes avoided carbon emissions associated with the infrastructure asset including potential for re-use, recovery and recycling of materials and/or energy and associated carbon emissions beyond the system boundary. Where relevant module D might also be used to record benefits or loads arising from additional functions of infrastructure.

The modularised approach presented in **Figure 7** also sets out the boundary condition of module D. Module D is for the representation of carbon emissions or removals (i.e. climate change benefits and loads) that occur outside the infrastructure life cycle. Therefore, when undertaking a carbon emissions quantification study module D can be used to present:

- avoided carbon emissions associated with the infrastructure asset including the potential for re-use, recovery and recycling of materials; and/or
- aspects such as energy and related benefits (and carbon emissions associated with this) that occur beyond the infrastructure system ;boundary under study;
- benefits or loads arising from additional functions that infrastructure might provide.

Carbon emissions reported in module D shall be reported separately when presenting data by carbon life cycle stage; i.e. it shall not be aggregated with other modules. Carbon emissions reported in module D are not defined as capital, operational and user carbon.

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Annex B (Informative)
Applying the carbon management process

B1 Applying the carbon management process to infrastructure delivery

Annex B summarises how the different carbon management process requirements relate to the infrastructure work stages when delivering assets or programmes of work. It provides an example on how leadership and the other carbon management process requirements could be applied in the delivery of an infrastructure asset or programme of work.

This Annex is informative only in recognition of the fact that processes and commercial arrangements used in the delivery of assets or programmes of work can vary between projects sectors and organizations. Further guidance on how each value chain member can contribute in each infrastructure work stage is provided in the Guidance Document for PAS2080.

Table B1 provides additional guidance, for all value chain members, on applying the requirements of the carbon management process to infrastructure assets or programmes of work. The relevant carbon management process requirements are presented in a timeline using the infrastructure work stages presented in this PAS.

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Table B 1 – Carbon management process responsibilities as they could be applied to an infrastructure asset and/or programme of work

	Strategy	Brief	Concept	Definition	Design	Construction | Commissioning	Handover | Closeout	Operation | Use	End of life
Leadership and Governance	Set objectives for carbon management (in organization and/or asset or programme of work), aligned with business goals. Define roles and responsibilities. Establish robust governance framework for infrastructure delivery	Communicate governance framework throughout value chain. Communicate objectives and carbon reduction targets, internally and externally. Set incentives, where appropriate, to encourage desired behaviours. Assign staff to roles. Delegate internally/externally to deliver carbon management process requirements, as appropriate.		Ensure sufficient (and trained) resources to deliver the carbon management process requirements. Apply governance framework to ensure challenge at each work stage and throughout value chain, to achieve or exceed carbon reduction targets and to promote sharing of current good practice. Recognise and reward innovative behaviours.			Review carbon reduction performance, act on feedback and drive continuous improvement through better data collection, capturing current good practice in carbon reduction, etc.		
Target setting | Baselines | Monitoring	Set measurable targets to achieve objectives. Determine responsibility for carbon baselines.	Challenge carbon targets where there is potential for improvement Develop appropriate and realistic baselines				Capture construction data and feedback to help improve baselines		Capture operational data and feedback to improve baselines.	
Carbon reduction hierarchy	**Build nothing:** Challenge the need for an asset and explore alternative approaches to achieve outcomes that minimise whole life carbon.		**Build less:** Maximise use of existing assets. Optimise operational efficiency to reduce construction and whole life carbon		**Build clever:** Use low carbon materials/ products to minimise resource use and select technologies for efficient operation	**Build efficiently**: Embrace construction techniques that reduce resource consumption.		Operate, maintain (and decommission) efficiently.	
	Identify carbon hotspots in existing asset operation and opportunities for reduction.	Identify carbon hotspots in proposed solutions and opportunities/approaches for reduction. Assess opportunity to reduce capital, operational and user carbon.		Ensure impacts of design on the carbon emissions of construction, future operation and use are minimised.		Minimise material use, transport to site, construction waste and maximise opportunities for reuse/recycling/ recovery.		Minimise operational use of energy, transport, chemicals and other consumables in new or existing assets.	
		Share/develop/deploy low carbon solutions technologies, materials, products or methods to be incorporated into solutions							
Quantification	Set and communicate functional unit(s) for measuring performance. Define and communicate quantification requirements. Identify appropriate data sources. Review suitability of existing tools.	Develop and apply appropriate tools to aid quantification (asset owner/manager could delegate this responsibility).							
		Define goal, scope and assumptions. Establish scope & boundaries of GHG assessment. Select calculation methodology.	Collect and assess data. Calculate GHG emissions. Ensure options are assessed within consistent boundaries. Take account of forecast emissions in operation and use.		Undertake more detailed quantification of forecast GHG emissions, as required.	Assess **actual** GHG emissions from construction up to handover		Assess actual GHG emissions of operation (from actual activity data).	
		Share existing information on GHG emissions quantification of technologies, products and materials considered or used.			Quantify GHG emissions of materials/products supplied, as required				
Reporting	Define reporting requirements and communicate throughout value chain.		Capture data on innovative approaches, technologies, materials and products to be used. Report forecast emissions and performance against targets, in accordance with general principles and reporting requirements.			Capture data on innovative construction techniques, materials and products used. Report actual emissions and performance against targets, in accordance with general principles and reporting requirements.		Report actual emissions and performance against targets, in accordance with general principles.	
		Provide reporting on the performance of technologies, materials and products (to be) used.							
Opportunity to reduce carbon	**Highest**						**Lowest**		

Key to table	Asset owner/manager	Designer	Constructor	Supplier	All parties

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Annex C (Informative) Bibliography

C1 Introduction

This Annex provides reference to a range of external standards and other documents from which asset owners/managers and infrastructure value chain partners seeking to comply with PAS 2080, will be able to select approaches and methodologies that will assist them in doing so. It is recommended that those intending to reference these publications check to ensure that they are consulting the most recent edition.

C2 ISO standards published by BSI and CEN

BS EN ISO 9001: Quality management systems – Requirements.

BS EN ISO 14001: Environmental management systems. Requirements with guidance for use.

BS EN ISO 14021:Environmental labels and declarations. Self-declared environmental claims (Type II environmental labelling).

BS EN ISO 14040: Environmental management – life cycle assessment – Principles and framework (Incorporating corrigendum No. 1)

BS EN ISO 14044: Environmental management – life cycle assessment – Requirements and guidelines (Incorporating corrigendum No. 1)

BS EN ISO 14064-1: Greenhouse gases. Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removal.

BS EN ISO 14064-2: Greenhouse gases. Specification with guidance at the product level for quantification and reporting of greenhouse gas emissions and removal.

BS EN ISO 14064-3: Greenhouse gases. Specification with guidance for the validation and verification of greenhouse gas assertions

PD CEN ISO/TS 14067: Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification and communication.

BS ISO 15686-1: Buildings and constructed assets - Service life planning - General principles and framework.

BS ISO 15686-2: Buildings and constructed assets - Service life planning - Service life prediction procedures.

BS ISO 15686-7: Buildings and constructed assets - Service life planning - Performance evaluation for feedback of service life data from practice.

BS ISO 15686-8: Buildings and constructed assets - Service-life planning - Reference service life and service-life estimation.

BS EN 15978: Sustainability of construction works — Assessment of environmental performance of buildings — Calculation method (Incorporating corrigendum November 2011)

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BS EN ISO/IEC 17021-1: Conformity assessment. Requirements for bodies providing audit and certification of management systems. Requirements.

BS EN ISO/IEC 17065: Conformity assessment. Requirements for bodies certifying products, processes and services.

C3 ISO standards published by BSI

BS ISO 21930: Sustainability in building construction – Environmental declaration of building products.

BS ISO 55000: Asset management - Overview, principles and terminology.

C4 EN standards published by BSI

BS EN 15804: Sustainability of construction works — Environmental product declarations — Core rules for the product category of construction products

BS EN 15978:2011 Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method.

C5 BSI publications

BS 11000-1: Collaborative business relationships. A framework specification

PAS 1192-2: Specification for information management for the capital/ delivery phase of construction projects using building information modelling

PAS 2050: Specification for the assessment of the life cycle greenhouse gas emissions of goods and services.

C6 Other significant documents

Greenhouse Gas Protocol: 2009

HM Treasury UK National Infrastructure Plan 2014

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