NHS

NHS Net Zero Building Standard

Contents

Acknowledgements

NHS England wishes to offer our sincere thanks to everyone who has contributed to the creation of this landmark NHS Net Zero Building Standard, and in particular acknowledge the contribution made by professional bodies, engineering consultants, healthcare specialists, our supply chain, government departments and NHS staff.

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Guidance prompts

To aid navigation and interpretation of the principles and requirements of this Standard, the following navigation prompts are used throughout.

Signpost:

Included in this document throughout are signposts to related documents (often hyperlinked) that provide background or further details relevant to the section. They include policy documents, Building Regulations, or applicable standards.

Rule of Thumb:

The rule of thumb icon indicates where consideration needs to be given to best practice that should be incorporated where feasible within the proposed development.

Whole Life Cycle Carbon Flag:

These flags note where there may be design parameters that require consideration and discussion of different aspects of whole life carbon performance, or other criteria that could impact decision making e.g. cost, risk and complexity. Typically, a flag may also indicate a juncture where the Project Team will need to make a judgement on what is the most appropriate solution or pathway is to meeting the requirements or Energy or Carbon Limits set out within the Standard.

Case Study:

Included in this document are case studies that have been delivered successfully. These projects highlight implementation of best practice and innovation in terms of energy and carbon reduction and provide examples of front runners for integration of emerging technology.

Language usage in the Standard

In the Standard, modal verbs such as "must, "should" and "may" are used to convey notions of obligation, recommendation or permission. The choice of modal verb will reflect the level of obligation needed to be compliant.

The following describes the implications and use of these verbs in the Standard (readers should note that these meanings may differ from those of industry standards and legal documents):

- "must" is used when indicating mandatory compliance with the Standard
- "should" is used to indicate a recommendation (not mandatory/ obligatory), i.e., among several possibilities or methods, one is recommended as being particularly suitable – without excluding other possibilities or methods
- "may" is used for permission, i.e., to indicate a course of action permissible within the limits of the Standard.

Usage examples:

- "All schemes must have an Energy and Carbon Strategy" [obligation].
- "All schemes should be delivering best practice" [recommendation].
- "Reuse of buildings may lead to lower operational energy performance compared to an equivalent new building" [permission].

Named documents

The following table summarises the documents and Compliance Tools that sit alongside the Standard and are required to either demonstrate or achieve requirements outlined within the Standard.

These tools and deliverables have been developed to help assist Project Teams comply with a new process and suite of requirements, and standardise reporting for ease of quality assurance, business case approvals and learning across capital investments.

Term	Description
Energy and Carbon Strategy (early stages) and Report (later design stages)	A combined report used to report the decisions for the building energy source(s), as well as capture other aspects of design decision-making and information that affects the energy and carbon performance of the building across the whole energy hierarchy. Also used as the basis of compliance to the Standard to capture reporting tabs from the Compliance Tools. To be updated across the design stages. See Chapter 5 for more information.
Adaptability Strategy	A building strategy developed at early stages with the Client Team to outline the proposals for building flexibility and convertibility, aligned to the Clinical model and Estate Strategy.
Monitoring (M&V) and verification plan	A Design Team document to establish project specific plans, processes, and responsibilities to monitor and verify building performance across hand-over and over the first three years of performance. The M&V Plan should be considered as early as RIBA 2, to help refine the metering and monitoring strategy for the building and informed by specific building outcomes that need verification. The M&V Plan should then be refined across the detailed design stages and embedded within the construction contract and handover procurement processes.
Whole Life Carbon (WLC) Compliance Tool	This Excel tool is needed to demonstrate compliance against operational Energy Limits, Performance Targets and provides a space allocation tab which is required to determine requirements for both upfront carbon and operational energy.
Operational Energy and Carbon (OE&C) Compliance Tool	This Excel tool is provided to demonstrate compliance against Upfront Carbon Limits and WLC reporting.
Design Management Tool	This Excel tool is provided specifically for the Net Zero Carbon Coordinator to manage the delivery of the net zero carbon requirements and capture qualitative elements of compliance.
NHS Net Zero Building Standard User Guide	A supporting document to help users interpret and apply the requirements within the Standard to their project.

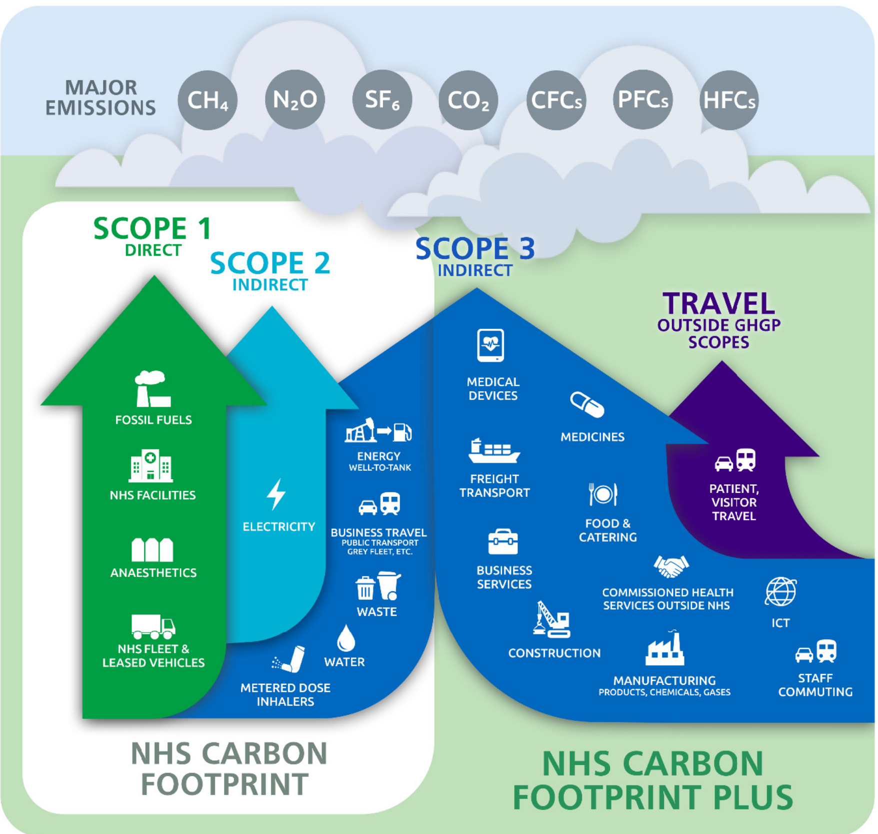
1 Introduction

1.1 Climate change threatens the foundations of good health, with direct and immediate consequences for our patients, the public and the NHS. In 2019, the UK became the first major economy to commit to net zero emissions by 2050. In 2020, the NHS became the first national health system in the world to commit to net zero emissions, launching its new National Programme for a Greener NHS.

1.2 'Delivering a "Net Zero" National Health Service' (2020) plots an ambitious yet feasible set of actions to respond to climate change with clear targets for achieving a net zero health service for direct emissions by 2040 and indirect emissions by 2045 (Figure 1).

- For the emissions the healthcare sector control directly (the NHS Carbon Footprint): net zero by 2040, with an ambition to reach an 80% reduction by 2028 to 2032.
- For the emissions the healthcare sector can influence (our NHS Carbon Footprint Plus), net zero by 2045, with an ambition to reach an 80% reduction by 2036 to 2039.

Figure 1 Greenhouse Gas Protocol (GHGP) scopes in the context of the NHS. Source: Delivering a Net Zero National Health Service, October 2020



1.3 NHS estate and facilities has a critical role to play in achieving this ambition. The operation of NHS facilities currently makes up 15% of the NHS Carbon Footprint Plus, of which 10% is building energy (operational carbon). Furthermore, emissions from construction projects (known as embodied carbon) also contribute to the NHS Carbon Footprint Plus.

1.4 Efforts to decarbonise the NHS estate are cost-effective, with low-carbon interventions often resulting in high degrees of cost-savings, which are in turn re-invested into the health service. Importantly, these measures improve patient care and create better environments for healing and the delivery of care.

1.5 Poor environmental health contributes to major diseases, including heart disease, asthma and cancer. Tackling climate change represents an opportunity to realise significant health benefits whilst reducing health inequalities. For instance, reaching a net zero UK economy would see an estimated 5,770 lives saved per year from reductions in air pollution and 38,400 lives saved per year from increased levels of physical activity.

1.6 The NHS Net Zero Building Standard ("the Standard") creates a clear set of performance criteria relating to various elements of a net zero carbon building – both in construction and in operation. The Standard lays the foundation for major construction and refurbishment projects in the NHS that are expected over the next decade. The Standard will be periodically updated to ensure it remains relevant as technology and modern methods of construction evolve.

1.7 The Standard sets out a vision for achieving whole life net zero carbon buildings whilst improving patient care, with a clear roadmap for reducing operational building energy demands, embodied carbon in construction and the whole life carbon of building elements used within them.

1.8 Improving energy performance is an investment in patient and staff health and wellbeing, as it leads to warmer, more comfortable buildings with better air quality, when paired with adequate ventilation (Figure 2). In the long-term, energy performance improvements also provide benefits such as:

- increased productivity and longevity for regular users of NHS buildings
- decreased poor thermal efficiency, thereby reducing excess cold and dampness and associated direct costs (i.e., higher energy bills) and indirect costs (i.e. reduced wellbeing and productivity).

1.9 The introduction of the Standard will support the growth and flexibility of zero carbon energy supplies by:

- increasing on-site renewable generation beyond current practice
- phasing direct fossil fuel usage out of all primary heating and cooling systems. The principles outlined in the energy and heat hierarchies (Figure 19 and Figure 20) will help guide this transition
- taking advantage of planned heat networks across the country and making use of hospitals as anchor loads for heat networks

- optimising self-supply from renewables with energy storage and demand response technologies
- fitting smart electric vehicle charging points to decarbonise the NHS fleet and tackle air pollution
- ensuring consideration of both embodied carbon and whole life carbon
- collecting and sharing data where appropriate, accelerating the industry's understanding of the carbon impacts in design and operation and providing data to continually improve industry benchmarks.

1.10 The scope of the Standard is limited to those projects subject to the Treasury business case approval process. The operational running of the retained estate is covered by the Estates Net Zero Carbon Delivery Plan.

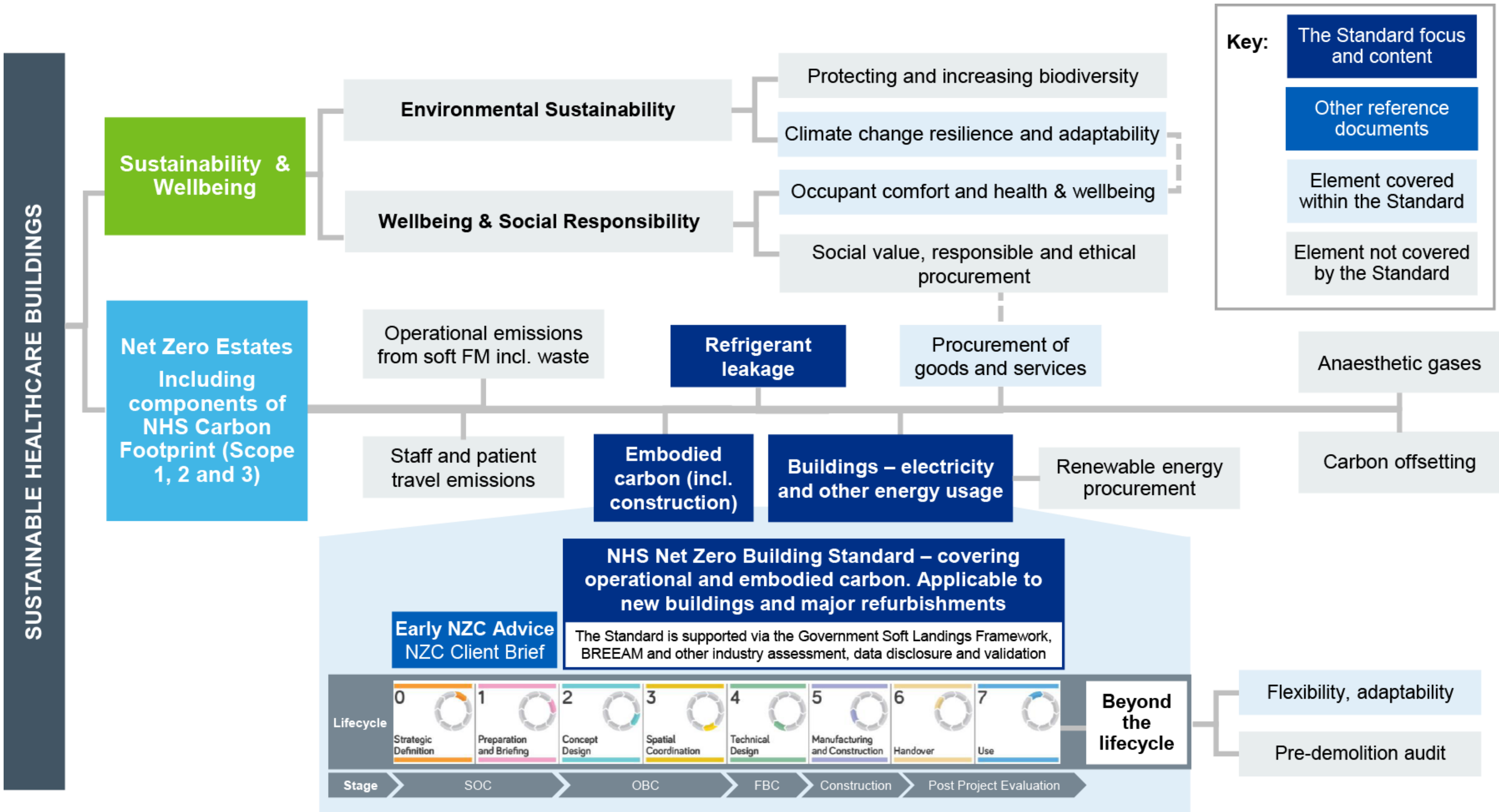
Application

1.11 There are different healthcare typologies that the Standard is applicable to in different forms, as it is recognised that there are a multitude of healthcare developments that take place within the NHS. Table 1 below summarises these into five core typologies and this Standard applies to all investments. The building types below are intended to simplify the use of the Standard.

Table 1 Summary of healthcare facility and application to this document

Building type	Application of this document
New acute healthcare facilities	Complete application.
Acute healthcare facility extension	Complete application.
New mental health facilities	Complete application. Note: The different space-types within mental health have been translated to the space categories defined within this Standard.
New large community or primary care facilities	Complete application. See detailed guidance within Chapter 5 for further information.
Major refurbishment of facilities	The design and compliance process laid out within this Standard should be followed for all major refurbishment projects. More bespoke operational Energy Limits and expectations may need to be derived based on the current performance and characteristics of the facilities. See other NHS guidance around existing estate for further specific refurbishment guidance and requirements. The refurbishment HBN (HBN 00-12) is currently under development (2021) which will provide supporting information for the refurbishment of facilities. An NHS Estates Net Zero Capital Planning Tool (2022) will assist in the identification of high-level interventions and costs.

Figure 2 The Standard in the context of other net zero and sustainable healthcare activities



Guiding principles and expectations of the Standard

1 Introduction - Section 2&3 of the Standard for more information

NHS England have a strong commitment to decarbonise their whole operation, and has set out a methodology to decarbonise all their scopes of GHG emissions and beyond. The continuous data collection and continuous learning ethos of the Standard itself, as well as project teams, will help us collectively make more informed whole life net zero carbon decisions. There is also a desire to supplement reporting to be per patient outcome or treatment given alongside estate intensity, supporting a whole system approach.

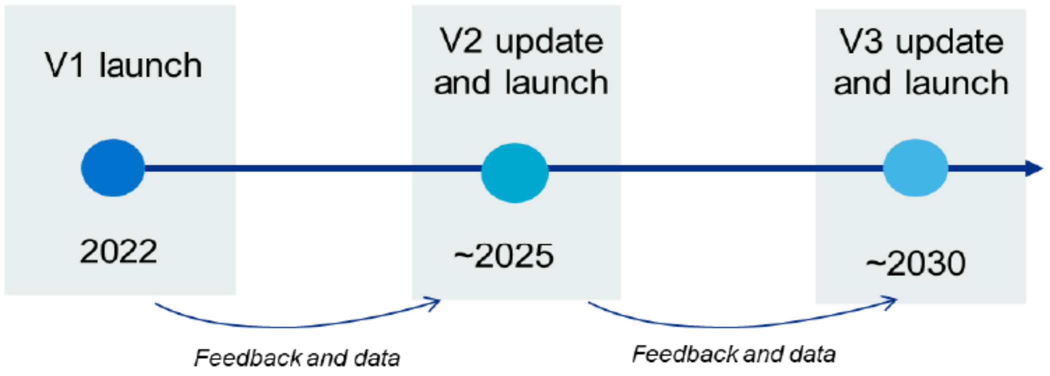
Firstly, pertinent to reducing the actual requirement for facilities is early decision making regarding the clinical strategy, creating the quantum and type of facilities required. This is further impacted by decisions regarding refurbishment opportunities and site. This translates into the design brief which must be challenged throughout the design process to ensure that the right scale and type of facilities are being designed – looking for carbon reduction opportunities.

2 An increasing ambition over time – Section 2

To balance the urgent action needed on climate change, with the current knowledge, experience, and data within the healthcare sector regarding carbon and energy, increasing ambition over time is pertinent for achieving net zero carbon facilities.

The Standard sets prioritised targets for elements of design and construction where there is good knowledge and data is robust. Additionally, there are specific requirements for assessing carbon and reporting so that this can inform other projects and drive performance, as well as informed decision making over time. Data collection as well as learning will be pertinent to implement the Standard across NHS England and the supply chain, by data gathered and the experience of implementation.

There is an expectation that the Standard will be iterative and will be updated frequently, as a minimum, as per the diagram below. This will reflect rapid changes within the industry and across the economy, as well as feedback from learning and experiences using the Standard. This ensures that it stays relevant, and suitably ambitious in line with other adjacent policies and aspects of the industry that will influence the Energy and Carbon Limits included within the Standard. The ambition of the Standard will likely be increased, towards the verification of whole life net zero carbon, and ultimately true zero carbon.



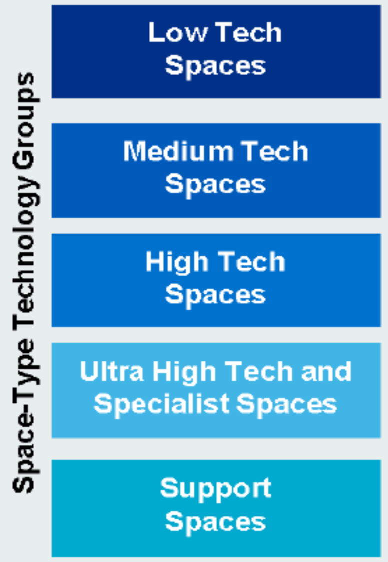
3 Space-type technology groups – Section 3

To assist with adaptable designs and also increase the granularity of energy and Carbon Limits, space-types technology groups have been established.

These group space-types into different levels of complexity – "technology" using common parameters and internal conditions.

This is important as lower tech spaces are much less carbon and energy intensive across their lifecycle than higher technology space-types.

These space-type groups are therefore used within the approaches for operational energy and embodied carbon to create bespoke project energy limits and requirements, as well as to support an adaptable estate strategy. *See Section 4 and 5*



4 Flexibility and adaptability – Section 3

Design solutions to provide space flexibility and adaptibility may come at a carbon cost due to the associated engineering allowances that may never be required.

Therefore, designs must be supported by a building adaptation strategy, supported by key decision making in relation to space-type technology groupings. Collaboration across the client and project team is required to ensure upfront carbon is suitably minimised, whilst making informed decisions for whole life.

Aligned to the space-type technology groups above, spaces should be able to decrease in technology easily, and change within their grouping, but not increase in technology group without intervention unless there are specific reasons for doing so.

5 Achieving Net Zero Carbon - Section 3

The approaches for reducing energy and carbon can be seen in the next two pages aligned with the UKGBC Net Zero Carbon Buildings Framework Definition. However, within the Standard itself, there are no requirements or guidance for:

- Purchasing of offsetting for individual schemes to reach net zero operational or construction carbon before 2040 unless offset payments are required through local planning policy.
- Purchasing or procurement off-site renewable energy to reduce operational carbon emissions or reach net zero operational carbon.

This is because offsetting and off-site renewable energy procurement is driven collectively through NHS England central strategy. Offsetting payments are likely to be continued investment in decarbonisation of the NHS until 2040 or 2045 depending on the scope of emissions.

An introduction to the approach for embodied carbon

See Section 4 – Embodied Carbon of the Standard for more information

1 Introduction

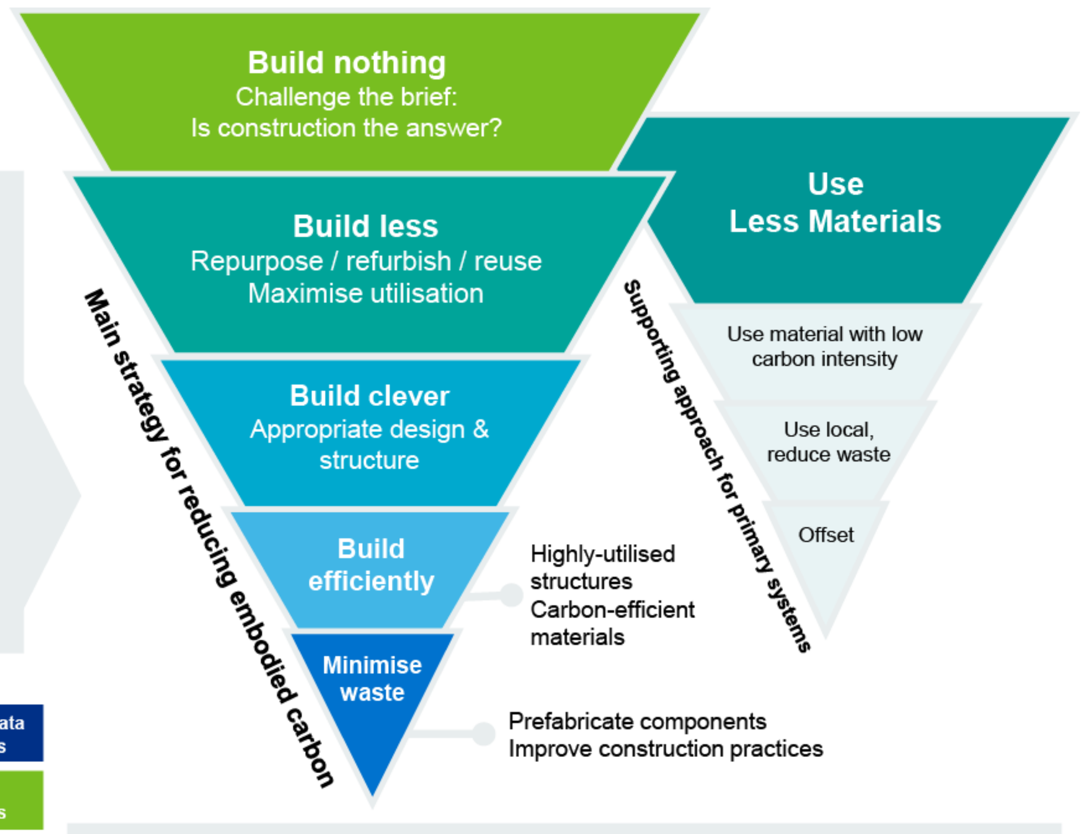
Understanding and reducing the embodied carbon throughout the lifecycle of the building is a crucial part of the overall drive for the NHS to deliver its vision of zero carbon healthcare.

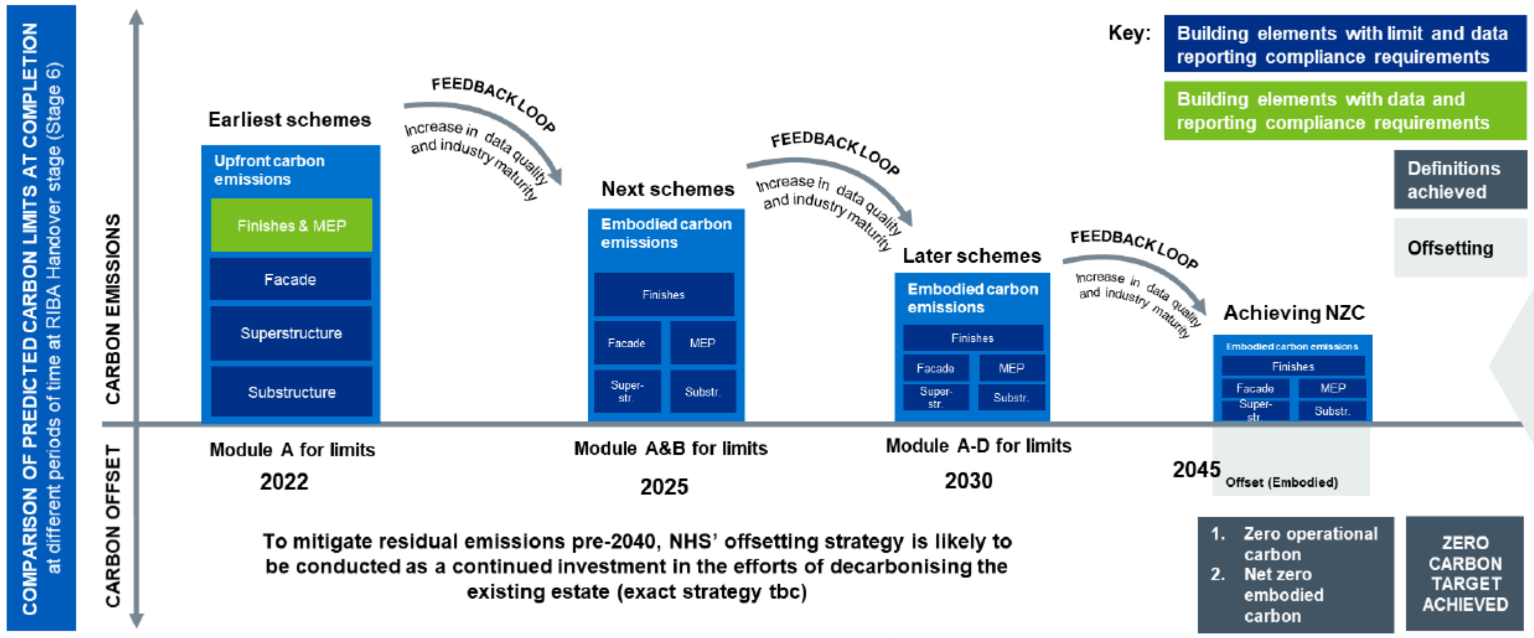
As operational carbon decreases through improved energy efficiency and the use of low/zero carbon energy sources, the relative importance of embodied carbon increases. It must therefore be considered and optimised as an integral component of the whole life carbon outcome.

The approach outlined within the Standard, supports a shift towards whole life approach and decision making.

2 Underlying principles

- Use embodied carbon reduction hierarchies to reduce the requirements for raw materials and optimise embodied carbon, supporting a circular economy
- Consider flexibility and adaptability carefully
- Capture all whole team design decisions regarding elements of the design that significantly impact energy and carbon performance – *see Design Register*





3 Approach of the Standard

Upfront carbon is prioritised given it is the most significant of the life cycle stages and the stage that we have highest data confidence.

Guidance on the key elements of design for healthcare buildings that affect embodied carbon have been outlined within the Standard.

Identification of trade-offs across the lifecycle stages and also across objectives have been provided to assist design teams to make more informed decisions – see the *Design Management Tool*.

Setting prioritised Carbon Limits for assets

Project bespoke Upfront Carbon Limits must be established by the client and project team using the *NHS Net Zero Building Standard Whole Life Carbon Reporting Register – refer to Section 6 for more information and the User Guide.* These Upfront Carbon Limits are set for "Tier 1 components" - sub-structure, super structure, and façade based on the project brief and schedule of accommodation. All other building components and lifecycle stages must be assessed and reported but are not expected to comply with the Upfront Carbon Limits.

It is expected that the scope of the Carbon Limits will be expanded in future as the industry matures and upon improved data availability.

For more information on the Embodied Carbon Limits see Section 4, Section 6, the User Guide and the WLC Carbon Compliance register.

4 Measurement and verification - Section 4 and 6

To support the ambition of the Standard, the following are critically important:

- Achieve increasing robustness of carbon reporting and data quality over time, pushing towards EPD data sets for all building elements.
- Mandatory reporting also into the Built Environment Carbon Database throughout the lifecycle.
- Carbon must be reported throughout the design stages at OBC and FBC as a minimum.
- Upfront carbon reporting must also be undertaken post construction to verify as built information.

An introduction to the approach for operational energy and carbon

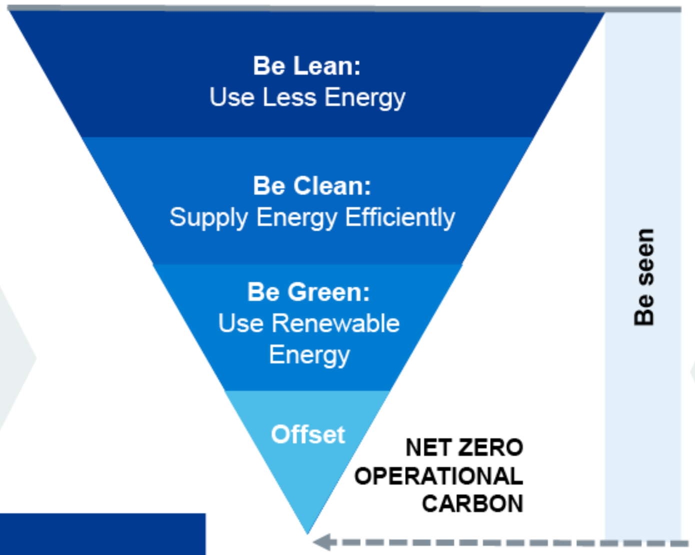
Introduction **See Section 5 – Operational Carbon of the Standard for more information**

In order to fundamentally reduce operational carbon of healthcare facilities, in line with fully decarbonising the estate, the energy hierarchy must be the basis of the approach taken; it first must be designed to reduce energy demands (be lean) and run efficiently, after which its energy requirements need to be met with sources that are zero or potentially zero with established decarbonisation trajectories.

Key expectations

To support reducing operational energy demands, bespoke project energy limits are to be derived based on the project brief - see methodology below

- Performance targets for other elements of the building – such as envelope and HVAC systems
- Maximise heat recovery through holistic approaches throughout facilities wherever possible
- Energy storage and demand response should be incorporated where appropriate
- Integrate and inform decision making with other elements of design, such as daylight, thermal comfort and embodied carbon impacts



Establish Low Carbon Energy Supply:

- Use heat and electricity hierarchies to support key decision making – solutions should typically be electrically led unless there are other site opportunities and constraints
- Establish committed decarbonisation trajectories for all energy sources used within designs
- Therefore, no new fossil fuels should be installed for primary energy sources. Fossil fuels used for resilience should have long terms plans for use of alternative biofuel.
- Maximise on-site renewable energy generation opportunities.
- Energy supply must be integrated with Trust Green Plans for off-site renewable energy procurement, lead by NHS England guidance.

Operational Energy Methodology

Step 1: Building Performance Targets

Whole Building
At whole building level, the performance targets are to be applied to the envelope and other whole building systems

Step 2: Space-type Energy Limit and Performance Targets

Space-type
Identify the relevant Energy Limit or Building Services Performance Targets in the Standard for all space-types in the design

Low Tech Spaces
- Low Tech Type 1 – E.g. Public Circulation, waiting areas
- Low Tech Type 2 – E.g. Offices, teaching areas

Medium Tech Spaces
- Medium Tech Type 1 – E.g. A&E, single ICU room
- Medium Tech Type 3 – E.g. Consultation
- Medium Tech Type 2 – E.g. Exam/Treatment, procedure room
- Medium Tech Type 4 – E.g. Single bedroom, maternity ward

High Tech Spaces
- High Tech Type 1 – E.g. Operating Theatre
- High Tech Type 2 – E.g. High tech laboratories

Ultra High Tech and Specialist Spaces
- Ultra High Tech and Specialist Spaces – E.g. Imaging, containment labs and burns units

Support Spaces
- Support Type 1 – E.g. Catering
- Support Type 1 – E.g. Server Rooms
- Support Type 3 – E.g. Plant spaces

Select Building Performance Targets

Select and specify the performance targets values that are best suited to the building, construction type and location.
Performance Targets include:
Envelope - U values, air tightness, glazing parameters.
Other - metering and monitoring of energy systems, refrigerant GWP, and domestic hot water (DHW) efficiencies

Energy Limits

Derive Energy Limits based on space-type, location, equipment and domestic hot water demand (DHW) based on provided ranges of values.

Advisory limits for DHW and unregulated loads.

Follow Performance Targets

Follow building services performance parameters for specialist and support spaces including AHU SFPs, SCOPs, SEERs, heat recovery efficiency and lighting loads.

Measurement and Verification – Section 6

- Engaging Facilities Management through Government Soft Landings and Post Occupancy Evaluation Rigorous enhanced commissioning
- Extensive monitoring, metering and controls of energy usage, including publicly reported and disclosed.
- Data collection to enable the ability to report per patient outcome and treatment in the future to support decarbonising the whole NHS

2 A vision for whole life net zero carbon

Introduction

2.1 The NHS has committed to decarbonising its healthcare services across its entire spectrum of operations. The NHS has stated that, “before the end of the decade, the NHS will no longer purchase from suppliers that do not meet or exceed our commitment to net zero” (Delivering a Net Zero NHS, October 2020).

2.2 As part of this transformation, NHS England has a vision for whole life net zero carbon facilities but recognise that transition is required across the whole supply chain to do so. Embodied carbon is best understood at the capital investment stage. Requirements are over and above Policy Procurement Note (PPN) 06/21.

2.3 Alongside the focus for action on climate change to transform how NHS healthcare services are designed and delivered, the following key ministerial priorities offer significant opportunities:

- embedding digitalisation
- increasing standardisation of design across facilities
- establishing patient flows
- delivering assets using modern methods of construction
- consider flexibility and adaptability to increase lifespan of existing buildings.

2.4 The ability to maximise benefit from the interdependencies is crucial and “systems thinking” is therefore critical for the NHS and its suppliers. Delivering the net zero ambitions is aligned to the priorities of the Construction Leadership Council’s Construct Zero[1] change programme for the construction industry.

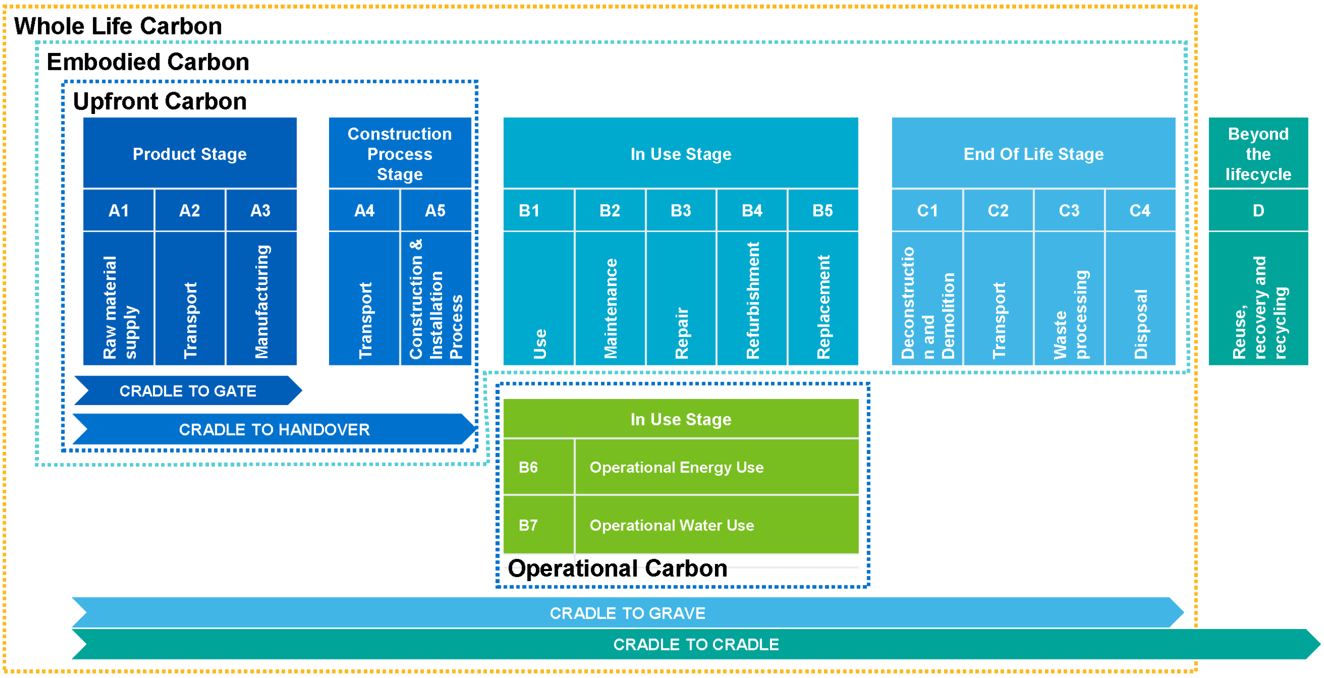
2.5 NHS projects must embed whole life thinking within the decision-making process to deliver net zero carbon and other commitments across NHS services and facilities, especially as acute NHS Trusts are typically owner-occupiers over the lifetime of an asset.

1 https://www.constructionleadershipcouncil.co.uk/constructzero/priorities/

Whole life assessment methodology

2.6 To enable data-based decision-making to be made, whole life carbon (WLC) assessments must be undertaken and supported with input from facilities management professionals. The proposed methodology aligns with other industry standards, frameworks and best practice guidance including: RICS Whole Life Carbon Assessment for the Built Environment, RICS Professional Statement, BS EN 15978 2011 (Figure 3), UKGBC Net Zero Carbon Framework, RIBA and LETI carbon alignment which are in line with RICS Whole Life Carbon Assessment for the Built Environment approach.

Figure 3 Scope of whole life assessment based on BS EN 15978, stages of life cycle assessment with typical scope boundaries drawn



- **Modules A1–A5 – Upfront carbon** represents the product and construction stages (excluding enabling works), which are the most significant of the lifecycle stages.
- **Modules B1–B5 – In-use embodied carbon** represents the carbon associated with replacement, repair, refrigerants and maintenance, which is a key consideration for systems with high replacement cycles and low durability.
- **Modules B6–B7 – In-use operational carbon** represents the carbon associated with the operational energy and water usage of a building.
- **Modules C1–C4 – End of life carbon** represents the carbon associated with deconstruction and demolition of a built assets.
- **Module D – Beyond the lifecycle** – this represents the carbon associated with potential benefit from future energy recovery, reuse, and recycling.

2.7 Note that biogenic (sequestered) carbon is reported separately in the assessment following RICS guidance. It should be included in Stage A totals when reporting whole life-cycle carbon, but critically sequestration benefits should be excluded from meeting Upfront Carbon Limits as these do not include Stage C and therefore the benefits of sequestration cannot be claimed.

2.8 See the key supporting documents list at the front of the Standard for additional guidance on whole life methodology.

The elements of continuous improvement

2.9 The following three elements of transition underpin the vision for how net zero carbon will be achieved for the NHS and will be expanded upon in the following sections. As healthcare projects typically have long design lives (comparatively to other built environment projects) the process of learning must be rapid and iterative to influence other schemes. Waiting until the handover and operation of new buildings would represent a lost opportunity to learn and inform other live schemes. These elements of transition and shared learning demonstrate the importance of regular monitoring and continuous feedback by the Project Teams to influence the wider investment programme:

1. **During design and construction:** Embodied Carbon Limits will decrease over time, as the scope and robustness increases. For example, to comply with later iterations of the Standard, it is expected to include embodied carbon of MEP products and furniture, fixtures and equipment (FF&E), with a requirement for third party verified Environmental Product Declarations (EPDs), as well as extend beyond upfront carbon (lifecycle Module A) emissions.
2. **Performance at handover:** the predicted upfront energy and carbon intensity of newly built schemes at handover should show a decreasing trajectory (in kWh/m^2 or $kgCO_2/m^2$) over time. This will result in an equivalent reduction in the number of offsets that each scheme will require to achieve net zero operational carbon or net zero embodied carbon. This will also be reflected in decreasing energy and Carbon Limits over time, as the Standard is reviewed and updated.
3. **In operation:** there must be established **decarbonisation pathways** for all energy sources to reduce their carbon intensity over time to reach **zero** operational carbon; reducing the need to offset residual emissions and align to global decarbonisation expectations.

Scope of carbon assessment and compliance

2.10 Recognising that the NHS commitment to decarbonising the whole operation and supply chain by 2045, includes all Greenhouse Gas Protocol (GHGP) emission scopes and beyond, there will be an increasing focus on all products and operations that are used within the healthcare estate across the lifecycle stages.

2.11 **Table 2** indicates how NHS England aspires to widen the scope, methodology and corresponding limits of the Standard to encompass WLC assessment, over time. This is pertinent to NHS England's vision to accelerate the rate of change and learning across the UK and the world. Delivering decarbonised healthcare facilities and services, improving health outcomes and additionally creating benefits across the built environment.

2.12 The Standard sets expectations for how this maturity will be developed and how data will be collected and reported over time. This insight will influence the scope of future carbon assessment targets in future iterations of this document (Figure 4).

2.13 It is imperative that good quality carbon data is collected and reported as a key process within all projects and that as more extensive and robust data becomes available, the scope and ambition of the Carbon Limits within the Standard become broader, covering more building elements and deeper in terms of data quality across the lifecycle stages.

Table 2 Expected scope of whole life assessment within Standard across versions, this is also presented graphically within Figure 4

	Version 1 – 2022		Version 2 – 2025 (indicatively)		Version 3 – 2030 (indicatively)	
Building elements and components of carbon assessment	**Data assessment and reporting**	**Carbon limit compliance**	**Data assessment and reporting**	**Carbon limit compliance**	**Data assessment and reporting**	**Carbon limit compliance**
Substructure and super structure	A – D	A1–A5	A – D	A & B	A – D	A – D
Façade	A – D	A1–A5	A – D	A & B	A – D	A – D
Building services and systems	A – D		A – D	A & B**	A – D	A – D
Energy generation systems and equipment e.g. PVs	A – D		A – D	A & B**	A – D	A – D
FF&E (including medical equipment)	A – D		A – D	A & B**	A – D	A – D
Operational carbon	B6 & B7		B6 & B7	B6 & B7**	B6 & B7	B6 & B7
Refrigerant usage and leakage within HVAC systems	B1 and C1		B1 and C1	B1 and C1**	B1 and C1	B1 and C1

** Additional guidance and compliance requirements may be issued on these Tier 2 building elements prior to 2025 following industry feedback and data collection.

2.14 Supporting notes to **Table 2**:

- All greenhouse gases, not only carbon dioxide, to be expressed in CO_2e, using the latest BEIS methodology and factors.
- Whole Life Carbon Assessments to be undertaken in accordance with RICS Whole Life Carbon Assessment for the Built Environment.
- Reporting forms have been provided, aligned to the RICS methodology, in the *Whole Life Carbon Compliance Tool.*
- Biogenic carbon stored must be calculated and reported separately – sequestered carbon does not count towards meeting the Upfront Carbon Limits.
- Embodied carbon associated with local renewable energy generation systems (e.g. PV systems) is not included in building upfront carbon totals, but a mechanism in the

reporting tool has been provided to assess these systems for embodied and operational carbon separately. This aligns to LETI guidance.

- Refrigerant leakage; mainly from HVAC systems, must be included within assessments for GHG emissions as it can create a disproportionate impact if the global warming potential of refrigerants is high. This can be magnified where there is undetected leakage from the systems. This commonly is not considered or designed out within HVAC design. Manufacturers' data should be used to calculate and report this where it is available over other estimates sources.
- **Not included** are expected emissions from anaesthetic gas usage within the operation of the facilities, as these are clinically led and typically outside the influence of the Project Team. Energy and emissions from the design and operation of the systems that use them though must be included as part of the building servicing. For clarity the embodied carbon for the installation and operation of the gas systems themselves are included.

2.15 As shown in Table 2, different building elements have been classified into tiers within the Standard. Both Tier 1 and Tier 2 components have guidance and reporting requirements, but Upfront Carbon Limits are only applicable to Tier 1 elements in the first instance, with Tier 2 elements desirable until new data becomes available. See Figure 4 for graphical representation.

2.16 This classification is based upon Tier 1 components having industry assessment methodology, relative maturity and availability of robust data sources to inform carbon assessments and benchmarking. Tier 1 components also present the highest percentage of embodied carbon emissions of healthcare facilities.

2.17 In comparison to Tier 1, Tier 2 materials have not been given defined emissions limits due to a lack of consistent and robust data. Both Tier 1 and Tier 2 materials require data collection and reporting. Calculation methodologies, such as CIBSE TM65 – Embodied carbon in building services should be used where available.

Increasing energy and carbon performance over time

2.18 Schemes are expected to deliver best practice and respond to the rapid change in emphasis due to the scale of the challenge presented by climate change. Because of the significant lead times of healthcare projects, schemes should be pushing the boundaries of product and system specification and performance at the earliest possible stage.

2.19 The first schemes to implement this Standard are likely to be early adopters of low-carbon technologies and approaches that in the future will become mainstream. These schemes will increase market appetite and readiness for such technologies that will benefit later schemes. Examples of such technologies and approaches include (but are not limited to) heat pump technologies, façade integrated PV, energy storage, increased digitalisation of design, construction and operation and use of modern methods of construction. Standardisation and repeatability of layouts is also an important consideration covered in paragraphs 3.16–3.19.

Figure 4 The scope and expected robustness of embodied carbon assessment will increase over time

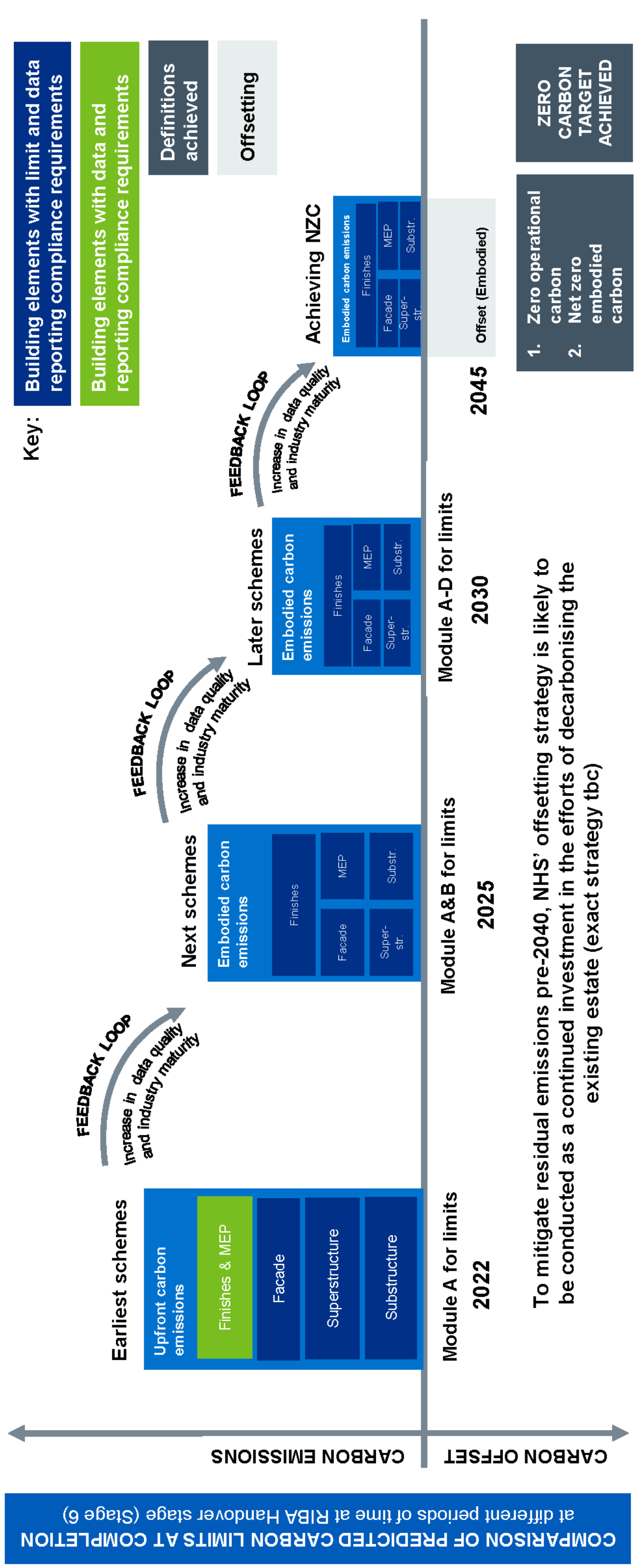


Figure 5 Tiers of building elements and impact within Standard

	TIER 1	TIER 2
	Main components of **Facades, Superstructure, Substructure**	Secondary components, **Finishes**, **MEP**, **FF&E**
CURRENT DATA	Robust	Minimal
QUANTITY EXTRACTION	Moderate	Difficult
CARBON CONTRIBUTION	~ 60 - 75% Module A Low % Module B	~ 20 - 35% Module A High % Module B
REQUIREMENTS		
APPROACH	• Module A Limit • Design Requirements • WLC Assessment • Data Reporting	• No Module A Limit • Design Requirements • WLC Assessment • Data Collection & Reporting

2.20 The following changes are expected to drive improved carbon performance over time:

1. **industrial decarbonisation** that will reduce the carbon emissions associated with products, materials, processes and services across whole life of assets
2. **innovation** increasing the energy efficiency of products and systems
3. **new technology** and innovations within the built environment driving low carbon outputs
4. increasing use of **digital techniques** such as advanced energy modelling, building and asset management systems and digital twins to optimise buildings and systems, reduce the performance gap and drive resource efficiency
5. increasing use of **modern methods of construction** to improve construction quality, reduce waste and increase the efficiency of material use
6. **sharing of best practice** and lessons learnt to accelerate scaling and improve the design and construction of net zero carbon buildings.

2.21 Many of the above are likely to be supported by increasing local and national policy, and legislation to support a green economy. As such, the Energy and Carbon Limits and Performance Targets (PTs) within this document will be updated over time to ensure that they suitably reflect the impacts of the changes listed above. For example:

1. improving operational energy intensity (kWh/m^2/yr)

2. improving carbon intensity ($kgCO_2e/m^2/yr$)
3. improving embodied carbon ($kgCO_2e/m^2$), both upfront and across lifecycle
4. improving and adapting the performance targets (whole building and building services).

2.22 It is therefore expected that later schemes will be designed and operate with lower Energy and Carbon Limits than older schemes in line with updates to the Standard, see Figure 6.

2.23 The following table summarises the expectations from projects if their programmes overlap various versions of the Standard. All future iterations of the Standard will be published with guidance.

Projects pre outline business case	Projects beyond or undergoing outline business case approval (e.g. undergoing full business case)	Projects within construction
Must comply with the newest version of the Standard in its entirety, including Energy and Carbon Limits.	Derogations permitted for missing new Energy and Carbon Limits in detailed design stage and construction.	No application of the newest version of the Standard required at this stage. However, organisations should be aware that the building will still have to achieve net zero operational carbon by 2040.
	Key reporting expectations from the Construction and Verification phase (RIBA 5 and beyond) of the latest version of the Standard should be met.	In-use energy monitoring and verification expectations should be taken as best practice by the Trust.

Establishing decarbonisation pathways for all energy sources used in operations

2.24 For the NHS to meet its carbon reduction targets, energy demand must reduce. This reduction can be driven through system efficiency and is pertinent for all capital projects. A shift away from fossil fuels across the NHS estate, especially for primary energy systems that are used 24/7, will be critical in ensuring the NHS achieves its net zero targets.

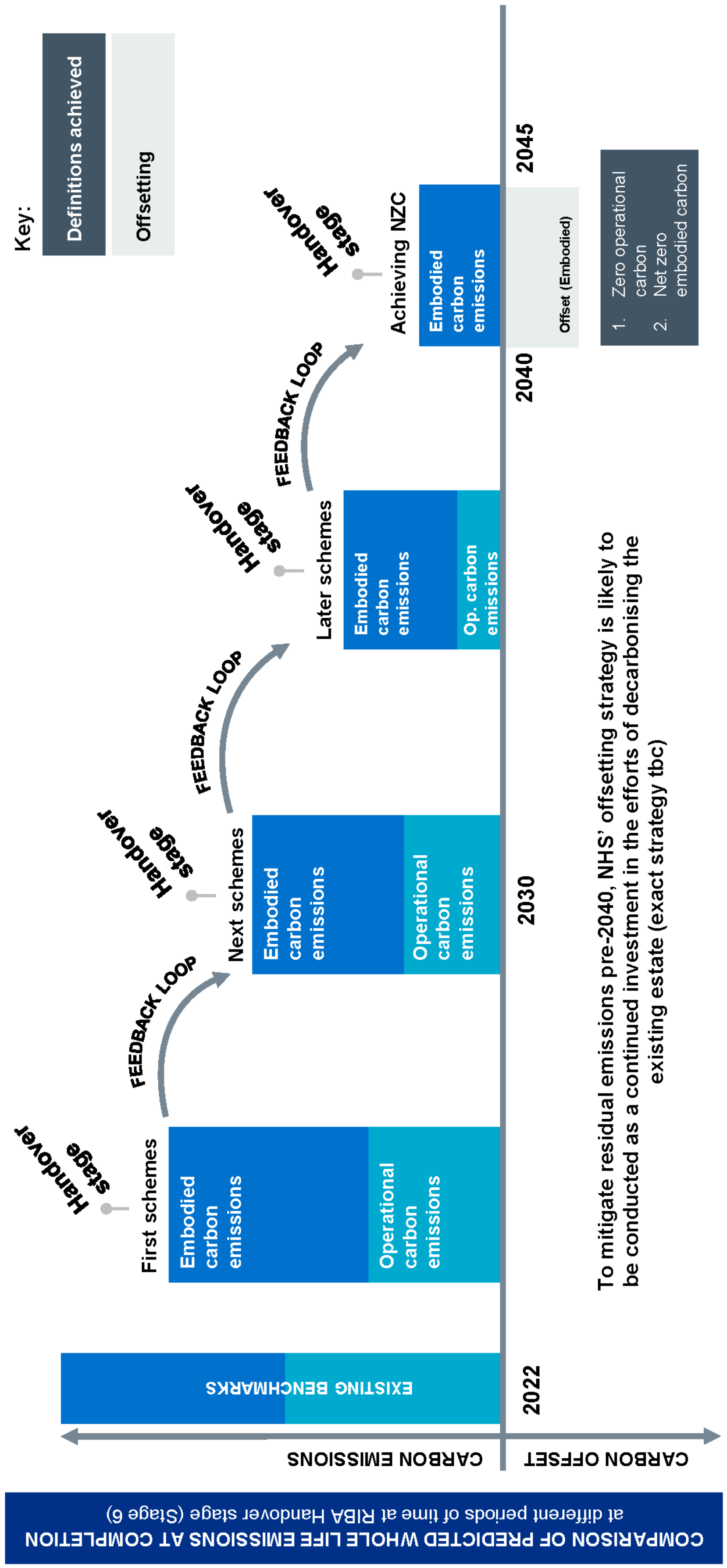
2.25 As part of Trusts' and Integrated Care Systems' (ICS) Green Plans,[2] all organisations are working towards a net zero NHS, with concrete plans in place to help tackle climate change and improve health. This includes plans to decarbonise their energy sources and to move away from fossil fuel systems, which is clearly required to transition to operational net zero carbon across the estate. See Figure 8 for a graphical representation of this.

2.26 The requirement set out within this Standard, however, is not necessarily to meet zero operational carbon upon handover. Teams must create an Energy and Carbon Strategy as part of the design of their scheme, aligning different processes that feed into the delivery of net zero carbon in operation.

2.27 The Strategy must be visible and prevalent within the design of these facilities and used to inform and monitor all design and construction decisions regarding energy and carbon. It will also form an important document to align with Trusts' Green Plans for broader estate decarbonisation and be incorporated into ongoing operation and maintenance planning. Consideration should be given when implementing the Standard

2 https://www.england.nhs.uk/greenernhs/wp-content/uploads/sites/51/2021/06/B0507-how-to-produce-a-green-plan-three-year-strategy-towards-net-zero-june-2021.pdf

Figure 6 Comparison of predicted whole life emissions of schemes at handover stage



to preparing sites for fleet decarbonisation and the associated operational infrastructure requirements necessary to achieve it.

2.28 Consideration needs to be given to local and regional constraints and opportunities for example, any local electric district heating or geothermal schemes. In most cases it is expected that a site-specific decarbonisation pathway will be achieved through a dominance of heat pump technologies, using renewable electricity and battery storage to top up peak demand. Thus, enabling projects to benefit from National Grid decarbonisation as well as other decarbonisation interventions (Figure 7).

Whole Life Cycle Carbon Flag:

There are clear plans for the UK grid to decarbonise by 2050. Organisations must however work to actively decarbonise their estates now, alongside this decarbonisation plan, to minimise the whole life cycle carbon cost.

2.29 Sources of future decarbonisation that are expected to be included within these energy and carbon strategies:

- decarbonisation of the National Grid and other energy sources i.e. referencing and aligning with key government policy and strategy
- where applicable, increasing on-site or estate-wide renewable electricity generation capacity to feed into the estate's energy mix. This can also reduce operational costs and limit the need for upgrade of incoming electrical capacity
- a plan for increasing the use of other sources of zero carbon energy within the building or estate, to phase out any residual emissions created within a transitionary period (e.g. utilising sources of waste heat and energy or using biomethane or hydrogen).

2.30 A reliance upon future investment to reduce energy demand outside the scope of the scheme i.e. post-handover, should not form part of the decarbonisation strategy for the scheme, as it is significantly more disruptive and expensive to retrofit technologies, compared to including these at design and construction stage.[3] Similarly, a reliance upon future renewable technology additions will not be considered a valid approach to achieving reduced carbon intensity over time, especially if these are intended to be added within/on the envelope of the building. Any such intervention should be included in the capital build of the facility unless there are significant site infrastructure constraints that cannot be overcome before the building's handover.

2.31 It is expected that future maintenance, lifecycle renewals, and upgrades of building systems will be proactively used to adopt the latest technology enhancements and instil benefit from additional energy and carbon efficiency savings.

3 Climate Change Committee, The UK's Contribution to stopping global warming, May 2019.

Figure 7 Historic and future projected carbon factor for the National Grid. Sources: 'BEIS Greenhouse gas reporting (historic carbon factors)'; National Grid Future Energy Scenarios (FES) 2021 (future projected carbon factors)

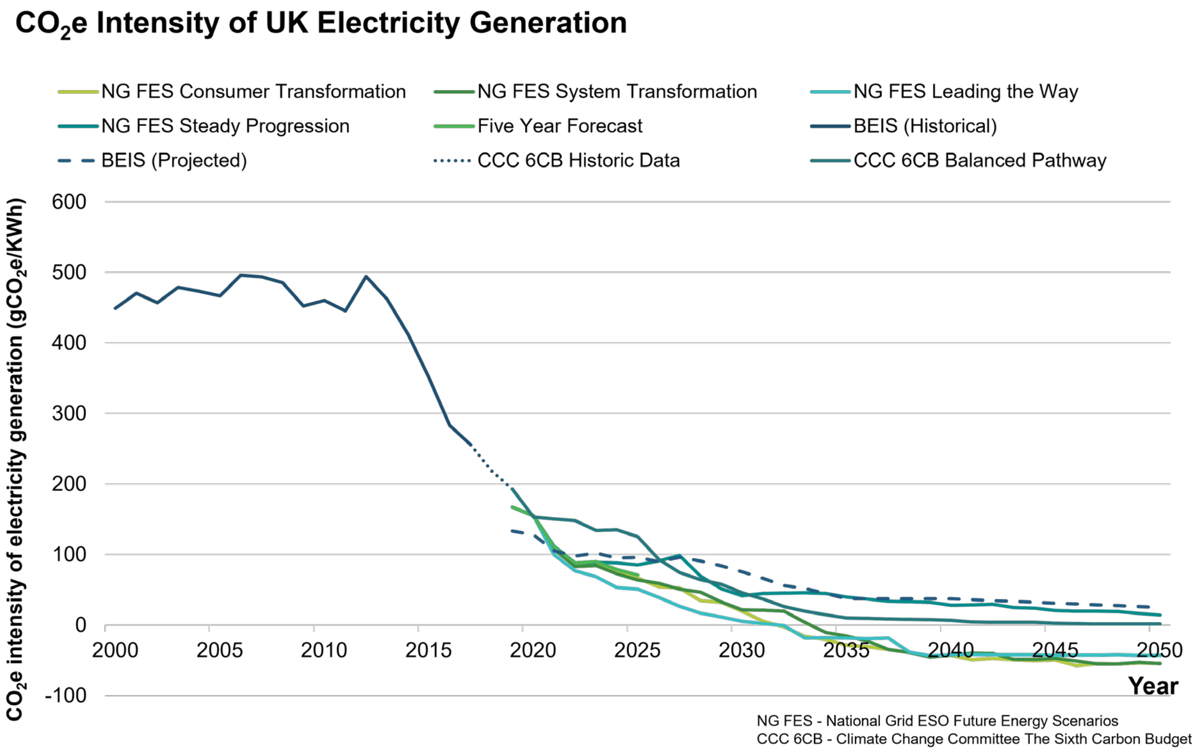
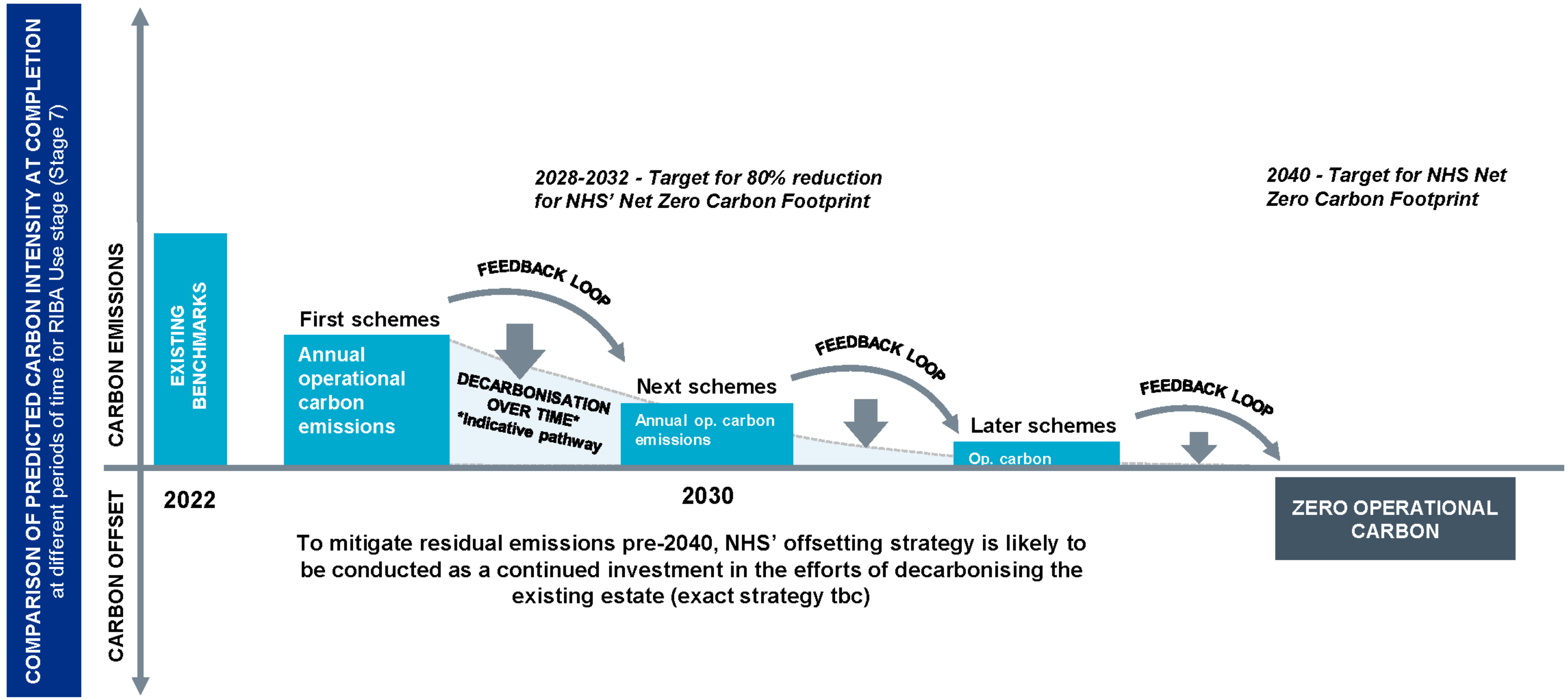


Figure 8 Comparison of predicted emissions of schemes in operation (RIBA 7 – Use stage) – there must be established further decarbonisation pathways to reduce offsetting requirements



3 Approach for whole life net zero carbon

Introduction

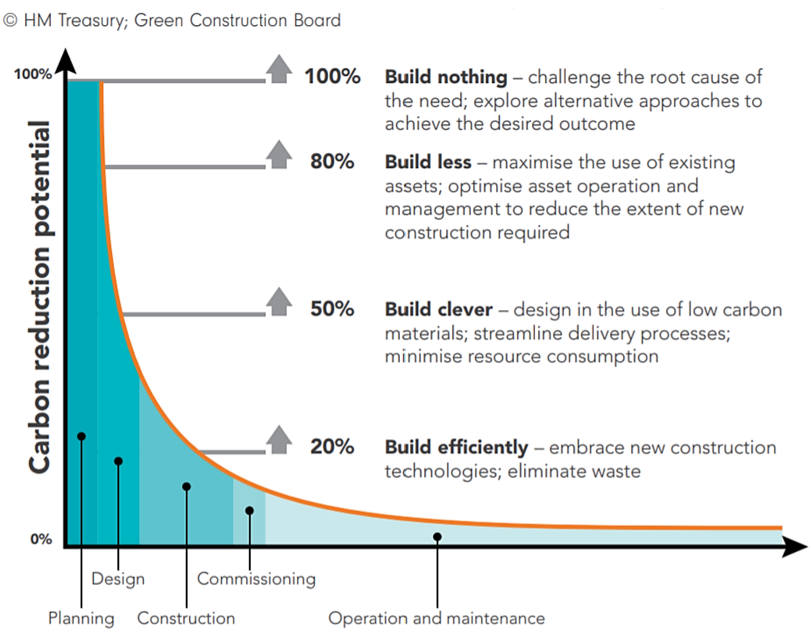
3.1 This chapter outlines key principles and methodologies that should be used to help approach the delivery of whole life net zero carbon healthcare facilities, achieving alignment to other aspects of the built environment guidance and methodologies.

3.2 This chapter is supported by further technical requirements and guidance for embodied carbon in Chapter 4 and operational carbon in Chapter 5.

The importance of early project stages

3.3 While the Standard focuses on the design development alongside the outline and full business case stages (OBC and FBC), decisions made at the strategic outline case (SOC) can have a significant impact on the carbon intensity of healthcare services provided (Figure 9). A key element in reducing carbon emissions across NHS scope 1, 2 and 3 emissions is the reduction in demand for healthcare services, especially for acute services.

Figure 9 Carbon reduction potential across the lifecycle, PAS 2080, Carbon Management in Infrastructure



3.4 For embodied carbon and where feasible, the greatest impact interventions are to build nothing or reuse and refurbish existing buildings i.e. 'building nothing' or 'building less' (Figure 9). This is likely to remain the case until the carbon intensity of construction materials have significantly reduced.

3.5 Planning services across ICSs will be critical as progression is made into a lower carbon world. It will be important for decision makers to consider the opportunities within Table 3 and challenge themselves as to the necessity of a new building or whether a refurbishment may in fact provide an equivalent, lower carbon solution.

Signpost, for more information on the Client Brief and how this should be used to help inform early stage decision making (including preferred option and site selection) see:

NHS Net Zero Carbon Client Brief (forthcoming)

3.6 The examples set out within Table 3 explore how carbon emissions across the lifecycle of an asset are affected by different decisions made within the design phase. Decision makers should consider and evidence these during early options appraisals for their scheme(s).

Case Study – New Odense University Hospital (Denmark)

Increase in outpatient treatment, which reduces the need for hospital beds. A 50% increase in outpatient treatment is expected to result in a 20% decrease of bed days

Table 3 Opportunities and their impacts on whole life carbon

Opportunity	Impacts
Achieving integrated healthcare systems and healthcare planning optimisation; trying to provide healthcare services and care within primary and community facilities instead of acute facilities that are likely to be remote from patients' and staffs' homes and require additional travel for them and any potential visitors.	• The NHS has committed to increasing digital options for people who need NHS care or advice. As more people opt out for a 'virtual' out-patient appointment, the footprint required for new buildings may change. • Clinical and space planning can lead to significant reductions in space requirements and changes within the schedule of accommodation; reducing overall scale of development, room and department sizing and adjacencies, and clinical support strategies to name a few. • Achieving integrated healthcare models may lead to an increased intensity of acute facilities per square metre of building space due to the need to relocate services for example out-patient facilities.
Interlacing the social and wellbeing benefits from sustainable designs, including investing in nature-based solutions and maximise patient and staff benefits from these.	• Incorporating sustainable solutions can reduce energy demand through improved efficiency of existing buildings, and more broadly through improving the health of the nation through sickness prevention (focused on NHS staff and patient recovery). • Sickness prevention is key component of the 'NHS Long Term Plan' and aim to reach net zero. Improved prevention will reduce patient numbers and recovery times. Thus, helping to drive down the need for additional healthcare buildings and their resultant carbon emissions. • At master planning stage, taking a holistic approach to healthcare by combining wellbeing outcomes with low carbon and often 'build nothing' options can lead to an enhanced staff and patient experience.

Opportunity	Impacts
Selection of building location and massing.	• The location of a building can have a significant impact on all elements of the NHS' footprint including aspects outside the direct control of the estate such as patient, staff and visitor travel. If a site is chosen that is well serviced by public transport, it is likely that more people will take this method of transport as opposed to a more carbon intensive one such as driving. • Projects can also be anchors for generation of lasting social value and economic development through their location – supporting local priorities e.g., developing next to existing social amenities and community anchors. • The exact impacts will vary per site with site and building location determining opportunities and risks for net zero carbon – an assessment should be completed to review key elements of the site including its size, micro-climate, topography, infrastructure, low carbon transport etc. • Vulnerability of site to changing climatic factors such as increased risk of flooding and overheating from heat island effects. This has impacts on quality of patient and staff experiences, and has potential to increase the energy and carbon intensity of the asset in construction and operation to mitigate these risks. • This aspect can significantly influence the operational carbon intensity of that asset due to, for example, the availability of renewable sources of energy and existing infrastructure. • Ground conditions can significantly influence complexity of groundworks and therefore influence the upfront carbon of the scheme. • When deriving stacking diagrams and massing for new buildings consider the following: – Medium rise buildings (4-8 storeys) are generally most efficient in terms of upfront carbon due to low rise buildings having large substructure/roof to GIA ratios and high rise buildings having inefficient stability and vertical systems. – Potential for passive shading, form and orientation as these can all significantly influence the carbon performance of a scheme across its life.
Refurbishment or repurposing of existing buildings	• This can be beneficial in reducing the quantum of embodied carbon in new buildings. The upfront carbon and raw materials used for a major refurbishment project is typically significantly lower than that of a new build (as by their nature, some building elements are retained in refurbishment projects). • Lower technology space-types have the greatest opportunity for refurbishment and repurposing, as these have the least bespoke servicing requirements for clinical intervention(s). • Existing buildings will have inherent characteristics, such as orientation, form and grid geometry and inter-storey heights, which will affect the building's energy use intensity and operational carbon (as well as functionality). • There may be other challenges and trade-offs for refurbishing buildings, see signpost overleaf for more information.
Spatial efficiency e.g. size and adjacencies of spaces (vertical and horizontal)	• A larger building would logically contain more embodied carbon; however, smaller more complex buildings can themselves lead to a higher carbon intensity per square metre. It is important to consider the tensions between minimising total floor area and adding complexity that may increase carbon – see discussion note below. • A more standardised and efficient structural grid offers further carbon savings through supporting adaptation and use of modern methods of construction to reduce waste, improve quality and often increase construction speed. • The SOC and design brief is ultimately responsible for determining the total spatial area of a building, which in turn will translate to its embodied carbon. Size and complexity should be challenged wherever possible throughout the process to reduce carbon.

Whole Life Cycle Carbon Flag – refurbishment:

There may be significant other reasons why buildings cannot be refurbished, such as the current quality of existing healthcare estate, as well as capacity challenges e.g. creating decant space to enable refurbishment.

See Chapter 4 – Embodied Carbon for more information on the implications for embodied carbon for refurbishment and the potential trade-offs for operational energy and carbon from refurbishing buildings.

Additionally, reuse of buildings may lead to higher operational performance (kWh/m^2) compared to new build facilities, however they will save a significant amount of embodied carbon within the sub and super structure, as well as potentially other building elements (façade, MEP, some finishes etc) depending on refurbishment extent.

Whole Life Cycle Carbon Flag – spatial efficiency and optimisation:

It is essential that the space requirements for clinical services are considered within the planning decisions. In doing so, the long-term usage and flexibility of the space should be considered alongside its immediate use. Designers are encouraged to make early consideration of the embodied carbon required for space types and to standardise these wherever possible.

Roles and responsibilities required

3.7 Delivering low carbon and energy buildings requires significant collaboration across the team over the project lifecycle. The responsibility assignment – RACI matrix in Figure 10 shows how different team members must participate within different activities and decisions across the project lifecycle. The RACI matrix below is a summary of the main activities, and these are supported by additional information for activities, processes, and responsibilities within Chapter 6.

Key roles

3.8 The following key roles are included within Figure 10:

- **Net Zero Carbon Coordinator** – an identified and trained member of the Design Team who is responsible for compliance against the Standard's process and technical requirements. Key skills and expertise for this role are included within Chapter 6.
- **Client, Project Team** – typically an NHS project management and delivery team that is formed with any major capital investment.
- **Client, Operations, Facilities and Estates** – representatives from the NHS Trust's (or other healthcare provider) estates and facilities management/operations team. This includes the Trust Energy Manager who will be responsible for the implementation of ongoing strategy/strategies including Estate decarbonisation.
- **Designers** – a combined team of architects, engineers, designers and other technical experts to support the design of the building/project.
- **Contractors** – those responsible for the construction and verification of the building as per proposed design outcomes.

3.9 It should be noted that within different procurement routes, these roles may be undertaken by the same or different organisations and may vary across the project stages.

3.10 Depending on the level of experience of the Client Team, there may need to be additional resource or assistance to help develop project briefs (and derive Energy and Carbon Limits) to communicate the proposed project outcomes within the Standard at early stages.

Process for compliance with the Standard

3.11 Figure 11 provides a summary of activities and expectations across each stage to comply with this Standard alongside the RACI matrix. Continuous monitoring and review should be undertaken throughout the project's lifecycle, for deviations to be mitigated and to ensure business case approval for schemes. Verification of project performance, including bespoke project limits and reporting against the Standard's requirements, should be undertaken at each project stage. More detailed guidance on the requirements for compliance is provided in Chapter 6.

3.12 Alongside compliance with the Standard, there is a requirement to assess assumptions and the basis of bespoke project Energy and Carbon Limits. The Design Team should also challenge the design brief and look for opportunities to reduce the carbon impacts of designs wherever possible.

3.13 Across all design stages, the Compliance Tools must be used such that the different tabs form reporting sections within the energy and carbon strategy, along with other key design reports or modelling outcomes that affect the project's performance.

3.14 Derogations to any requirements within the Standard should be presented within all business case approval stages. Reporting these should be the responsibility of the Net Zero Carbon Coordinator and should be done via the compliance tools whatever possible for ease. See Chapter 6 and Figure 10 for further information on roles and responsibilities.

3.15 As well as the key activities required for conformance with the Standard, there are a set of recommended activities that support delivering net zero carbon buildings across the project lifecycle. These are aligned with BREEAM and the Government Soft Landings Framework where applicable and can be seen in Chapter 6.

3.16 Table 4 below summarises the components of the Standard and how they assist this process for the Standard.

Table 4 Summary of the aspects of the Standard and how they are used across the design and business case stages

Aspect of the Standard	RIBA 0–1	RIBA 2	OBC	RIBA 3	RIBA 4	FBC	RIBA 5	RIBA 6	RIBA 7
The Standard itself	✓*	✓	✓	✓	✓	✓	✓	✓	✓
Supporting business case guidance notes	✓*		✓			✓			
Design Management Tool – to track decision making across the project and ensure compliance process is being followed		✓		✓	✓		✓	✓	✓
Compliance Tools – to capture modelling and assessment results and used to monitor progress against performance expectations		✓		✓	✓		✓	✓	✓
Submit Reporting Tabs of Compliance Tools			✓			✓			

* See SOC guidance section in Chapter 3 for considerations. As per the Usder Guide – supporting business case guidance, Energy and Carbon Limits and PTs can be used as rules of thumb to help inform SOC decision-making.

3.17 The process flowchart within Figure 12 is an overarching process for new build schemes. Refurbishment schemes should also see additional guidance and expectations within Chapter 5 – Additional process for refurbishment projects. Embodied carbon impacts of refurbishment schemes can be seen within Chapter 4.

Supporting processes and reporting across delivery stages

3.18 The following key processes and actions across the design stages, as shown in Figure 12, should be used to support the design and delivery of low energy and carbon healthcare facilities. There is a comprehensive list of requirements and explanation in **Chapter 6**.

Figure 10 RACI matrix for the NHS Net Zero Building Standard

Stage	Activity	Description	Roles: Client - Project Team	Roles: Net Zero Carbon Coordinator	Roles: Designers	Roles: Client - Operations and Estates	Roles: Contractor(s)
RIBA 0-1	Brief	Minimise new-build requirements and assess re-use options at pre-design stage as well as site opportunities such as demolition, and broader sustainability impacts of site selection.	R & A		I	C	
RIBA 1-2	Brief	Establish low-carbon brief for operational and embodied carbon considering site selection and building massing.	R & A		I	C	
RIBA 1-2	Appointment	Appoint designers and technical advisors with appropriate capability to deliver design outcomes and design activities within the Standard.	R & A			C	
RIBA 1-2	Appointment	Identify a Net Zero Carbon Coordinator to be responsible for compliance to the Standard and facilitate collaboration and coordinate design activities and reporting to support this.	R & A			I	
RIBA 1-2	Design	Establish net zero carbon strategy for the scheme using key criteria within the Standard, including high level energy strategy, approach for reducing operational energy and carbon demands as well as upfront carbon. Considering benefits and impacts on whole lifecycle carbon	R & A	C	I	C	
RIBA 1-2	Setting Limits	Calculate upfront carbon limit and operational energy limits and performance targets	R & A	C		I	
RIBA 1-2	Soft Landings	Establish a Soft Landings Champion as well as the overarching process and activities for Government Soft Landings	R & A	C	I	C	
RIBA 1-7	Lessons Learnt	Ensure that progress, key milestones, and lessons learnt are captured and fed back to NHS E/I as appropriate to benefit other schemes and drive continual improvement.	A	R	C	C	C
RIBA 2-3	Management	Facilitate conversations across the client, clinical, and design teams regarding decision making that affects adaptability of the building	C/a	R & A	C	C	I
RIBA 2-4	Management	Communicate operational energy and embodied carbon limits to the design team	C/a	R & A	C	C	I
RIBA 2-4	Management	Host regular design team meetings to ensure activities that influence energy and carbon are undertaken	C/a	R & A	C		I
RIBA 2-4	Design	Attend design team meetings and undertake collaborative design following requirements of the Standard	C/a	C	R & A	C	I
RIBA 2-4	Design	Consider energy and carbon performance when assessing design options and record design decisions in the design register at each RIBA Stage	C/a	A	R	C	I
RIBA 2-4	Design	Undertake iterative operational energy and whole life carbon assessments throughout each design stage to reflect increasing design detail and refine assumptions	C/a	A	R	C	C
RIBA 2-4	Design	Integrate aligned LCA and LCC options appraisal activity to inform design decisions and product specification to reduce carbon and cost	C/a	C	R/A	C	I
RIBA 2-4	Design	Engage with clinicians regarding unregulated energy loads and equipment profiles to optimise design and gather better understanding of in-use operational demands for the building, influence procurement of equipment and drive innovation throughout the design to achieve reductions.	C/a	C	R/A	C	
RIBA 2-4	Compliance / reporting	Use Operational Energy & Carbon Tool and Whole Life Carbon Compliance Tool to demonstrate compliance to Energy and Carbon Limits at each business case stage	C/a	A	R		I
RIBA 2-4	Compliance / reporting	Report derogations if required, including justifications for deviating from requirements	C/a	A	R		I
RIBA 2-6	Checking and Assurance	Check the energy and carbon limits reflect the design brief and ensure design proposal complies with the Standard requirements.	A	R	C		
RIBA 3-4	Supply Chain	Use contractor and supply chain engagement to shape design development, test and refine modelling and assessment assumptions and input into specifications	R & A	C		C	C
RIBA 3-4	Soft Landings	Progress activities within Government Soft Landings.	A	C	I	C	
Varies	Appointment	Appoint contractors and suppliers with appropriate capability	R & A	C	C	I	
Varies	Appointment	Ensure procurement method encourages and rewards low carbon solutions, MMC and innovation to reduce carbon	R & A	C	C	I	C
RIBA 5-7	Management	Host meeting to share key outcomes of Net Zero Carbon design register	C/a	R & A	I	C	C
RIBA 5-7	Management	Communicate operational energy and embodied carbon limits to the construction team	C/a	R & A	C	C	I
RIBA 5-7	Compliance	Record carbon data for all significant products received on site, including EPDs, transport data, waste and site emissions	C/a	C	I	C	R & A
RIBA 5-7	Compliance	Use NHS Operational Energy & Carbon Tool and the NHS Whole Life Carbon Compliance Tool to demonstrate compliance to Energy and Carbon Limits at handover	C/a	A	C	R	I
RIBA 6	Verification	Measure and report system performances and overall building/departmental performances against energy limits and assumptions in operation.	I	C	C	C/a	R & A
RIBA 7	Reporting	Report operational energy and carbon emissions through ERIC and other building management systems				R & A	
RIBA 7	Evaluation	Corrective action plan and investigate non-compliance				R & A	

Key

R	**Responsible**	Those who are carrying out the work.
A	**Accountable**	Those accountable for ensuring carbon is considered, reduced, calculated, reported.
C	**Consulted**	Those consulted throughout design stage to provide comments and feedback.
I	**Informed**	Those who are kept aware of design stage outputs.
a	**Accountable for support**	Accountable for ensuring carbon ventures are supported and prioritised. Client only.

Figure 11 Process flowchart for compliance requirements in this Standard

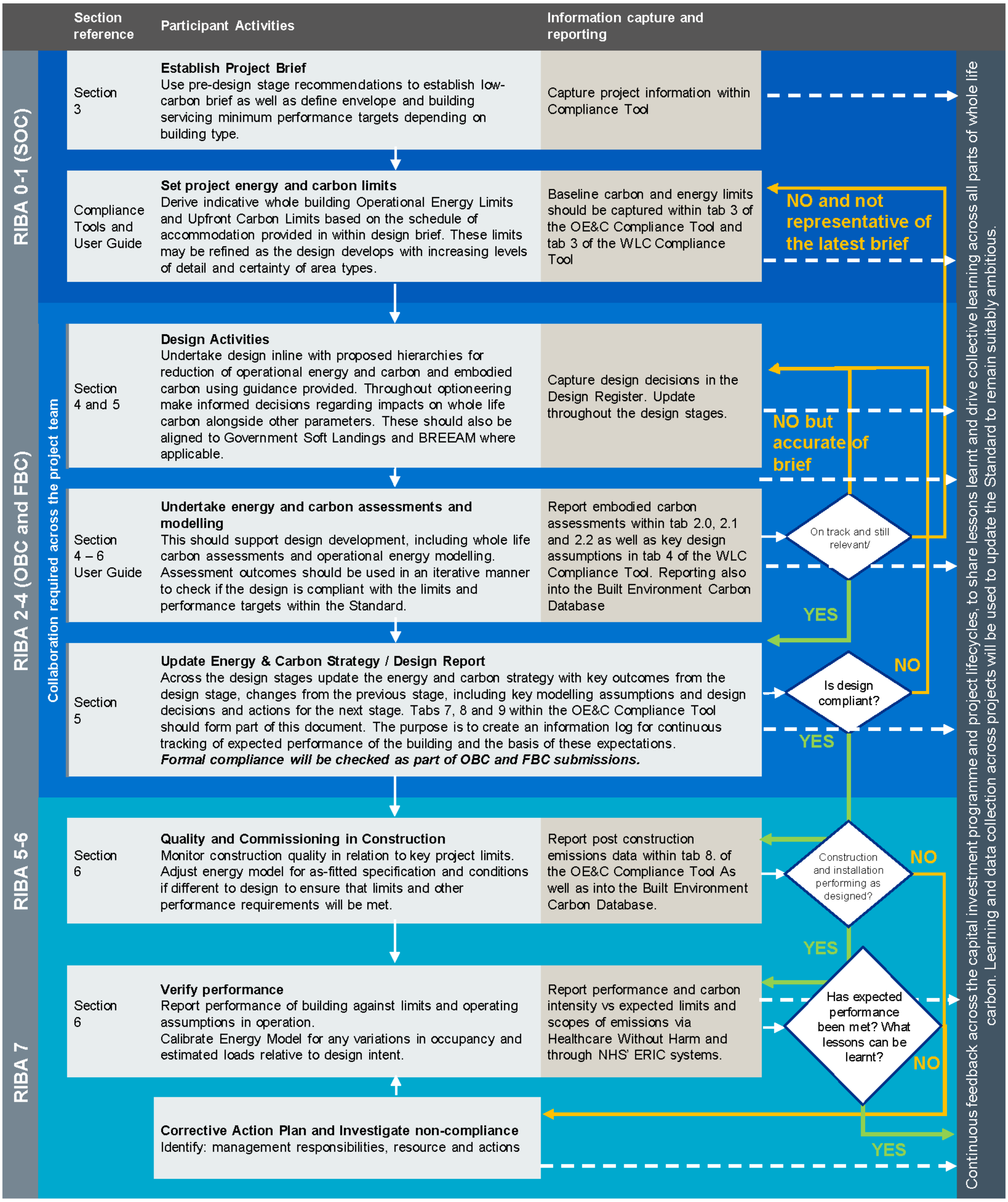
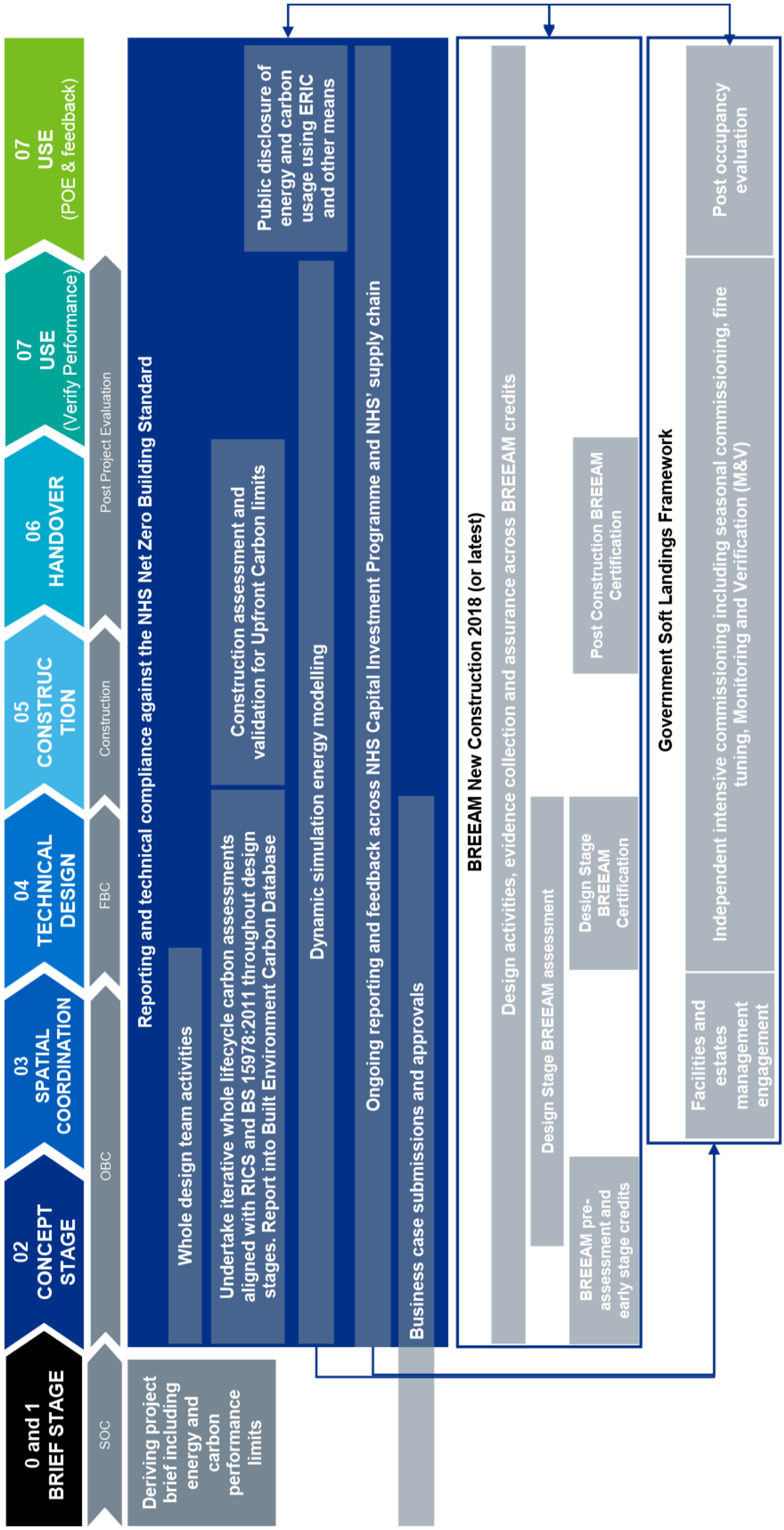


Figure 12 Supporting processes to the NHS Net Zero Building Standard



The role of standardisation

3.19 Standardisation is a key enabler to reduce embodied carbon across the lifecycle of a building. It underpins decision-making regarding adaptability and flexibility, reducing excessive or blanket over-design within all building elements and systems. Standardised design solutions also enable lean industrialised low carbon solutions, and adoption by NHS schemes encourage investment in the supply chain to drive this.

3.20 To support the methodology for net zero carbon across different parts of healthcare facilities, the following sections introduce various principles that enable approaches for standardisation, including:

- differing approaches and focus for different building elements
- categorising space-types into similar groups.

3.21 It is key that standardisation and modern methods of construction (MMC) are considered and included from design inception as these provide a significant opportunity to reduce WLC as well as supporting reduction of operational carbon through improved construction quality. This will require designers, procurement teams, suppliers, and manufacturers to be engaged in the design process as early as possible.

3.22 MMC should go through a rigorous multi-criteria assessment alongside traditional methods of construction as part of a selection for the final solution(s) to ensure intended project values and reductions in carbon are achieved.

Building elements

3.23 A building has a series of different elements, each of which influences adaptability and impacts on operational and embodied carbon to varying degrees. This is typically related to the lifespan of different building elements, for example:

- primary building elements (>50 years),[4] the base of the building with longest lasting elements including structure, envelope and vertical circulation. They contribute to Module A emissions most significantly
- secondary building elements (~20 years), infill of the building with infrequently changing parts e.g. building servicing systems, interior partitions, floor finishes and false ceilings. These contribute significantly to Module A & B emissions
- tertiary building elements (~5–10 years), infill of the building with frequently changing parts, e.g. FF&E. These contribute significantly to Module B emissions due to high replacement rates.

3.24 The Standard is focused on the primary elements of the building – structure, envelope and services; based on the long design life of these components as well as being the aspects that the Design Teams have the greatest influence over. Whereas infill elements (typically FF&E) are much more subjective to clinical decision-making and product specification.

4 Kendall, S. (2005). Managing change: The application of open building in the INO Bern Hospital.

Signpost:

The NHS is increasingly looking at product specification and supporting other government initiatives for reducing the environmental impact of procured products and goods. E.g. DEFRA – waste prevention programme for England.

Adaptability and durability

3.25 Establishing the appropriate level of adaptability within the design is pertinent as it can have significant impacts for the building's WLC impact, as well as cost and functionality across its lifespan. See section below for more information on the potential impacts.

3.26 This Standard does not specify the appropriate balance of adaptability as this is driven at the outset by the clinical system, strategy, and plan, as well as the estate development plan of the organisation. The following information should be used to help assist Project Teams make more informed decisions alongside requirements set out within HTM documentation.

Signpost:

Allowances for additional plant space and capacity included in HTMs and HBNs must also be incorporated as a basis of this strategy.

An additional 25% on tested plant space for future flexibility should be included within schemes. This includes internal and external technical space, and risers.

It is advised that documents and methodology historically used at the early stages will, in most cases, be insufficient to meet the Net Zero Building Standard due to a change in the plant space and corresponding technologies used.

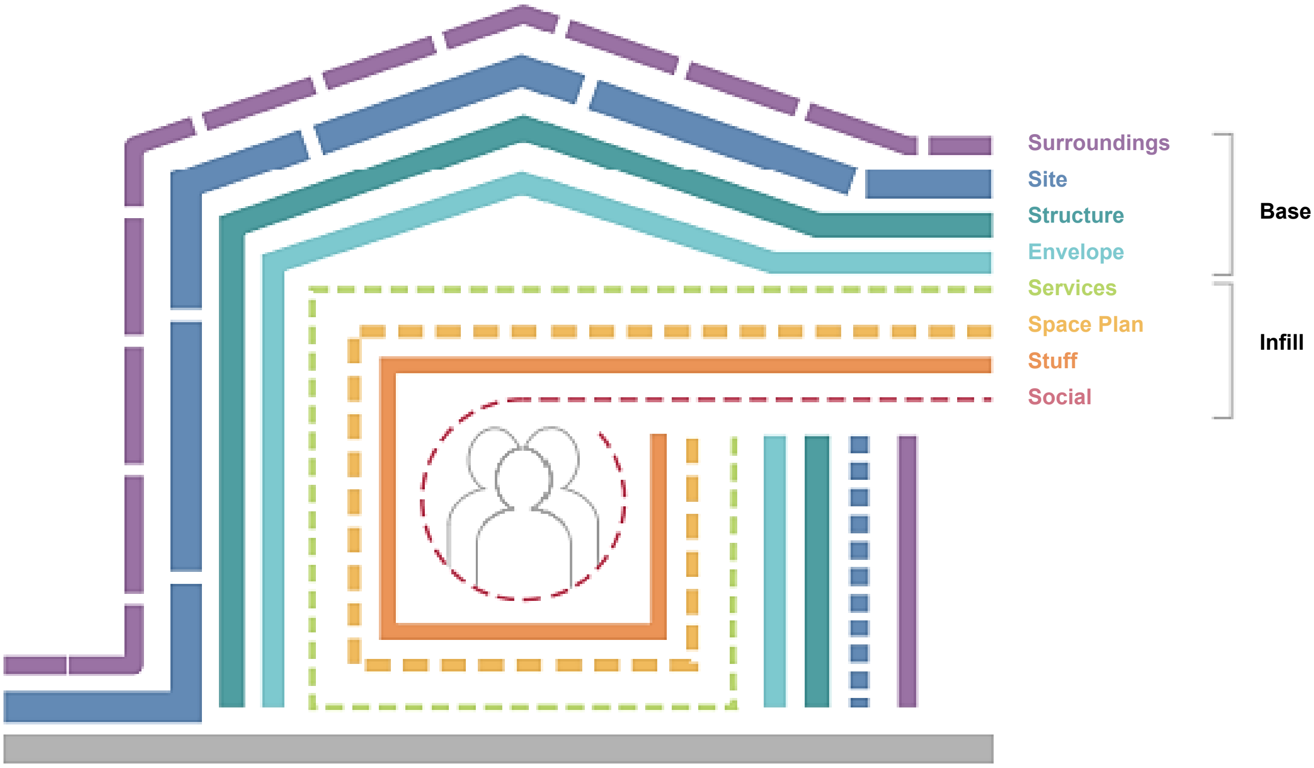
3.27 An Adaptability Strategy must be developed and included within design reports through engagement across the Client and Design Team to establish the right balance. This strategy must include rationale for why and how it is/is not included within the design and report expected lifecycle impacts (positive and negative) for such decisions.

3.28 This Standard focuses on the importance of the building's space plan (see **The importance of early project stages** section) and primary systems – structure, envelope and services; as this has the largest investment impact within the building and are the elements that the Design Team has the most control over, see **Figure 13.** It should also be noted that when designed well, a building's space plan can positively influence social and low carbon behaviours.

3.29 The concept of adaptability can be broken down into a number of simple strategies that are familiar to most designers.[5]

5 Assessing Buildings for Adaptability, IEA, Annex 31, November 2001.

Figure 13 Functional and building layers, adapted from Adaptable Futures and Pressler by HKS, 2019



3.30 Flexibility – enabling minor, rapid change in space planning. Created when changes can be made to the building's spatial function(s) to suit operational needs without needing to make changes to the core infrastructure. There are different scales of flexibility,[6] e.g. using open spaces for other functions and changing single patient rooms to consult rooms.

3.31 Convertibility – allowing for changes in use within the building. Requiring more significant changes to the building's features – structure, envelope and services. The extent of how adaptable the building's infrastructure is to allow for this can vary as shown below:

1. Convertibility **on** floor plate – "the floor can accommodate it" – this is akin to a traditional office fit out where the core services and structural allowances to the floorplate remain within the original considerations and groupings. There is extensive reconfiguration of the space and usage that then requires new on-floor service routing. Preference is to retain a service spine on the floorplate that can be utilised to serve these reconfigured areas. Major corridors typically stay where they are and there is no change in the core fire strategy.
2. Convertibility **of** floor plate – "the building can accommodate it" – a full refit and reconfiguration of the floor that will lead to large changes in servicing. Main services and floors are designed for upper limits of a variety of clinical space requirements and include resilience allowances for this future adaptability. There should not be need for changes to the structural allowances, but the central plant and services delivered to the floorplate will change. There may need to be local strengthening of a floorplate to adapt to new requirements (for example if the

6 Flexx, A Study of Flexibility in Outpatient Settings, CABRE 2019.

level of technology changes on the floorplate, see Table 5) if these exceed the baseline allowances in the original design these are undertaken – e.g. to allow for major clinical reconfiguration where whole internal fit-out is removed.

3.32 Expandability (alternatively "shrinkability"), or facilitating additions to the quantity of space in a building, this could be via vertical or horizontal extensions.

3.33 As well as adaptability, durability is a key consideration for achieving WLC and is most prevalent for latter design stages and product specification.

3.34 Durability – selecting materials, assemblies and systems that require less maintenance, repair and replacement. Since durability extends the useful lifetime of materials and technology in a building, it is complementary to adaptability.

3.35 There is an aspiration that new hospitals are high quality, durable and are designed to have a long design life. Durability and circular economy principles should be considered when specifying materials and products to minimise whole life car. Building elements should be used for their entire design life to reduce lifecycle replacements and the burden on facilities management.

Case Study – North Zealand Hospitals (Denmark)

North Zealand Hospital has a focus on incorporating nature with healthcare and is designed with the need to 'plan for uncertainty' and 'design for change'. The hospital must be flexible enough to accommodate technology that is yet to be invented and handle epidemics that may yet be unleashed. In addition, as requested by the hospital board, the design is to be fully led by best practice in patient care.

3.36 See case study below for further information on adaptability.

Whole life impacts of adaptability and durability

3.37 Inherently, the impact of embedding adaptability, flexibility and durability within the design and the asset itself, will have significant carbon implications, both in upfront carbon (Modules A1–A5) and over the building's WLC emissions (Modules A–D).

3.38 The benefits are dependent on whether future changes are realised and how many refurbishments or change of use occur. Alongside the carbon impact there is an undoubted cost and space consideration when the building is being designed to adapt in future. Assumptions for changes of use must be considered in the context of the overall building life and the anticipated benefits, occurring through improved adaptation and modification to meet changing clinical needs.

3.39 The following examples are sources of uncertainty in healthcare facilities and have potential consequences linked to increasing adaptability and durability:

- Changing clinical models may significantly reduce or change the requirements for healthcare facilities, leaving potentially stranded assets that are not fit for purpose.
- Adaptability can help increase the useful life of a building, entirely or in components parts, increasing the ability to respond to a change in space-type.
  - This can also reduce the cost and disruption of refurbishment for change of use.
  - This is of high importance as the Covid-19 pandemic has highlighted the need for rapid provision to respond to unprecedented and uncertain events.
- Increasing adaptability will often increase the upfront carbon of an asset. However, if a building cannot adapt to accommodate a new function, then it can be very upfront carbon intensive to replace that asset.
- Increasing design life through increasing the durability of materials, can lead to increased upfront carbon emissions.
- Assumptions over the asset's useful (design) lifespan can significantly influence embodied carbon payback. This can also potentially impact securing warranties for buildings with very long design lifespans.
- Making informed decisions regarding the items above is challenging because:
  - There is currently a data gap regarding Modules B and C emissions for facilities, including current replacement and refurbishment cycles.
  - There is uncertainty of future emissions associated with products and processes, and the frequency of replacements.
  - There is a lack of data regarding how many buildings use the adaptability allowances within their designs to enable changes of use.
  - The impact of changing clinical models and potential future technologies is unknown.

Space-type technology groups

3.40 The healthcare estate has a very diverse set of functions, space-types, and their characteristics; driven by the HTM and HBN requirements. To allow appropriate granularity for limit calculations and support a methodology for flexibility and adaptability across facilities, Table 5 gives a categorisation of spaces into groups based on their technical equipment and servicing needs. A full classification of space-type technology groups is presented in the User Guide.

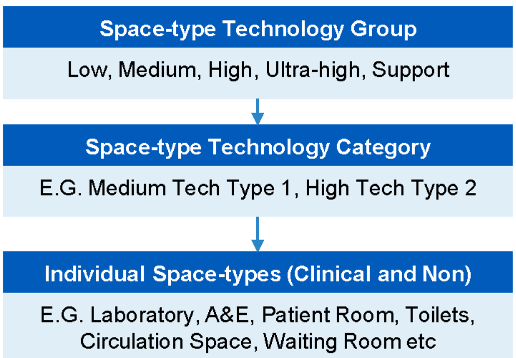
Table 5 Breakdown of space-type technology groups

Space-type group level	Clinical nature	Typical space-types	Key description
Low	Non-clinical	Offices and administration spaces, public circulation spaces,* teaching spaces, waiting areas, reception	These spaces historically make up a large proportion of healthcare buildings and have less onerous characteristics that allow for low carbon guidance from other parts of the built environment to be applicable.
Medium	Clinical	Consultation and patient rooms Most hospital wards including A&E Outpatient departments Maternity Ward and Birthing Room Post-mortem room Endoscopy	These spaces have clinical requirements but typically low loading requirements, albeit there may be different exact parameters (air change rates and vibration limits) across these space-types. They typically need to be adaptable and inherently flexible.
	Non-clinical	Dry laboratories	The classification of laboratories for medium or high technology typically depends on the specific requirements and extent of equipment.
High	Clinical	Operating theatres	Highly serviced spaces with very tight internal environmental controls and conditions.
		Intensive and critical care	Highly serviced ward type spaces that have much higher equipment gains.
	Various	Precision or wet laboratories	Laboratories typically requiring stricter vibration limits and interior environmental controls.
Ultra-high or specialist units	Varies, typically clinical	Diagnostics and imaging	These spaces can have very specific and often high equipment load, abnormal servicing requirements.
		Burns units and containment labs	These spaces can vary within their category depending on whether considering building servicing or parameters which affect the structure. For servicing, they typically have abnormal requirements comparatively to other space-types.
Support services	Non-clinical	Plant and storage Facilities management including waste, catering	Additional spaces that are needed to run a healthcare building. Not necessarily linked in scale to the provision of clinical services outlined above.

* Note: In the limits set out in Chapter 5 and the User Guide, circulation spaces, and some storage and support spaces, e.g. nurse stations and operating theatre preparation or scrub rooms, have been proportionally attributed to the adjacent spaces. They are therefore factored into the Operational Energy Limits for that space-type as well as Upfront Carbon Limits.

3.41 See Figure 14 for the hierarchy of space type breakdowns, with increasing granularity.

Figure 14 Hierarchy of space-types



3.42 These space-types technology groups and categories are used and expanded where applicable within Chapters 4 and 5 as well as in the Compliance Tools. Specific energy and Carbon Limits are derived based on these space-type technology groups and further methodology provided where applicable.

Offsetting and renewable energy generation

3.43 Currently, the Standard does not include:

1. detail of the proposed methods for off-site renewable energy and power purchase agreements, as this is being developed by the NHS England Estates and Facilities team. The off-site renewable energy requirement(s) for new builds are expected to be incorporated into Trusts' Green Plans alongside other existing infrastructure requirements for maximal benefit and value
2. any requirements or methodology for offsetting different scopes of emissions for new healthcare projects.

3.44 The Standard and Compliance Tools within allow the estimation of carbon emissions, based on the design brief, that can be used to inform offsetting strategies and requirements.

3.45 Some schemes may be subjected to immediate offsetting payments due to local planning conditions. It is suggested that guidance on appropriate renewable energy procurement as well as offsetting is sought through reviewing local requirements alongside best practice guidance.

Signpost for further guidance on renewable energy procurement:

UKGBC Renewable Energy Procurement and Carbon Offsetting Guidance for Net Zero Carbon Buildings

NHS Net Zero Carbon Client Brief (forthcoming)

4 Embodied carbon

Introduction

4.1 Understanding and reducing embodied carbon throughout the lifecycle of a building asset is a crucial part of the drive for the NHS to deliver its vision of net zero carbon healthcare. This chapter provides requirements to ensure embodied carbon is considered in the development of the design and is minimised through the adoption of mandatory whole life-cycle assessments, Upfront Carbon Limits, and design activities. This chapter should be read and applied in conjunction with Chapter 5 – Operational carbon, to provide an optimum WLC approach.

4.2 Upfront Carbon is prioritised in this Standard given it has the most significant impact of the embodied carbon components of the lifecycle and the one where the Project Team have highest confidence and control. Mandatory limits are established for upfront carbon with guidance provided for whole life stages where appropriate. The requirements are summarised as follows.

Mandatory carbon assessment and reporting

4.3 The embodied carbon for all materials must be assessed and reported using the *Whole Life Carbon Compliance Tool* (see Chapter 6). Assessment and reporting is required for Tier 1 and Tier 2 materials and for all lifecycle stages.

4.4 In some instances, a lack of data and/or uncertainty may restrict the ability of the Design Team to accurately assess carbon, but this should not deter from undertaking assessments. It is important that:

- assumptions are clearly reported alongside assessments (transparent reporting)
- uplift factors are used where necessary to make an informed allowance and ensure options can be compared on a like-for-like basis to the highest level of accuracy as is feasible
- where data is lacking, the Design Team (including Client and Contractor) proactively engage with the supply chain to accelerate industry data availability, e.g. through all suppliers providing EPD information.

4.5 The requirements are the following:

✓ **Ensure a WLC assessment is undertaken at each design stage, and used to inform design decisions, with data assessed, captured, and reported for all materials.**

✓ **The WLC assessments should be accompanied by a lifecycle costing assessment to demonstrate the impact carbon reduction has on total capital and operational expenditure.**

Mandatory Upfront Carbon Limits

4.6 Upfront Carbon Limits must be set for the project at the start of RIBA Stage 2 in the *Whole Life Compliance Tool*. The scope of the limits is restricted to elements where carbon can be robustly and accurately calculated, reported and assessed (Tier 1 elements).

4.7 The Carbon Limits are set based on the brief, using the space allocation tab in the *Operational and Energy Compliance Tool* to determine technology levels of space-types as well as other key project information required to develop the Upfront Carbon Limits. Detail on how they have been developed can be found in the User Guide.

4.8 The requirement is the following:

✓ **Ensure the Carbon Limits are set using WLC compliance tool at the start of the project and shared with the Design Team**

Mandatory design activities

4.9 These supplement the limits, ensuring the necessary processes are followed to arrive at low carbon solutions that consider whole life impacts. These are primarily focused around a collaborative design approach, although some discipline and element specific considerations are also necessary.

4.10 The process allows for consideration of cases where whole life benefits can be demonstrated from increased upfront carbon emissions. The activities are detailed in the following section.

4.11 The requirement is the following:

✓ **The activities must be recorded using the Design Register in the *Design Management Tool*. The Design Register follows the same principles as the CDM register and must be regularly updated through the project, and passed to the Contractor when appointed.**

Principles for embodied carbon compliance

Space-type technology classification

4.12 Healthcare building space-types have been categorised in Table 5 to allow setting appropriate Carbon Limits. The embodied carbon implications have been summarised in Table 6.

Table 6 Breakdown of space-types with embodied carbon narrative

Clinical Nature	Space-type technology group	Example Space-type	Embodied Carbon Summary
Non-Clinical	Low	Ancillary Spaces	These space-types have low loading requirements and limited vibration requirements, although basic floor finishes will be required. Generally, these floors will be low carbon, particularly within the structural elements
Clinical	Medium	Emergency, Out-patient Treatment & Consultation, and In-patient Areas	These space-types generally have low loading requirements and relatively minor vibration requirements, with none or very limited floor finishes. Generally, these floors will be low carbon, but slightly higher than the low-tech space-types within the structural elements
	High	Operating Theatres and Laboratories	These space-types have higher loading requirements and/or stricter vibration requirements than medium tech space-types and therefore are likely to be higher carbon within structural elements, and increased services
	Ultra-High	Specialist Spaces	These space-types have very strict and specific functional requirements, which results in higher embodied carbon. To mitigate this, these space-types should be located at ground level where possible.
Non-Clinical	Support	Plant Rooms	These space-types typically have higher loading requirements due to the plant weights. Roof space and basement/ ground space should be used, but for taller buildings interstitial plant rooms are typically required to meet functional and operational demands

Flexibility and adaptability

4.13 Design for flexibility and adaptability increases upfront carbon but may offer WLC benefits. It is important to consider the future change of use of a building, and its likelihood, to develop an Adaptability Strategy that informs important decision-making to minimise WLC.

4.14 The room layouts, sizes, fit out and equipment may change over time, to various extents of predictability. Historic data should be used to predict changes in trends and inform where future proofing offers carbon value. The design must assess the impact of internal reconfigurations to balance over-design against adaptability.

4.15 The requirement is the following:

✓ **An Adaptability Strategy must be developed as part of the early design stages. The Design Team must demonstrate the benefits of adaptability over the lifetime of the building are likely to lead to an overall reduction in WLC.**

Structural capacity

4.16 The structural strategy must focus on minimising upfront carbon and include provision for strengthening rather than adding capacity upfront which may not be required. The design for now and strengthen later approach is likely to use less carbon, because:

- strengthening will be less carbon intensive in the future due to grid decarbonisation and technological developments reducing the carbon intensity of production and construction

- additional capacity may not be required, so carbon is more likely to be wasted if used now.

4.17 A future strengthening approach could include allowing space under floors in specific areas to facilitate strengthening works, allowing for drop out panels for future service distribution, or adding capacity to vertical elements that are less carbon intensive, and more prohibitive to strengthen later. The additional upfront carbon associated with these suggestions (and other solutions) must be justified through a whole life-cycle benefit and a high likelihood that the benefits will be realised.

4.18 Flexibility must be provided using the spatial categorisation system in Table 6, with the intention that any space can be converted to another space in the same category or lower i.e. medium space-type technology group can be used for medium or low, but not high or ultra-high. This offers a degree of flexibility without overdesigning and using unnecessary carbon.

4.19 The requirement is the following:

✓ **The structural design loading and vibration requirements must allow for change of use of space within same category (or lower technology group). The design for now and strengthen later approach to lean design must be taken for converting spaces to higher tech.**

Service zones and change of equipment

4.20 The operation of building service systems comprises a significant amount of embodied carbon during the in-use stage with continued use requiring significant maintenance, replacement, and refurbishments.

4.21 With changes in plant and equipment driven by modern healthcare (and net zero operational requirements), floor to floor heights may require changing from those traditionally provided. If service distribution space below slabs is increased without a consequential reduction in other elements, then the embodied carbon in vertical elements such as structure, façades and partitions will increase. It is important to balance additional embodied carbon with potential savings in plant, services, and operational carbon during the lifetime of the building.

4.22 Building services designs must seek to reduce the future embodied carbon impact of refurbishment through adaptability in the distribution and core design principles. This might include, for example, allowing additional space in risers and horizontal routes to enable adaptations to be made without significant removal or addition of plant and distribution.

4.23 Where feasible, space should be allowed for future plant replacement of day one equipment and minimise the inherent embodied carbon that this generates. Allocation of future expansion space should consider future distribution and routing to serve the building.

4.24 The requirement is the following:

✓ **Levels of adaptability must be demonstrated in the MEP design with consideration of change of use load requirements. A WLC assessment should be used to aid decision-making on built in adaptability, e.g. floor to floor heights, additional spatial provisions, etc.**

Approach for embodied carbon compliance

Classification of building components

4.25 The lack of data, standardised modelling, standardised quantity extraction and low certainty of design assumptions being realised is challenging the development of Carbon Limits for whole healthcare buildings.

4.26 Therefore, Carbon Limits have been developed for certain components, which:

- have robust EPD data that can provide accurate carbon factors
- are accurately modelled during design to enable accurate quantification
- those which are thought to represent the majority of carbon, such that focusing on these will provide the lowest carbon outcomes for the least design effort.

4.27 Building elements have been categorised into two groups, so called tiers, as shown within Figure 5:

4.28 Tier 1 – Tier 1 represents systems comprising materials that have a sufficiently robust dataset to undertake carbon calculations, using assumptions and guidance provided in this document. They are thought to represent the majority of upfront carbon emissions.

4.29 Tier 2 – Tier 2 represents systems comprising materials that have insufficient information to enable robust benchmarking and limit setting at this stage. They must be included in WLC calculations and reporting but are not required to be considered against the Carbon Limits. Data collected during the operation of this Standard will enable more elements to be moved to Tier 1. For example, the embodied carbon emissions of MEP systems may be difficult to calculate in detail due to a lack of EPDs. Where EPDs are not available the CISBE TM65 methodology should be used to calculate the embodied carbon of MEP at product level.

4.30 The detail of materials in Tier 1 and Tier 2 is provided in the *Whole Life Carbon Compliance Tool* reporting tabs. The tiering will be reviewed and updated in future versions of the Standard in line with greater data quality.

Establishing Carbon Limits

4.31 Mandatory Upfront Carbon Limits have been developed to account for key variables (both generic and healthcare specific), such that a limit for the whole building can be derived from the project brief. The methodology for developing the Upfront Carbon Limits is presented in the User Guide.

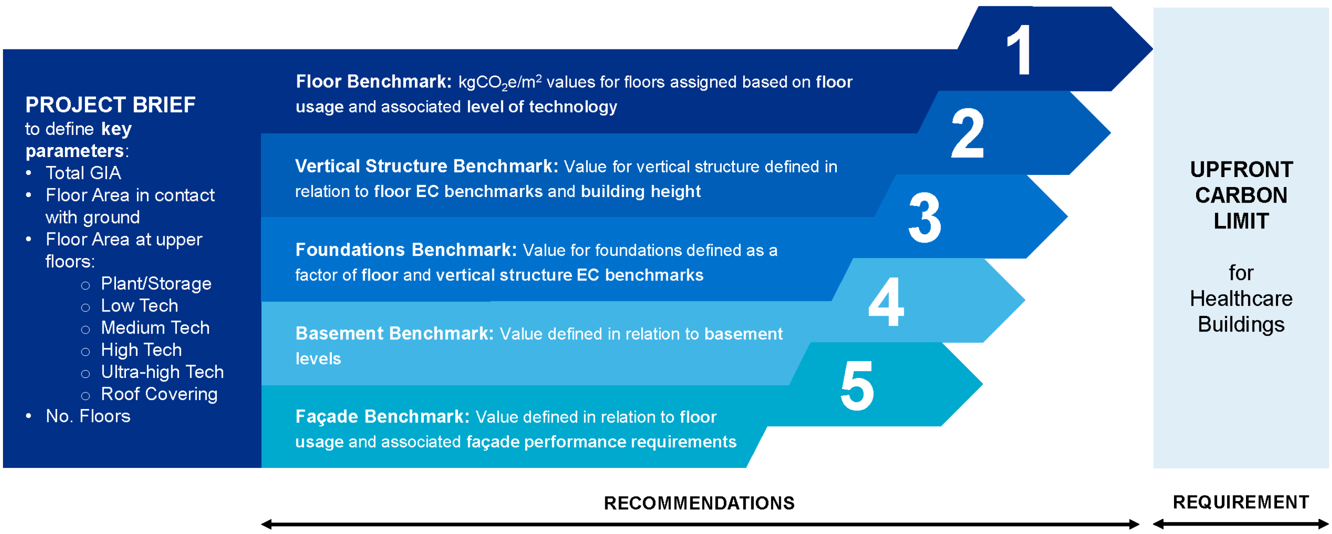
4.32 The limits are built upon a granular level, to arrive at a total Upfront Carbon Limit for the building considering each of the key building elements:

- superstructure – floor structure
- superstructure – vertical structure
- substructure – foundations
- substructure – basements
- façades
- building services (excluded from Upfront Carbon Limits at this stage) and
- fixtures, fittings and equipment (excluded from Upfront Carbon Limits at this stage).

4.33 Note that finishes have been included in the elements above as appropriate, rather than separated into a unique category – Refer to the *WLC Compliance Tool* Reporting tabs.

4.34 Figure 15 provides an overview of the approach, using the brief requirements to develop a project specific Carbon Limit. More detail for how this is derived, including worked examples can be seen within the User Guide.

Figure 15 Approach to setting a unique Upfront Carbon Limit



4.35 In addition to accommodation types, building height has been incorporated into the limits by considering allowances for low, medium, and high-rise hospitals, defined as:

- Low-Rise – lower than four storeys
- Medium-Rise – between four and eight storeys (inclusive)
- High-Rise – taller than eight storeys.

Meeting Carbon Limits

4.36 The designers should use a collaborative approach to produce the best design that falls within the overall Carbon Limit i.e. not apportion the individual limits by element. However, breaking down the total carbon by element when undertaking the assessment is encouraged to ensure the design roughly aligns with best practice.

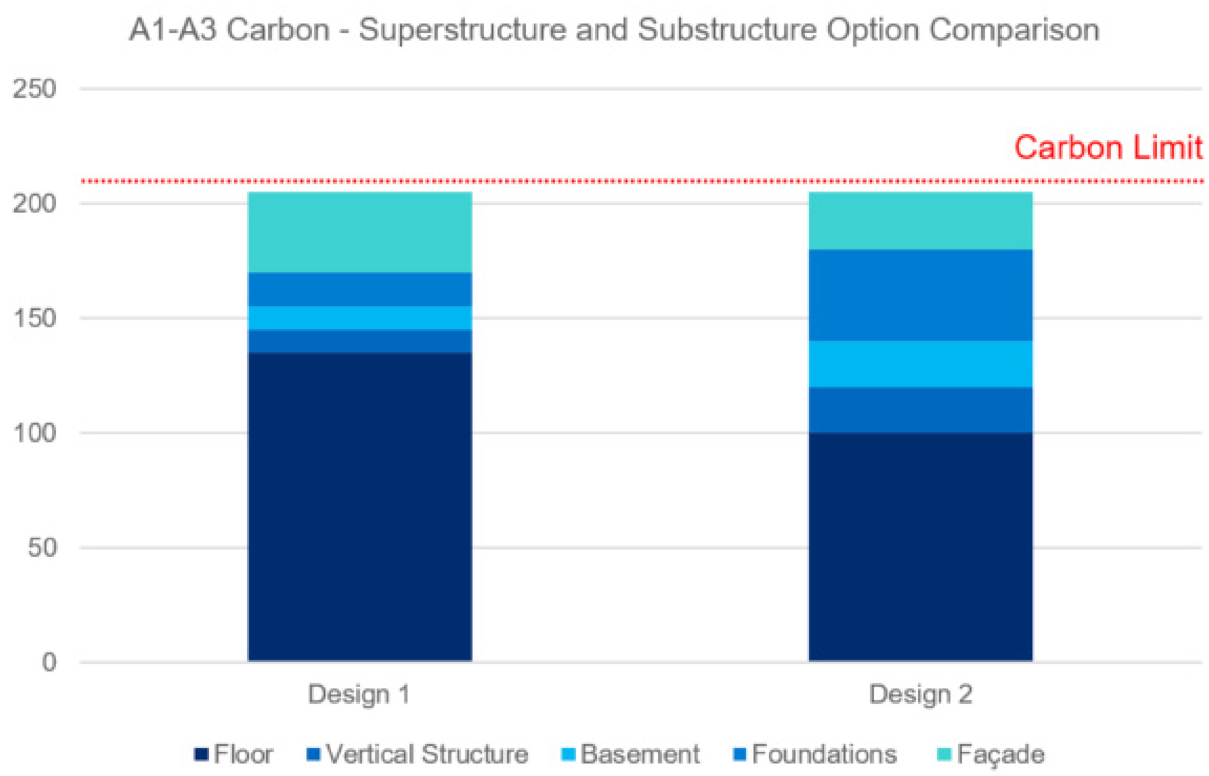
4.37 A theoretical example is shown in Figure 16, with two very different ways of meeting the limit for the project.

4.38 Carbon sequestration cannot be included towards meeting the Upfront Carbon Limits as the limits are Stage A only (don't include Stage C). This is automatically formulated into the *WLC Compliance Tool*.

4.39 For the full whole life-cycle assessment, sequestration is included in Stage A totals as Stage C emissions are included.

4.40 A derogations process is outlined in Chapter 6, with an allowable derogation to meeting the Upfront Carbon Limits being where whole life-cycle benefits can be demonstrated – depending on the end-of-life scenario assumed this derogation may be applicable to the use of biogenic materials.

Figure 16 Two ways of achieving the Carbon Limit



Incorporation of existing assets

4.41 The Upfront Carbon Limits outlined in this Standard apply directly to all projects but have principally been developed based on new build requirements.

4.42 If existing assets are reused to provide some part of the building, there may be significant upfront carbon savings compared to an entirely new build. Therefore, it is encouraged that a structural and functional assessment is undertaken on existing buildings to identify and maximise reuse potential.

4.43 The embodied carbon of the existing asset that is being retained, and measurement of this retention (i.e., historic emissions) is not required within this Standard. Therefore, when compared to building new, it is recognised that there is a carbon saving and the Upfront Carbon Limits within this Standard will be easier to achieve, or not challenging enough.

4.44 Whilst there may appear to be significant carbon savings within reuse, there may be challenges to reusing assets, and additional carbon that may be spent over that required for a new build. This is summarised below for different levels of reuse:

Reuse of foundations

4.45 There is a risk that despite reducing carbon in the foundations, carbon in the substructure and superstructure may increase due to:

- inefficient grids to match foundation locations
- transfer systems to suit foundation locations
- supplementary works to existing foundations if not sufficient.

4.46 The carbon saved by reusing foundations should exceed the carbon required in additional transfer structures and supplementary foundation systems to ensure that reusing foundations does not cost more carbon than it saves.

4.47 As it is likely to save carbon, it is important to maximise this opportunity if available. The most significant barrier to reusing foundations is a lack of knowledge and early testing to inform the design. The design must consider several factors and it is essential to ensure early specialist involvement to unlock opportunities and advise on design impacts.

Signpost:

Refer to IStructE article 'A short guide to reusing foundations' for further information.

4.48 The requirement is the following:

✓ **If reusing foundations is feasible, an assessment is required to demonstrate that reusing foundations offers a carbon benefit, with additional carbon in substructure and superstructure not exceeding the foundation savings.**

Case Study – 22 Bishopsgate:

22 Bishopsgate was erected on the site of an abandoned project, reusing 100% of the existing foundations from three previous buildings, and incorporating more than 50% of the basement built for its predecessor.

Horizontal extension

4.49 Horizontal extensions can offer carbon savings compared to new builds due to reduced façade requirements, possible structural reductions and possible reductions on new infrastructure and servicing – they can also provide an efficient use of available space

4.50 However, there are potential inefficiencies due to tying into existing grids and floor to floor heights, as well as the removal of facades that otherwise may not be required. To meet the Carbon Limits for horizontal extensions, carbon savings must be sought to offset these inefficiencies and a review is required to assess the impacts of tying in against isolating the new build.

Vertical extension

4.51 Vertical extensions offer the benefit of not requiring new substructure, but may increase carbon elsewhere due to:

- inefficient grids to match existing and/or
- transfer systems to suit existing grids
- supplementary works to existing vertical structure and substructure if not sufficient
- inefficient façade and services fit out.

Signpost:

Refer to IStructE article ‘Vertical extensions: technical challenges and carbon impact’ for further information.

4.52 As it is likely to save carbon, it is important to maximise this opportunity if available. This must be supported through the provision of design and as-built information as well as the required testing to provide the designers with the required information to ensure the capacity of the existing structure is fully utilised.

4.53 The requirement is the following:

✓ **If the project is a vertical extension, the Carbon Limits must be developed based on a new low-rise building (no. floors equal to the extension). The carbon assessment must demonstrate (through meeting the limits) that the additional carbon in superstructure and façade does not exceed savings from substructure.**

Case Study – 1 Triton Square:

1 Triton Square is a sustainable commercial office redevelopment project in London that has achieved a BREEAM Outstanding rating by maximising retention and reuse of the existing structure and façade.

The structural reuse and strengthening strategies adopted enabled three additional storeys to be added to the existing building to increase the floor area by 70%, while resulted in an overall carbon footprint per unit area for the scheme of 136kg CO_2e/m^2 and a SCORS A rating.

Refurbishment

4.54 The following inefficiencies will add embodied carbon for refurbishments (mostly in Tier 2 elements and site emissions) and must be carefully considered:

- Façade is likely to be more intensive due to existing architectural constraints, e.g. irregular grids/floor-to-floor heights and additional fixing systems required.
- Building services distribution and systems are likely to be inefficient due to existing constraints, impacting spatial use efficiency.
- Less usable space, although carbon metrics are normalised by gross internal area (GIA), the carbon/useful space will be higher and should be considered in assessments.
- Processes such as intrusive testing, structural strengthening and replacement works, repainting and finishing will add carbon and must be carefully considered in optioneering.
- Structural capacity may be limited in some areas, requiring assessment of requirements considering carbon cost of strengthening versus functional requirements.

4.55 Most requirements of this section are equally valid for refurbishments as for new builds, with additional considerations for refurbishments identified where relevant.

Signpost:

Refer to the IStructE article series 'An Introduction to refurbishment' for further information.

4.56 Future versions of the Standard may introduce Carbon Limits for refurbishments, when an increased scope of Carbon Limits (expansion of Tier 1, and inclusion of Module B) has been established.

4.57 The requirements are as follows:

✓ **All the requirements in this section of the Standard are valid for all levels of reuse, with some additional considerations for refurbishments. The WLC assessment for refurbishments should be undertaken as follows:**

✓ **If the design life of the structure is not being extended, embodied carbon associated with the refurb considered in Module B.**

✓ **If the design life of the structure is being extended, embodied carbon associated with the refurb considered in Module A.**

4.58 Further, retrofitting of existing building elements, e.g. upgrading of systems will be required to provide performance benefits over the lifetime of all buildings, which comes at an initial upfront carbon cost. It is important to ensure this upfront cost does not exceed the operational carbon and future embodied carbon savings.

4.59 The requirement is the following:

✓ **When retrofitting, an assessment must be undertaken to demonstrate a WLC benefit to the proposed works.**

Design considerations for compliance

Form and function

4.60 The form of the building has a significant impact on carbon, as well as functional requirements. Healthcare buildings typically benefit from larger façade areas relative to the plan areas, to maximise natural light into key spaces and improve patient experience.

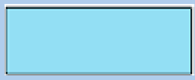
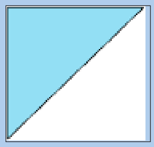
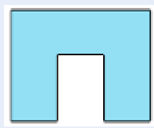
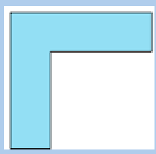
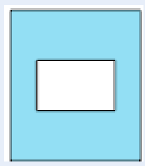
4.61 The shape of the building directly affects the building surface area and therefore how much façade is required. For a given floor area a circular building will require the minimum amount of façade (however, this is not recommended and is purely here for comparative purposes). As the building shape become more complex, the façade area will increase relative to floor area.

4.62 Table 7 summarises the relative surface areas of common floor-plan geometries, showing that significant savings can be made by using an efficient shape.

4.63 The requirement is the following:

✓ **The Design Team should determine the minimum shape factor that meets the functional requirements, provides daylight, and satisfies site constraints.**

Table 7 Effect of floor-plan geometry on façade areas

Geometry	Shape	Façade % of increase compared to rectangular benchmark
Rectangular		/
Square		–10–15%
Triangular		+5–10%
"C" shape		+15–25%
"L" shape		+15–25%
Hollow square		+30–60%

Operational performance

4.64 The operational performance is directly impacted by façade characteristics. The glass to opaque ratio of the external walls affects numerous parts of operational performance, including:

- daylight quality
- solar gains
- natural ventilation
- exhaust ventilation
- insulation
- overheating.

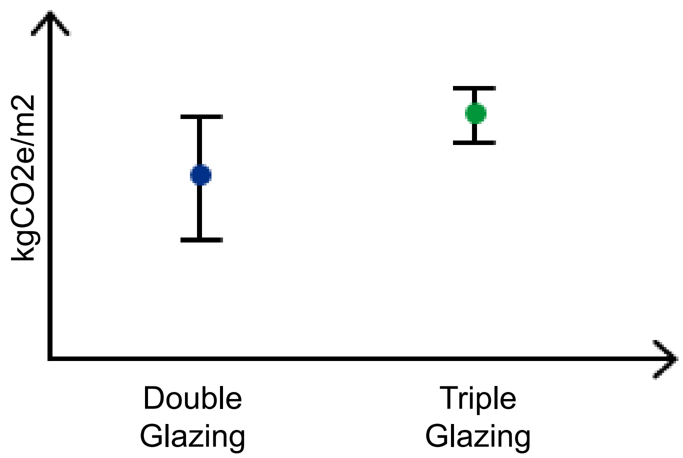
4.65 Current guidelines suggest a minimum of 20% of the external walls are glazed to achieve basic daylight standards, although glazing ratios of up to 40% may increase occupant wellbeing benefits and patient recovery, without adversely impacting energy performance through potential solar gains depending on orientation. See the User Guide for more guidance on daylighting design.

4.66 It is important to consider glazing ratios on each face of the building considering orientation and other parameters, noting that impacts on healthcare buildings differ from other typologies due to the level of mechanical ventilation. Studies into optimal glazing ratios for each elevation are recommended, taking account of the embodied carbon impacts of the cladding and glazing systems. For example, north elevations could benefit from increased glass percentages whereas on south elevations it is recommended to use lower ratios to prevent solar gain and overheating.

4.67 The impact of the use of double glazing or triple glazing on operational carbon is also important. Chapter 5 outlines that hospitals that are highly serviced are less likely to benefit from the use of triple glazing, so it is important to assess whether the energy savings justify the additional upfront carbon cost.

4.68 The embodied carbon in a glazing unit is influenced by the materials and treatments selected and set by the glazing specifications. Light transmittance, coating films, laminated panes and plastic-based thermal breaks will vary the embodied carbon contribution of each window system and it is important all the components are considered in the build-up, especially the framing. This can lead to a significant variance in differing systems, as illustrated in Figure 17.

Figure 17 Variation of embodied carbon for different glazing options



4.69 Finally, different cladding systems also have significantly different carbon intensities to provide the same functional requirements, with a large variance in embodied carbon in like-for-like systems, so it is important to consider the range of values as well as different cladding options when assessing build-ups.

4.70 The requirement is the following:

✓ **A parametric study should be undertaken to inform decisions on building fabric, varying the cladding system, glazing system, and glazing ratios for each elevation to meet operational energy requirements for the lowest embodied carbon cost.**

Optioneering

4.71 To ensure a robust study of design options is undertaken, considering **WLC**, the Design Team must undertake the following at the relevant stages of design, considering the information presented elsewhere in the chapter as appropriate:

- Review reuse opportunities for existing assets.
- Undertake optioneering study of different foundation systems.
- Undertake optioneering study of different ground retention systems, including distinct waterproofing systems.
- Undertake optioneering study of different structural floor systems, including using timber where appropriate, e.g. open-plan spaces and in low technology/ non-clinical space-types.
- Undertake massing model studies using different façade systems.
- Undertake assessment into different glazing systems.
- Undertake optioneering study of different landscaping systems.
- For refurbishments, undertake optioneering study into strengthening options, including consideration of increase of design life.

4.72 The requirement is the following:

✓ **Optioneering studies must be undertaken as part of whole life assessments as specified above.**

Case Study – 100 Projects UK cross-laminated timber (CLT):

The Dyson neo-natal care centre was the first use of solid laminated timber in a tertiary healthcare environment. This single storey extension was designed to support the 'developmental care' model, providing space and privacy for parents to engage with their babies.

The timber solution provided a quick, clean, and quiet form of construction, essential in an acute healthcare environment. It also provided an opportunity to challenge healthcare construction and look at a more sustainable material with a low embodied energy.

A palette of natural materials alongside the exposed CLT creates a sense of calm bringing warmth and tactility to the clinical facility. Combined with the quality of daylight and sunlight, this helps lower stress levels and lifts the spirits of the parents, staff and infants being treated.

The arrangement of spaces and functions

4.73 The layout of the building has a significant impact on embodied carbon, principally due to the proportion of carbon that the floor slabs are responsible for. Careful consideration must be made by the Design Team to arrange the accommodation within the building to allow a low carbon structural solution whilst satisfying functional requirements. Some key examples are given below.

Room locations

4.74 Location of accommodation in relation to the building perimeter has a significant impact on façade design and operational performance. Decisions should be taken across the Design Team based on WLC calculations balancing Upfront against in-use and operational carbon. This should include consideration of U-values and air-tightness of the façade, and glazing ratios and whether windows are openable or sealed.

4.75 The highest carbon intensity façades are those required adjacent to spaces such as theatres, laboratories and spaces which do not necessarily require daylighting. Carbon can be minimised by placing these within the building and away from floor edges (see Table 8).

Table 8 Façade requirements

Classification	Key façade requirements
Support, e.g. plant	Plant and storage rooms have no minimum required daylight but will require acoustic and thermal insulation. Plant may need access to external faces of the building for operational and maintenance reasons.
Non-clinical low-tech and clinical medium tech	These spaces require consideration of thermal, acoustic, daylight and internal comfort requirements. Some of these spaces may need to be adaptable for future reconfigurations. To optimise the design and minimise the embodied carbon, these areas benefit from high standardisation using modular components reducing cladding material wastage.
Clinical high-tech	These spaces require special consideration of enhanced performance requirements, such as acoustic performance in theatres. Daylight may be required in laboratories, but generally the spaces will have low levels of glazing for privacy and performance. These systems will be higher carbon due to the increased requirements. Spaces should be positioned away from façades where possible.
Specialist clinical ultra-high tech	Special consideration is required for façades adjacent to ultra-high tech areas. Daylight is not required and strict performance requirements for shielding, thermal and noise insulation increase embodied carbon. These rooms should be located away from façades.
Atria, receptions and waiting areas	These spaces require higher glazing percentages to maximise the daylight intakes, with glass curtain walls favoured. They are typically specified in circulation and entrance areas. High specification glass may be required to prevent excessive solar gains or for structural stability. Additional design considerations include vandalism, blast, and terrorism.

4.76 Increasing the specification of a standard façade element to satisfy the needs of small amounts of high technology façades should be avoided. Where possible a kit of parts approach should be adopted to allow an efficient standard panel to be used with additional elements where enhancement is required.

4.77 The requirement is the following:

✓ **The building layout should maximise the spaces requiring natural light on the external parts of the floor plans. Spaces not requiring light and requiring enhanced façades should be placed within the floorplate.**

Plant location

4.78 The location of plant within the building can have a significant impact on carbon.

4.79 Plant rooms should be located to allow ease of access for maintenance and replacement. Heavy plant should be placed on ground bearing floors and lightweight plant on upper levels. Where possible and where compliant with HTM requirements, some rooftop plant areas may remain uncovered to avoid the carbon associated with creating an additional roof level. Further, an assessment should be made into the carbon impacts associated with additional maintenance and replacement. Where additional roof coverings are provided for plant, it may be beneficial to use this space to house PV panels to enhance the on-site renewable energy production.

4.80 To meet operational demands in taller hospitals, and meet demanding specific fan powers, interstitial plant floors may be used. These offer operational benefits and reduce distribution equipment and systems but may increase upfront carbon in the supporting structural elements over a standard floor plate due to higher loadings. This can be mitigated by housing lightweight plant on interstitial floors and ensuring the accurate loading is used for structural design (not using a high blanket allowance for plant).

4.81 The requirement is the following:

✓ **The building layout should maximise the placement of heavy and dynamically sensitive equipment on ground bearing strata and lighter plant at roof level. The need for interstitial floors must be assessed and WLC carbon quantified, if possible, comparing multiple options to determine the best whole life carbon solution.**

Circulation and distribution

4.82 Efficient circulation and distribution of services, locating plant as close as possible, can ensure embodied carbon in these systems is minimised and improve operational efficiencies.

Whole Life Cycle Carbon Flag – distribution and circulation of building services

There are design considerations which may increase the whole life carbon/embodied carbon. For example, efficient ductwork may require more vertical space, increasing floor-to-floor height and therefore embodied carbon in vertical elements (columns, walls, façades).

4.83 Distribution routes should be direct with minimal changes in direction or areas of constriction. Early coordination with the Design Team is vital to ensure that allowances are made to ensure that this can be achieved efficiently.

4.84 Installing and maintaining the significant services in hospitals is also easier with a flat soffit solution without downstand beams. Operational carbon considerations dictate unhindered and straight distribution routing for services which are often more challenging should there be localised downstand beams.

4.85 This may exclude the use of more efficient structural systems, such as thin slab systems spanning between stiff downstand beams. However, a downstand beam solution can increase the overall floor to floor height, increasing façade and vertical structure carbon, so the carbon implications are complex.

4.86 The requirement is the following:

✓ **Solutions must be considered holistically and the impact of the structural solution on services, overall building volume and cladding area assessed in selecting a system.**

Grids

4.87 The layout of accommodation affects the grids required. Various grids have been adopted in historic healthcare designs, with a lack of convergence towards a standardised approach.

4.88 Long spans increase structural depth and therefore embodied carbon. Although fewer vertical elements are required, they must take a greater load due to the increased weight of the slabs. Grids should be minimised to smallest practical grid while achieving clinical function and flexibility.

4.89 Transfer and cantilever structures increase embodied carbon due to structural inefficiency, and are commonly introduced where columns do not align through buildings or cannot be placed below floor edges, typically due to:

- changing uses between different floor plates, for example wards over basement car parking
- interstitial plant floors which may require different grids
- tight spatial restrictions and focus on minimising Gross Internal Floor Area
- canopies requiring structurally free zones below
- restrictions on plan area at low level but potential to increase floor areas above
- heavily constrained sites with difficult access, or existing ground constraints.

4.90 Structural grids should be regular and strive for closer spacings to reduce embodied carbon (also see IStructE lean design guidance).[7]

4.91 The requirement is the following:

7 Lean design: 10 things to do now – The Institution of Structural Engineers (istructe.org)

✓ **A study into grid options must be carried out. Grids should be regular vertically and horizontally and based on the minimum spacing suitable to the demands of the brief i.e. transfers and cantilevers should be avoided.**

Basements

4.92 Basements require more carbon per square metre to construct than upper floors. However, for hospitals they are often favoured due to constrained sites, significant plant requirements and use of ground floor space for ultra-high tech space-types, entrance, and circulation space.

4.93 There are several complex considerations associated with basements which must be considered to determine the carbon cost (see Table 9).

Table 9 Carbon Impacts of basement compared to above-ground floor space

Positive impacts	Negative impacts
Reduced façade requirements	Increased slab requirements for propping walls
Better ground conditions at formation level	Material required for retaining walls, lining walls, beams and waterproofing
Reduced depth of deep foundation system	Excavations
Ensuring high loads are ground supported	Uplift forces due to buoyancy

4.94 Carbon cost increases significantly as basement depth increases, so it is recommended to keep basement depths to a minimum.

4.95 Solutions for air intake and plant replacement should be considered in the preliminary option designs considering carbon impacts of the options

4.96 The requirement is the following:

✓ **A calculation must be undertaken to compare the carbon cost of basement space versus additional above ground floor space. Basement depth should be minimised.**

Car parks

4.97 The provision of car park space is a typical requirement for hospitals, and where possible it is recommended that this is provided outside of the main building envelope to avoid carbon intensive basements and transfer structures.

4.98 Where external car parks are included in the scope of works, they are excluded from Upfront Carbon Limits but a separate whole life assessment must be undertaken. The consideration of WLC is essential given the unpredictable long-term requirement for personal car use. To this end, circular economy principles should be used to guide the design decision-making, e.g. demountable structures may be prioritised. Otherwise, an Adaptability Strategy should be provided to ensure future usage in an alternative function.

4.99 The requirement is the following:

✓ **For external car parks, an independent whole life assessment must be conducted, with option comparisons including change of use and deconstruction for reuse.**

Lean design

4.100 This section discusses a range of considerations around designing the building in a lean and efficient way.

Loading

4.101 The loading requirements adopted for the design will influence the structural material required, with increased loading increasing carbon. The following considerations should therefore be made:

Permanent loads

- The Design Team should take a co-ordinated approach to accurately determine permanent loading – ensuring floor finishes, ceiling, and services are accurately calculated may allow the structural engineer to reduce the loading requirements and structural material required.
- The use of screeds should be assessed to ensure the usage is limited to where benefits are clearly seen, as these add significant carbon and mass to the structure.
- Additional loading above theatres is required to account for ceiling hung equipment. Strengthening in localised areas should be used to accommodate this additional loading rather than allowances made over large areas.

Variable loads

- Variable loads adopted in design are often conservative. A collaborative Design Team effort can be used to accurately determine plant loads and loading reduced from blanket allowances.
- Structural design loading from partitions should also be accurately determined and used to inform the design allowance.
- Functional room requirements and associated loading should be assessed, with recommendations of codes considered as upper limits which can be reduced through measurement or calculation.

4.102 The requirement is the following:

✓ **The Design Team must record decisions made against the permanent and variable loading assumptions. These must be reviewed at each stage to ensure an accurate approach avoiding over conservatism. Additional loading may be required on adaptability grounds and should be recorded and justified as such.**

Vibration

4.103 The vibration requirements adopted for the design will influence the structural material required, with lower response factors increasing carbon. The following considerations should therefore be made:

- The functional room requirements and associated vibration response as required in HTM 08-01 should be assessed.

- Manufacturers' requirements for medical equipment, e.g. MRI vibration control stipulations.
- The Design Team should undertake a detailed calculation for footfall response, using FE modelling and full excitation analysis, considering corridor locations and limited free movement in rooms.
- The Design Team should consider room layout to control vibration. Avoiding long corridors and introducing stiff points can effectively control vibration without adding significant mass and carbon.
- The Design Team should incorporate requirements for post construction vibration assessments, to assess and validate design results. These should also include requirements for measuring and monitoring vibration performance over the building lifetime to aid flexibility and adaptability where it may be required (i.e. areas which may be upgraded to higher technology spaces in the future). This should mitigate and reduce the need for future strengthening works.

4.104 The requirement is the following:

✓ **The Design Team must record decisions made against the vibration requirements. These must be reviewed at each stage to ensure an accurate approach avoiding over conservatism. Vibration requirements may be increased on adaptability grounds and must be recorded and justified as such. Post construction assessments must be used to validate design results and monitor performance to inform future adaptability.**

Optimisation

4.105 Optimisation must be carried out to ensure an efficient minimum carbon design at elemental level.

Floor plates

4.106 Floor plate optimisation is paramount to meeting limits due to their significant contribution to total embodied carbon. If spans vary, optimising the structure in these locations is important to ensure the carbon benefits of shorter spans are achieved. As structural member utilisations in buildings are historically low (particularly in steel buildings[8]), it is essential that structural member designs are optimised to remove unnecessary carbon.

4.107 Studies have also shown a significant contribution of carbon in floor finishes, particularly when using thick screeds and raised access floors. Carbon in floor finishes can be minimised by:

- designing out screeds
- omitting raised access floors
- ensuring structural design loading reflects actual finishes used.

8 https://www.istructe.org/journal/volumes/volume-98-(2020)/issue-10/rationalisation-versus-optimisation/

Vertical structure

4.108 While cores are frequently large in acute hospitals to facilitate large lifts and significant service risers, cores and columns in high-rise buildings are often oversized and not optimised for reduced design actions at higher levels.

4.109 The vertical structure should be optimised every three floor levels where possible, although some structural systems may have different requirements.

Foundations and ground retention systems

4.110 Where ground conditions vary, a balance must be struck between rationalisation and optimisation to unlock carbon savings. Design for a single worst case must be avoided.

4.111 Opportunities exist in utilising the existing ground to support the slab (avoiding suspended ground slabs). Ground strengthening and stabilisation can be considered and prioritised to enable ground bearing slabs and to minimise depths of piling mats and haul roads.

4.112 The requirement is the following:

✓ **Structural utilisations must be reported by the designers for superstructure and substructure. At RIBA 4, member utilisations and reinforcement optimisations should ensure that the average member utilisations should be a minimum of 80%.**

Façades

4.113 Opportunities to optimise the façade systems exist through:

- avoiding bespoke panels and fixings
- simplifying geometries
- using lower specifications in areas where requirements are reduced
- off-site manufacture to improve quality and reduce waste.

Partitions

4.114 Partition requirements vary through the building, with sound insulation requirements governing the thicknesses and spatial requirements governing the quantity of partitions in the space.

4.115 An optimised layout and partition design can unlock carbon savings and should be investigated as the design develops.

4.116 The requirement is the following:

✓ **Optimisation of façades and architectural elements must be undertaken and reported, including minimisation of floor finishes and partition requirements.**

Building services

4.117 The design must consider the embodied carbon impact for all components of the building services systems including the plant and the distribution systems within the building. The embodied carbon emissions of MEP systems may be difficult to calculate in detail due to a lack of EPDs. Where EPDs are not available the CISBE TM65 methodology should be used to calculate the embodied carbon of MEP at product level.

4.118 Plant and equipment must be assessed on their embodied carbon values as well as their performance metrics with a clear indication given on the final selection. Resilience measures should be considered in the context of embodied carbon with a robust and pragmatic approach to ensure that the systems are optimised with minimal overhead on the operational plant, other than that required for fluctuating demand and inherent resilience. Within the embodied carbon reporting requirements there are subcategories for embodied carbon of plant used for backup, as well as primary plant.

4.119 The locations of plant rooms should be optimised to allow for reduced system losses and a reduction in distribution system length. Consideration should be made of the impact of multiple localised plant rooms versus centralised plant areas and the ongoing maintenance strategies needed.

4.120 Material selection for plant and distribution systems should consider the wider embodied carbon impacts and the anticipated lifespan of the products as well as the anticipated operational life related to the areas being served. It may be that a more robust system is used on the primary routes with a lower carbon intensive system on the local distribution to facilitate lower impact change driven by future change of use of spaces.

4.121 Consideration should be given to the systems used to ensure the correct balance is struck in terms of embodied carbon of the fixing systems used as well as the materials used in the systems themselves. The system choices may impact the installation duration and labour intensity and should be considered in conjunction.

4.122 The choices made regarding fittings, their type, location, and quantity can have a large impact when considered over a large system(s). The inclusion of additional components within a system above those should be avoided through early consideration of control and commissioning strategies and, where possible, mounting systems should be simplified to reduce bracketry.

4.123 The requirement is the following:

- ✓ **Optimisation of building services design must be presented by the Design Team to include the distribution, servicing strategy and main plant selection. Requirement for accessibility and future partial or phased upgrades needs to be considered, so that component parts can be swapped/replaced with ease without having to discard entire systems.**

Specification

4.124 Specifications should be used to optimise the selection of systems and products, using low carbon solutions where possible.

4.125 The requirements are as follows:

✓ **Product selection should be informed by carbon assessments of like-for-like products, prioritising low carbon EPDs, and specifications must be used to communicate selections.**

✓ **EPDs should be compared to each other according to CIBSE TM65 methodology and to BS EN 15804:2012+A2:2019 (BSI, 2019). The number of EPDs provided/ available must be reported against the number of products specified.**

Replacement, maintenance and durability

4.126 For systems which are replaced over the life of the building, it is critical to consider the carbon impact of replacement and maintenance (Stage B) as well as upfront and operational carbon to develop the overall lowest WLC solution.

4.127 The following best practice approaches should be followed to minimise the Stage B embodied carbon.

- Increase durability – the durability and potential for increased lifecycles for plant and equipment must be included when considerations are made on selection. While an increase in durability might come at an upfront carbon premium, the extension to lifespan can deliver a WLC benefit.
- Upgrade carefully – when replacing systems, efficiency improvements in operation should be balanced against embodied carbon costs to ensure WLC benefits.
- Minimise replacement – façades should be designed to maximise the service life of components, minimise maintenance and provide easy access for inspection. The design should allow replacement without requiring removal of adjacent components.
- Maintain regularly – scheduled maintenance can extend the service life of the components and reduce WLC.
- Consider fire and corrosion protection – consider options for protection of elements and relevant maintenance requirements, where comparing systems ensure protection is included in studies (e.g. reinforced concrete versus steel schemes) to arrive at a fair like-for-like comparison.
- Prioritise mechanical fixings – mechanical fixings are preferred over structural glues, welds, and permanent components. Mechanical fixings minimise disruption in case of replacement and maximise the potential for recycling and reuse.

4.128 The requirement is the following:

✓ **Consideration of replacement, maintenance and durability must be built into the design process through the use of a whole life assessment approach to decisions. Note that an allowable derogation to Upfront Carbon Limits is where whole life and circular economy benefits can be demonstrated for additional upfront cost.**

Adoption of Modern Methods of Construction (MMC)

4.129 Design should be open to a range of solutions. A standardised design helps to enable MMC approaches, which in turn can aid robust embodied carbon calculation and improved operational energy performance.

4.130 Standardised design allows the supply chain to focus more effort on refining standard components instead of a bespoke approach for each project. Through a more integrated supply chain MMC can also enable circular economy practices, and opportunities for future re-use and recycling of materials, as well as other benefits across the lifecycle stages.

4.131 Considerations that suit MMC approaches include:

- adoption of a standard grid and floor to floor height
- repeated use of standard components
- making decisions as a Project Team and not a discipline
- minimising the number of elements and connections through simplification of structure, façade, and direct routing of MEP distribution systems
- optimising building services module sizes, reducing the extent of supporting framework and linkages required
- optimisation of MEP frames to reduce ancillary steelwork, with finishes, MEP and FFE integrated into solutions
- wastage reduction using standardised design parameters (and compliance with BREEAM waste requirements).

4.132 The requirements are the following:

✓ **The design process must consider how to optimise MMC, with decisions made as an integrated Design Team.**

Whole Life Cycle Carbon Flag:

Clients should ensure that every opportunity for carbon saving is maximised including utilising the skills of the supply chain during the procurement process to optimise the final design.

5 Operational carbon

Introduction

5.1 Understanding and reducing the operational carbon throughout the life of the building is a crucial part of the overall drive for the NHS to deliver its vision of zero carbon healthcare and act on climate change as well as improve patient outcomes and care.

Case Study – Healthcare Denmark

New Odense University Hospital will be equipped with a large solar power plant that will supply one third of the power for the construction of the hospital and one fifth of the power for operation when completed in 2022.

Introducing increased use of daylight lighting and natural air ventilation into the healing environment to improve patient care.

5.2 Healthcare facilities are generally some of the most energy and carbon intensive buildings due to their 24-hour operation, large amounts of specialist equipment and highly serviced spaces. As a result, most hospitals' operational energy is disproportionately large for the size of the building because of the extensive use of HVAC systems and highly intensive clinical equipment. Additionally, ERIC data and international case studies demonstrate the significant operational efficiencies and carbon emission benefits that can be achieved through imporved monitoring, controls and management of HVAC systems.

5.3 The benchmarking review completed during the background work for this Standard identified that heating (including DHW and space heating), ventilation and cooling are the major energy users within a healthcare facility, in addition to clinical and non-clinical equipment. These need to be the focus on energy efficiency through design and operation of facilities as they will create the greatest improvements.

5.4 Given the long operational lifetimes of schemes and their inherent high energy intensities it is critical that their operational performance is pushed to the extents of what is technically feasible, while remaining practical to deliver.

NHS Net Zero Building Standard Energy Limits and Performance Targets (PTs)

5.5 Energy Limits must be set for the project from SOC, based on the methodology presented in Chapter 3. The scope of the Energy Limits is restricted to space-types where carbon can be robustly and accurately calculated, reported and assessed, with BSPTs being specified for other space-types.

5.6 Whole Building PTs are applicable to the entire building.

5.7 The Energy Intensity Limits are set based on the brief, using the *Operational Energy & Carbon Compliance Tool*. Detail on how they have been developed can be found in the User Guide.

5.8 The requirements are the following:

- ✓ **PTs that are applicable to the whole building are identified at the beginning of the project.**
- ✓ **Ensure the building is broken down based on the space-type technology categories using the schedule of accommodation.**
- ✓ **Additional requirements in the form of Energy Limits and building services Performance Targets are derived based on these space-type technology allocations.**
- ✓ **These requirements must be communicated across the Project Team.**

NHS Net Zero Building Standard energy and carbon modelling and reporting

5.9 The operational energy and carbon for the project must be assessed and reported using the *Operational Energy & Carbon Compliance Tool (OE&C Compliance Tool)*. The energy and carbon modelling must be carried out utilising Dynamic Simulation Modelling (DSM), employing detailed HVAC modelling and following CIBSE TM54 methodology. Two DSM exercises are required for the completion of the *OE&C Compliance Tool*. Refer to the DSM Methodology Checklist in the User Guide for more details regarding the two DSM exercises:

1. The first one ('NHS Standard compliance DSM') is for compliance with the Operational Energy Limit aspect of the Standard.
2. The second one ('full DSM') is a full DSM for all spaces, for reporting and future planning purposes capturing predicated whole building loads across energy and carbon.

5.10 The Project Team must work out the relevant operational energy compliance requirements, including project specific Energy Limits using the *OE&C Compliance Tool* and following the approach detailed in this chapter. The Energy and Carbon Strategy must follow the Heat and Electricity Usage Hierarchies to ensure that the compliance requirements can be met. The reporting tabs will be shared with the NZC Coordinator to demonstrate compliance and share with NHS England databases.

5.11 Ensure the Energy and Carbon Strategy and associated DSM is undertaken at each design stage, and used to inform design decisions, with inputs and results captured, assessed, and reported for the building and all relevant systems.

Supporting design activities

5.12 These supplement the approach to compliance with the Standard, ensuring the necessary processes are followed to arrive at low carbon solutions that consider whole life impacts. These are primarily focused on a collaborative design approach, although some discipline and element specific considerations are also necessary.

5.13 The process allows for consideration of cases where whole life benefits can be demonstrated from increased operational carbon emissions.

5.14 The requirement is the following:

✓ **The design activities undertaken, along with their outputs must be recorded using the NZC Design Register. The NZC Design Register follows the same principles as the CDM register and must be regularly updated through the project and passed to the Contractor when appointed and then back to the Client to aid future decision-making.**

Principles for operational carbon compliance

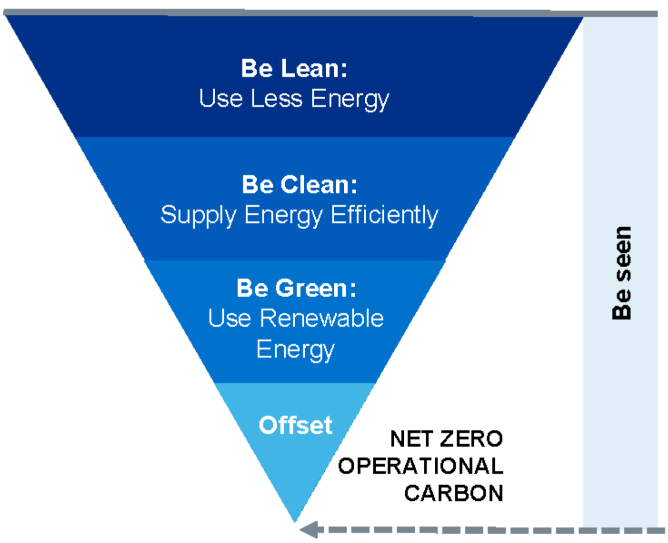
Introduction to the energy hierarchy

5.15 The energy hierarchy defined within Figure 18 below is an approach for how energy and carbon must be reduced throughout the design stages, and into the commissioning, handover and fine-tuning of the building's operational performance.

5.16 The energy hierarchy follows a "fabric first" approach and addresses different design areas targeted at each step in the following order:

- **Be Lean**: Efficient design (fabric and HVAC) to reduce energy demand
- **Be Clean**: Clean and efficient energy supply
- **Be Green**: Renewable energy provision
- **Be Seen**: Effective metering and monitoring, with usable output data.

Figure 18 Overview of energy hierarchy to be adopted



5.17 The following sections of the Standard outline the mandatory requirements associated with different stages of the energy hierarchy. Additional guidance and considerations for how to reach these design targets and requirements can also be found within the User Guide.

Summary of measures to be considered

5.18 The types of measure to be considered at each step and the design principles that are important in hospitals, are described in Table 10. These are further detailed in Appendices F and G of the User Guide.

Table 10 Key measures to be considered for each step of the energy hierarchy

Energy hierarchy step	Measures
Be Lean	**Fabric performance:** low air permeability, U-Values and thermal bridging (fabric first approach). **Natural and hybrid ventilation:** optimise opportunities wherever practical. **Glazing performance:** optimisation needed to ensure natural light can be utilised to reduce use of artificial lighting, while solar gains are controlled to reduce space cooling demand. **Lighting performance:** use of high efficiency light fittings. **Lighting occupancy (PIR) and daylight controls (daylight linking):** reduce lighting energy use, based on occupancy and outdoor conditions. **HVAC efficiency:** high system efficiencies and low distribution losses. **Refrigerants:** specification of refrigerants with both a low global warming potential (GWP) and direct effect lifecycle (DELC). **High efficiency heat recovery:** from low-grade heat sources including within the air distribution system(s) and from large clinical equipment. **HVAC controls:** use of smart BMS and energy management system to optimise plant operation. **Demand side load management control** to optimise time of use and peak load.
Be Clean	**Zero Carbon aligned energy supply solutions:** Electric solutions such as Air Source Heat Pumps (ASHP), Water Source Heat Pumps, Ground Source Heat Pumps (GSHP). **Low temperature heat distribution networks.** **Offsite district heating networks (DHN).** **Assess feasibility of other emerging technologies** e.g. hydrogen/biofuel combined heat and power (CHP), hydrogen fuel cells within existing infrastructure decarbonisation planning.
Be Green	**Renewable energy generation on site,** e.g. Photovoltaic systems (PV), wind power, solar thermal. **On-site storage** of electricity from renewable energy sources to optimise peak load and electricity demand time of use, and maximise use of energy generated on site.
Be Seen	**Metering and monitoring:** Adoption of a Soft Landings approach for performance verification and fault-finding. **Seasonal commissioning and annual review** in line with Soft Landings and BREEAM to provide continuous improvement. **Post-Occupancy Evaluation** (POE).

5.19 The requirement is the following:

✓ **Ensure the Design Team considers the energy hierarchy and includes these measures within the design. The measures should be captured within the Energy and Carbon Strategy and entered on the Design Register.**

Case Study

There are a series of case studies following the 2020 release of Salix funding looking at decarbonisation of heat and energy saving initiatives.

Gundersen Health System At Sparta Clinic

Located in Wisconsin, USA. An exemplar for low-energy design and renewable energy generation. The project installed on building and site solar panels as well as off-site renewable energy sources. Also achieved 50% energy reduction in energy usage and LEED Gold

Operational carbon compliance

Introduction

5.20 The Standard supports NHS England's ambition to remove reliance on fossil fuels and reduce our carbon footprint by switching to clean and renewable energy, while supporting green economic growth. This priority is focused on the NHS running on renewable, low-carbon energy, either generated on-site or purchased.

5.21 Operational carbon compliance of the Standard primarily comprises two hierarchies for electricity and heat as shown in Figure 19 and Figure 20. These are to complement the energy hierarchy illustrated in Figure 18 and have been developed to respond to specific energy and resilience challenges for healthcare estates, the decarbonisation strategy for NHS England and UK Government's Industrial decarbonisation strategy. These priorities support the ambition to run zero operational carbon buildings wherever possible in the future without requiring significant future investment or intervention.

Signpost for additional information on energy sources see:

- Roadmap to Delivering Net Zero, IHEEM/HEFMA CEF, March 2021
- NHS England Estates Net Zero Delivery Plan
- HTM 07-02: EnCO2de 2015 – making energy work in healthcare

5.22 It should be noted that as per industry guidance and definitions, any scheme that uses fossil fuels for primary systems (excluding emergency backup) will not be able to claim or be verified to be "net zero operational carbon" in the future, even if offsets are purchased to offset residual emissions. This includes district networks for heat.

Methodology

5.23 This section presents the methodology Project Teams must adopt when developing the project and gives key requirements for what must inform the basis of their decision-making at early project stages to ensure that they are delivering in line with NHS expectations.

5.24 The Energy and Carbon Strategy must be used to report the decisions for the building energy source(s), as well as capture other aspects of design decision making and information that affects the energy and carbon performance of the building across the whole energy hierarchy.

5.25 The Energy and Carbon Strategy must reference the following where applicable:

- NHS Trusts' Green Plan
- NHS England's net zero commitments
- Local Authorities' net zero commitments
- National Policy, such as Industrial Decarbonisation Strategy, the British energy security strategy and the BEIS Energy White Paper.

5.26 A summary of the expectations within this document across the RIBA stages is seen below in Table 11. The Energy and Carbon Strategy will also be a reporting log for review and sign off by the Client Team as well as the business case approval team.

Table 11 Summary of expectations within an Energy and Carbon Strategy/Report

	Expectations	Limits/Targets	
Energy and carbon design strategy	**RIBA 0–1**	• High level Net Zero Carbon Strategy and Delivery Plan, including: – Site opportunities and constraints. – Key assumptions within the design that relate to energy and carbon performance e.g. alignment to electricity and heat hierarchies, building massing and relationship to the rest of the estate infrastructure. – Key stakeholders.	• Undertake preliminary Energy Limits and PT setting based on estimates of building massing and departmental areas.
Energy and carbon design strategy	**RIBA 2, OBC**	• Narrative on how the building's energy needs will be met by an appropriate mix of onsite and remote low and zero carbon technologies and other energy sources on handover and throughout operation. • Report decision making against electricity and heat priority hierarchy. • Confirmation of decarbonisation strategy for all energy sources, expected carbon factors for all energy sources, including assumptions/references. • Low and zero carbon technology study, including feasibility study for ground source heat pumps and availability of other low-grade on-site heat sources. • Passive design analysis including assessment of free cooling. • Early HVAC strategies. • Considerations for demand response technologies and storage to balance generation opportunities and minimise operational emissions associated with peak loads.	• Review preliminary Energy Limits and PT setting, update where applicable where there has been a change in brief, SOA or assumptions. • Compliance evidence: – early design intent – Dynamic Simulation Modelling (DSM) with early-stage assumptions.

		Expectations	Limits/Targets
Energy and carbon design report	**RIBA 3**	• Update to energy and decarbonisation strategy if applicable from RIBA 2. • Include full decarbonisation plan of all energy sources by FBC. • Confirmation of the dates that net zero carbon is expected to be reached, and any residual emissions from energy sources based on various interventions and assumptions. • Refinement of on-building renewable strategy including capacity calculations, reporting through OE&C Compliance Tool. • Further detail of demand response and peak electrical demand reduction, reporting of all integrated technologies and proposed practices, as well as the benefits it creates.	• Refine Energy Limits and PT further based on increasing detail of design • Increasing compliance evidence: – Energy model updated with any new information on use data, with final specifications to be updated with any changes. – Additional whole building dynamic simulation modelling (DSM). Including HVAC system details, bespoke operational regime (occupancy, equipment loads etc) – Metering and controls – Integration of design
	RIBA 4, FBC		• Refine limits further based on increasing detail of design • Increasing compliance evidence: – Energy model updated with any new information on use data, with final specifications to be updated with any changes. – Integration of design – Move towards specifications and Employers Requirements for façade, BMS and servicing
	RIBA 6–7	• Used on an ongoing basis as part of the estate decarbonisation strategy (Green Plan) where applicable	• Compliance through commissioning, testing and verification • Energy model updated with monitoring data and FM to be notified of discrepancies. • Reporting through NHS England and other systems

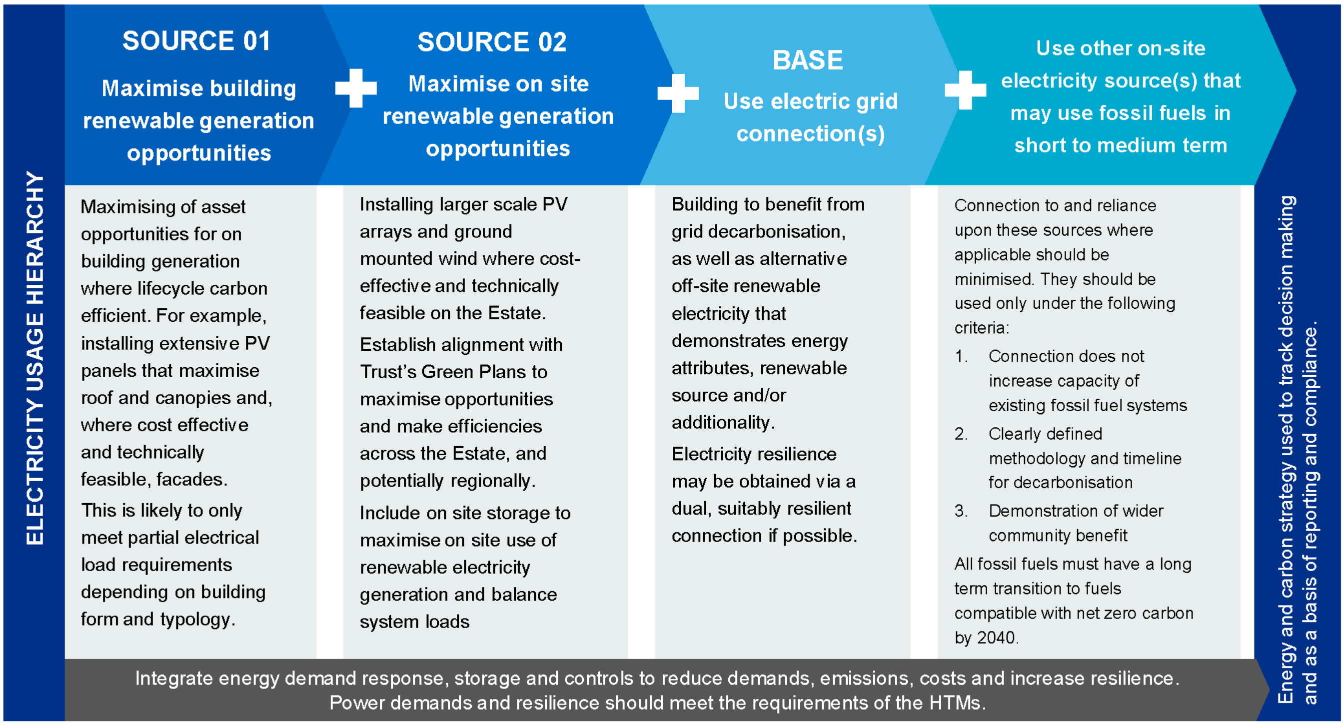
Signpost:

For energy sources sizing and capacity design including future flexibility allowances, HTMs and HBN guidance must be followed, such as HBN 11-01 (2013) Facilities for Primary and Community Care Services and HTM 00 Policies and principles of healthcare engineering.

Electricity usage hierarchy

5.27 The electricity usage hierarchy provides an order of how electricity systems must be considered and utilised within the building's operation. These are to be reflective of resilience requirements and not used as a basis for deriving plant or electrical capacity (see Figure 19).

Figure 19 The Standard's electrical usage hierarchy



5.28 Feasibility studies must be undertaken to demonstrate the maximisation of on-building and on-site renewable energy generation opportunities for different available pieces of land/space, and ensure they are implemented where they demonstrate whole life value. This must include any ancillary buildings such as car parks that may be part of the capital scheme/funding.

Case Study – Milton Keynes University Hospital

Over 2500 solar panels have now been installed on site, producing 853MWh (megawatt hours per year) – this is equivalent to the total power used in a year by 213 average homes. The plan is to generate more than 1.5GWh of free electricity each year.

Blacktown Hospital - Located in New South Wales, Australia, the hospital's new solar project is expected to have an annual output of more than 1GWh, equivalent to removing 737 metric tonnes of carbon dioxide emissions from the atmosphere.

They installed 1,900 panels during the Covid-19 Pandemic, and will see an 11% reduction in electricity costs, savings of $194,000 per year on electricity bills – additional link.

5.29 Electricity sources that utilise fossil fuels must be minimised as far as practically possible with long-term plans to shift towards biofuels. This includes provision for backup sources.

5.30 To reduce operational carbon emissions and costs, renewable generation must be developed in parallel with energy and thermal storage and controls to help balance energy profiles, increase resilience and reduce the required capacity of energy sources.

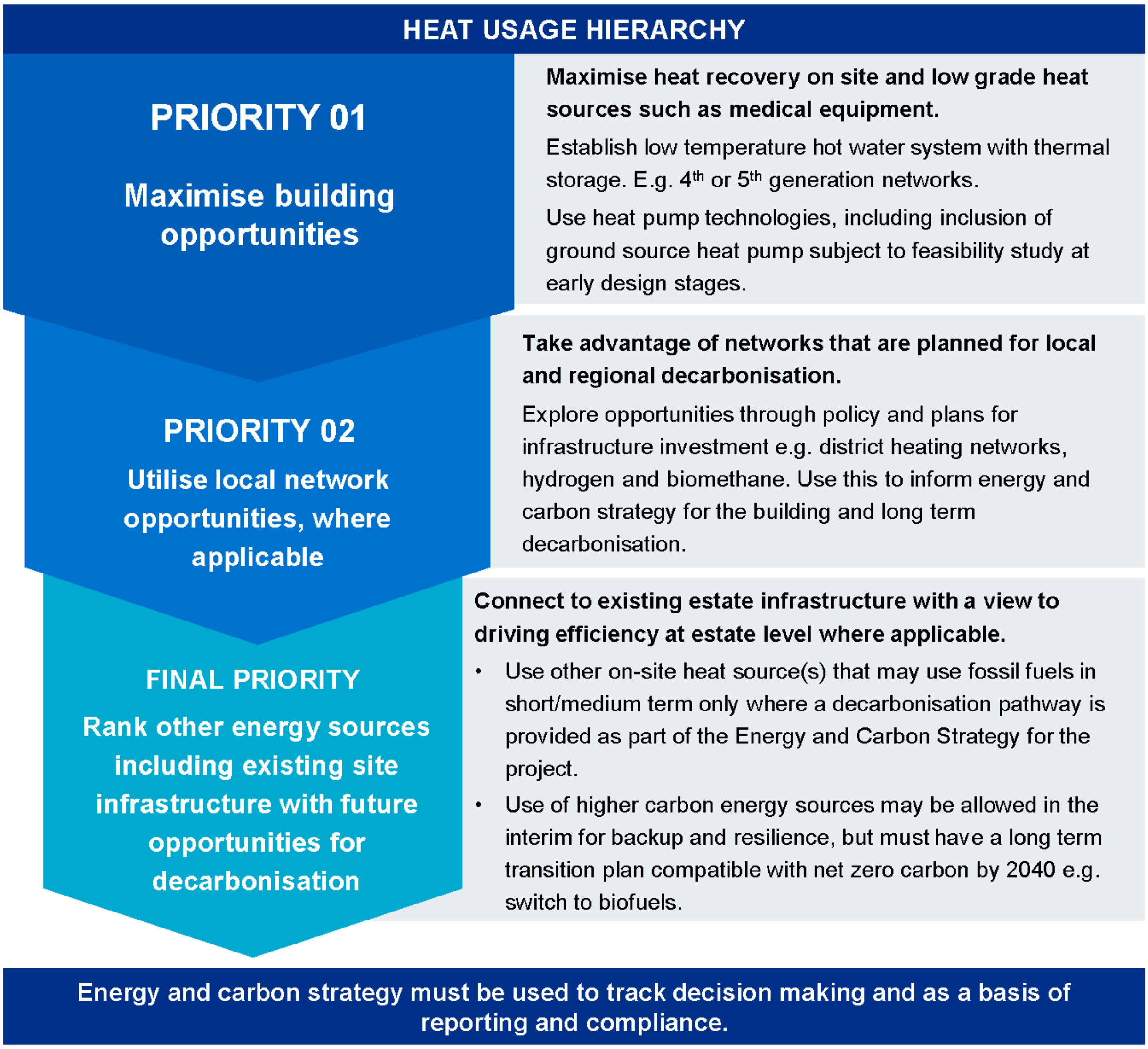
Rule of Thumb:

Incentives will include increasing energy and carbon taxation to reduce energy consumption and decarbonise power utilisation, as indicated in the Climate Change Committee's 6th Carbon Budget. The changed taxation environment will inevitably place financial pressures on NHS trusts if still using high carbon sources.

Heat usage hierarchy

5.31 The following hierarchy (Figure 20) must be used to give a set of priorities for how heat must be used within the building's operation, which is also reflective of resilience requirements. A low and zero-carbon-technology feasibility study must support this hierarchy, which identifies cost-effective and technically feasible solutions.

Figure 20 The Standard's heat usage hierarchy



Rule of Thumb:

Air source heat pump solutions drop in efficiency at lower temperatures, so local climate and resilience measures should be factored into the building's heating strategy e.g., using numerous sources of heat, to ensure supply of heating and DHW all year around.

5.32 Healthcare developments must also support local and regional plans for decarbonisation, provided they meet the criteria expressed within paragraph 5.33. Similarly, connection to existing infrastructure could be a viable option for Trusts as part of a broader decarbonisation strategy.

Criteria for usage of existing infrastructure

5.33 As shown within the energy usage hierarchies, usage of existing or planned infrastructure for primary sources must be used subject to demonstration of:

- established decarbonisation pathways for all energy sources in line with NHS England decarbonisation targets
- no additional fossil fuel capacity being installed based on new project connection(s), e.g. there must be spare capacity within the existing system(s)
- a broader community benefit of a connection e.g. enabling or supporting a district heat network or enabling broader site decarbonisation through energy centre investment
- WLC benefit of energy systems and sources
- building must be capable of conversion to low-grade heat source(s) in the future, if higher temperatures are used upon initial operation.

5.34 These expectations are the case even if the new building is both very energy efficient and has a proportion of its energy demands met with on-building clean and green energy.

5.35 All energy sources must have a clear decarbonisation strategy at OBC submission and a committed decarbonisation action plan as part of FBC submission.

5.36 The following section provides an overview of how opportunities and constraints of existing site infrastructure must be identified and decarbonisation pathways that must be considered.

5.37 Further guidance on usage of existing infrastructure and utilising regional opportunities can be seen in the User Guide.

Rule of Thumb:

To utilise an existing energy centre or existing estate infrastructure **an established decarbonisation plan** must be in place for that asset and energy source to be compliant with this Standard. To support this, interventions on assets must be planned to drive energy efficiency and be in an operational mode that is least emission intensive, such as CHP being heat led rather than electrically led.

Existing site infrastructure assessment

5.38 The first step in applying the hierarchies is understanding the opportunities and constraints across a site through conducting a detailed survey of existing site infrastructure and regional opportunities. By the end of RIBA Stage 2 (OBC) an existing infrastructure survey must be carried out to establish the following where relevant:

- existing energy centre(s) on site, including system and fuel type and capacity
- local heat networks near to the site, current and planned
- utility network capacities and other limitations of utility connections through engagement with network providers
- potential and planned future upgrades to the existing infrastructure including existing decarbonisation plans
- identification of low-grade heat recovery opportunities
- estate-wide renewable energy opportunities – these must be evaluated together with existing estate development plans and land analysis
- site-wide energy storage and microgrid opportunities – these must be evaluated together with existing estate development plans.

5.39 This information must be used to inform the strategies for heat and electricity for the building and estate where applicable and be included within the Energy and Carbon Strategy.

Rule of Thumb:

Transitioning to electrically led heating and cooling systems will impact the future considered capacity requirements over and above the increases suggested in the Healthcare Technical Memoranda which do not allow for these systems as part of the electrical growth. A revised growth factor should be estimated to identify the expected lifetime realisation of the system over capacity allowances and the point at which the additional plant areas and rises are likely to be needed. Nuances also need to be considered that may be unique to a certain clinical typology.

Overview of reporting requirements

5.40 In addition to reporting detailed energy demand predictions, operational carbon reporting must be undertaken; an operational carbon calculation must be carried out and the results reported in the *OE&C Compliance Tool* at the end of each design stage. These must be formally submitted as part of business case submissions.

5.41 Tab 8.0 Energy Strategy Reporting (in the *OE&C Compliance Tool*) requires carbon emission and energy generation inputs for monitoring purposes as well as to inform NHS England's strategy for renewable energy procurement and offsetting.

5.42 See Chapter 6 for further information on data reporting and compliance across the design and business case stages.

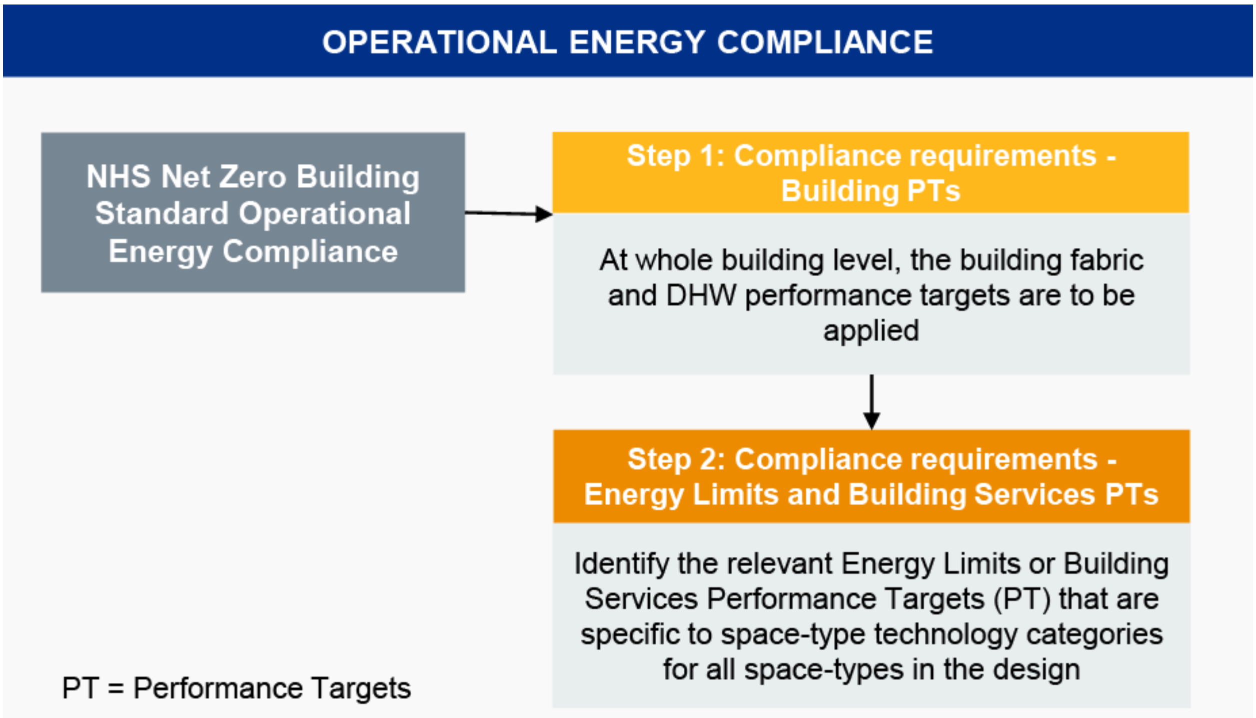
Operational energy compliance

Overview

5.43 Operational energy compliance comprises deriving and achieving the following steps (see Figure 21):

- **Step 1** – PTs for the entire building including building fabric and DHW.
- **Step 2** – Energy Limits or Building Services Performance Targets (BSPTs) that are specific to space-type technology categories.

Figure 21 Operational Energy Compliance Summary



5.44 These limits and targets have been developed so that they can be applied across different healthcare building types and spaces and are tailored to different design requirements based on space-type technology groups. These design requirements must not be exceeded. This approach ensures that the majority of the proposed building is covered by ambitious Energy Limits within the scope of the Standard.

5.45 In relation to Step 1 of the methodology for building performance targets, these have been lineated across different types of healthcare buildings – primary and secondary. Primary healthcare buildings are defined as buildings that include services that provide the first point of contact in the healthcare system. Examples include general practice, community centres and mental health facilities. Secondary healthcare buildings are defined as buildings which include services which are either planned care or urgent and emergency care. Examples include general acute and teaching hospitals.

5.46 For space-types that have a high degree of variance, primarily due to high equipment loads and clinical requirements (namely ultra-high technology space-types), these space-types do not have Energy Limits and instead high HVAC performance is the priority.

5.47 The NZC Coordinator is responsible for collating the compliance requirements, as summarised in the *Design Management Tool* and *OE&C Compliance Tool*. Firstly, the NZC Coordinator must follow the process of allocating spaces by the space-type technology categories, and then must derive the PTs within the *OE&C Compliance Tool* for different space-types technology groups. Further activities associated with design should be captured in the *Design Management Tool*.

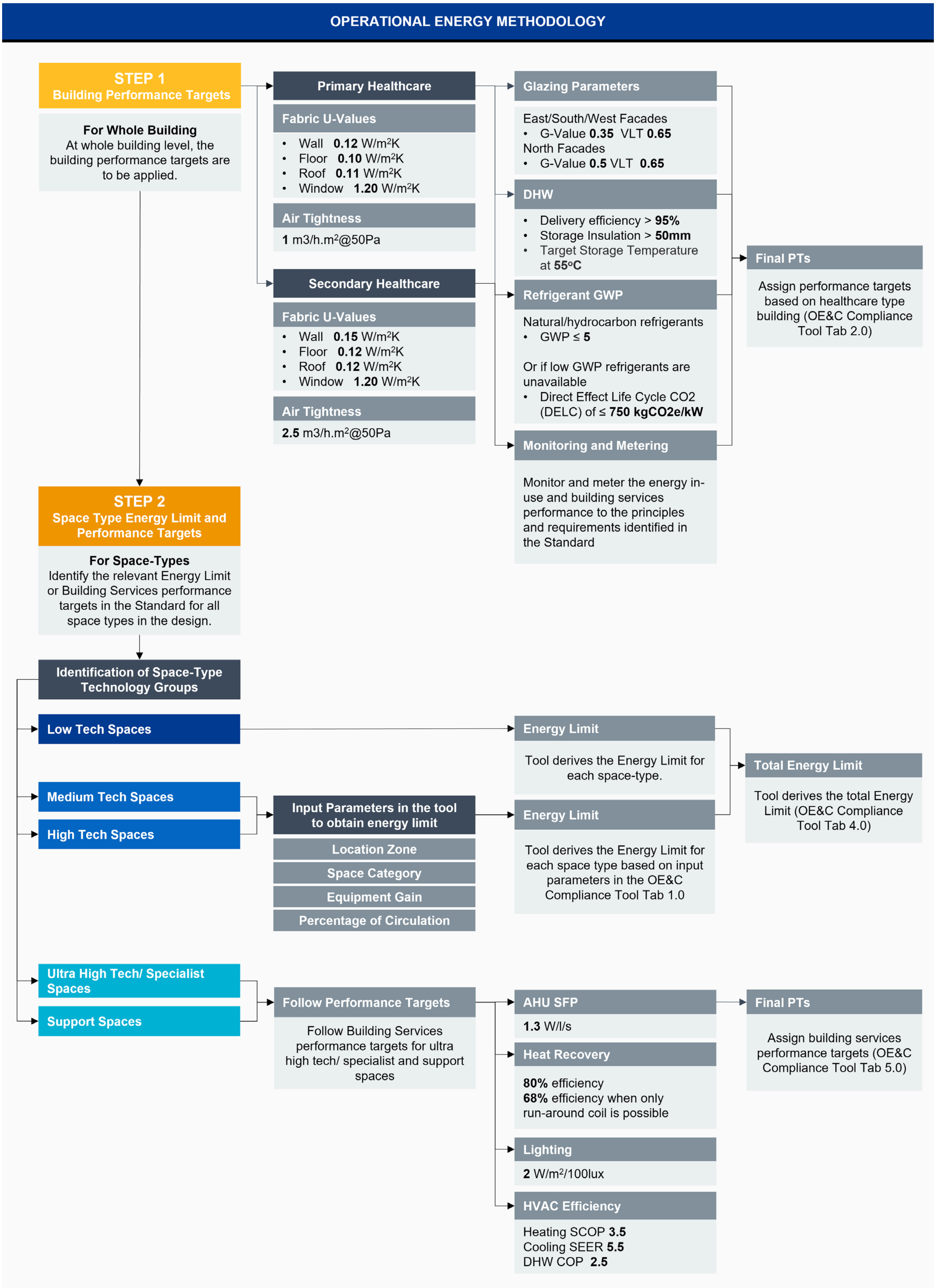
5.48 Based on the brief, the healthcare building must be split into departments that can be matched to one of the seven clinical or five non-clinical Space-Type Technology Categories – see overview in Table 5 in Section 3 and detail in Table 1 within the User Guide. Each Space-Type Technology Category includes ancillary areas (waiting areas, support spaces, stores, toilets, and internal circulation), meaning that ideally a whole department should be matched to a Space-Type Technology Category. Where this is not possible, the department area must be divided into sub-departments that can be matched to an individual Space-Type Technology Category. Any outlier spaces within the department must be identified, and depending on conditioning and use, either matched to a suitable Space-Type Technology Category or excluded.

5.49 The *Operational Energy and Carbon Compliance Tool* within the User Guide provides further detail on how this is to be done.

5.50 This process must be recorded in Tab 1.0 in the *OE&C Compliance Tool*, which will populate the Compliance Requirements per space entered. The tool derives the Energy Limit per space and calculates the total Energy Limit for the building. The tool will identify space-types for which an Energy Limit is not applicable, for which compliance is based on achieving the specified BSPTs.

5.51 Figure 22 provides a summary of the overall compliance process that must be followed along with the relevant tabs in the *OE&C Compliance Tool*.

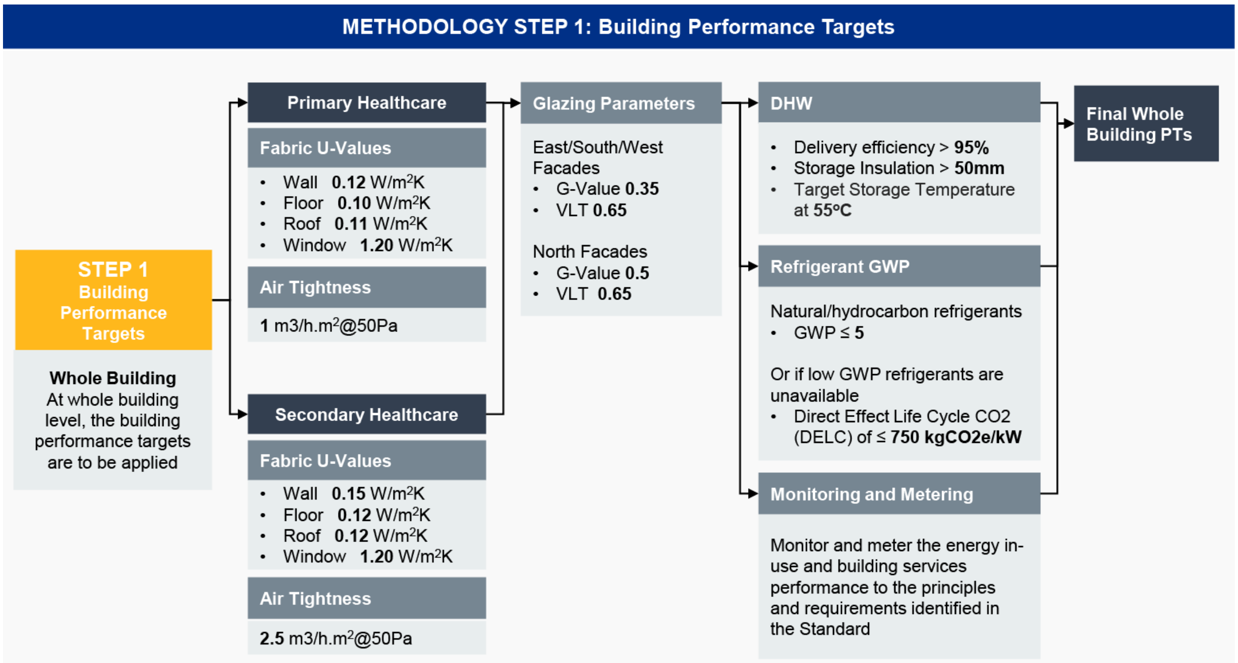
Figure 22 Operational energy methodology



Step 1: Whole building PTs and requirements

5.52 The aim of this first step is to ensure that performance areas in the building that are not dependent on the use of the space are addressed at a whole building level. Areas covered under this step include building fabric and glazing performance, DHW storage and distribution, energy metering and monitoring and refrigerant GWP (GWP) (see Figure 23).

Figure 23 Flow Chart for Step 1: Whole Building Performance Targets



*Note: This includes the distribution and storage systems only: from the outlet to the heat generation to the inlet of the outlet. Efficiency of pumps and heat generation is separate to the efficiency.

5.53 The whole building PTs should be integrated in the building design from concept stage and should be used when defining the overall building energy strategy, and as inputs in the DSM.

5.54 The whole building PTs can be updated as the design progresses and the energy strategy are refined but should always be met. Any valid derogations from the PTs need to be noted *OE&C Compliance Tool*.

5.55 The following sections should be read in conjunction with the User Guide, which provides further detailed guidance and background information to how the PTs and requirements can be met.

Building fabric and glazing performance targets

5.56 Figure 23 includes the building fabric PTs. These targets depend on the type of the building, with primary healthcare buildings requiring compliance with more ambitious building fabric targets, in terms of U-values and airtightness, since the impact of fabric performance is larger than in secondary healthcare buildings.

5.57 Further to building fabric performance, glazing performance is specified for different orientations to reflect changing sensitivity to thermal gains on different elevations.

5.58 Thermal bridging must also be considered and actively reduced within the design and installation of the façade system. Industry design guidance should be followed based on the type of façade system implemented within the design to mitigate energy loss.

Domestic hot water (DHW) performance targets

5.59 Figure 23 summarises the DHW PTs. While DHW is not included as part of the compliance requirements for the operational Energy Limits element of the Standard, setting targets on delivery efficiency and circulation ensures that regardless of the source, the distribution of DHW will be highly efficient.

5.60 Hot water usage within healthcare varies greatly dependent on the proposed departmental usage. In some instances, the volumes of hot water used can fall significantly short of those suggested in initial calculations. The following DHW system targets are required by the Standard:

- minimum distribution efficiency of 95%. (This includes the distribution and storage systems only; from the outlet of the heat generation plant to the intake of the hot water outlet. Efficiency of pumps and heat generation is separate to this efficiency)
- storage vessel with a minimum of 50 mm factory insulation
- target storage temperature should be 55°C where possible, making allowance for the system to be able to increase the temperature periodically to eliminate risk of legionella.

5.61 Systems installed should be capable of modulating to the required hot water load without impact to efficiency of the system.

5.62 Should buffer vessels be installed to reduce peak load requirements, these must be insulated to minimise heat loss. Similarly, if anti-stratification systems are employed these must limit the heat loss of the system.

Refrigerant Performance Targets

5.63 Figure 23 summarises the refrigerant PTs. Energy efficiency should be paramount to reducing the carbon emissions from refrigerant based systems. However, the refrigerant chosen within these should not be overlooked, with the refrigerant availability being dictated by the size of system. A low refrigerant GWP target must be complied with, as part of Step 1.

5.64 As a core set of principles, to support reducing refrigerant leakage, designers must consider:

- reducing refrigerant needs
- using low GWP refrigerants
- reducing refrigerant charge
- mitigating refrigerant leakage and
- enhancing refrigerant recovery.

5.65 Refrigerants selected for new-build systems should meet or improve upon the following criteria:

- use natural/hydrocarbon refrigerants with GWP $\leq$5. e.g. R1234ze, R1234yf, ammonia, CO_2, propane, isobutane, HFOs.

5.66 Or if low GWP refrigerants are not available:

- any refrigerant-using systems are specified with a Direct Effect Lifecycle CO_2 (DELC) of $\leq$750 kg CO_2e/kW.

5.67 Refrigerant choices must take into account the Toxicity and Flammability class with a preference for A1 before others and no refrigerants to be used below Class A2L.

5.68 Projects must report the total quantity, type, and GWP of each refrigerant contained in all base building HVAC systems.

5.69 To mitigate refrigerant leakage the following requirements must be in place:

- individual system: leak detection, high quality sensors
- distributed system: pressure test, room sensors, hybrid systems
- centralised system: leak detection, high quality sensors.

5.70 The embodied carbon of estimated refrigerant leakage within use stage (B1) and deconstruction (C1) should be captured within the WLC assessment, see additional industry guidance for more information.

Signpost for additional guidance of refrigerants:

Refrigerants and Environmental Impacts: A Best Practice Guide, Elementa

LEED v4.1 New Design and Construction

Refrigerant options now and in the future, Danfoss, Feb 2020

Refrigerant rethink: measuring the environmental impact of HVAC, CIBSE

Embodied Carbon Primer, London Energy Transformation Initiative, Jan 2020

General Ventilation System Requirements

5.71 Ventilation requirements for healthcare buildings are set out in the Health Technical memoranda (HTM) guidance documents (specifically HTM 03-01), which are to be complied with. The ventilation requirements are generally determined based on the use of the space and factors such as control of airborne pathogens, reduction of excessive moisture levels, and extraction of odours, vapours, and gases, amongst others.

5.72 Where compliance with HTM guidance allows, designers should allow for modulation of air volumes (e.g., Variable Air Volume (VAV) systems) to floor plates and rooms based on the demand and use of the space. Where cluster systems, separate ventilation zones or single patient rooms are used, systems should be able to control airflow to these spaces to limit unnecessary energy usage.

5.73 As detailed in the Operational carbon compliance section, BSPTs for Ultra-high Tech, Specialist and Support Spaces have been set for the ventilation design, which include targets for:

- specific fan power
- heat recovery in the ventilation system.

5.74 While these specific PTs are only formally required for Ultra-high Tech, Specialist and Support space-type groups, it is recommended these are used as a best practice guide for all space-types across the project (the User Guide gives an overview of example room spaces with their associated technology types). While these are not strict requirements, it is expected that a range of best practice energy efficiency solutions are considered within the design to reduce energy demand, see the User Guide for more detailed ventilation control design guidance where an overview is given of example room spaces with their associated technology types.

Other Passive Design Requirements

General Approach

5.75 By the end of RIBA Stage 2 a comprehensive feasibility study that factors in both the architectural and engineering design must be completed explaining in detail how the design reduces energy demand through passive design measures. This should assess the opportunities for energy demand reduction and sensitivities associated with the following:

- location
- landscape
- orientation
- massing
- shading
- material selection
- insulation
- internal layout
- direct solar heat gains
- natural daylighting
- natural ventilation.

5.76 See the User Guide for further guidance on these topics.

Natural ventilation

5.77 Where feasible, opportunities for natural ventilation are to be assessed for all spaces where this strategy is compliant with the clinical requirements of the space. Computational Fluid Dynamics (CFD) simulation(s) should be undertaken in more complex situations where buoyancy or wind-driven strategies are being considered, e.g., in the case of atria. This is to study and verify in detail air flows within spaces and through openings in the building envelope, to ensure adequate fresh airflow rates are achieved, and air quality and thermal comfort can be maintained.

Daylighting and visual comfort

5.78 These aspects although they may not be directly impacting energy and carbon intensity, they have huge implications for patients and staff wellbeing, and so need to be considered alongside energy intensity when optimising the design.

5.79 Climate Based Daylight Modelling must be carried out to gauge the performance of different spaces within the building across the year, where daylight will be beneficial, including circulation, wards and other clinical spaces.

5.80 CIBSE Guide LG2 (2019) – 'Lighting for Healthcare Premises' must be complied with where deemed appropriate, or other appropriate standards. All relevant spaces are to be designed to meet an Average Daylight Factor (ADF) of 2-5% and with an average ADF of 3% achieved across the building. Valid justifications should be given in design reports where this is not achievable.

5.81 To avoid glare issues, daylight factors of above 5% should be avoided. Other suitable daylight metrics can be used to demonstrate a low risk of glare, including Useful Daylight Illuminance and Annual Solar Exposure.

5.82 Films used on windows to reduce glare and solar gains must maintain a suitable colour-rendering index within the building to ensure clinical operation is not impacted. All glazing is to achieve a minimum colour-rendering index of 96%.

5.83 A lighting control strategy with daylighting dimming and occupancy sensing should be applied to ensure use of artificial lighting is reduced to requirements. Sensors must have low parasitic power, especially when on all the time. See Lighting Controls Section for further details on artificial lighting control requirements.

Thermal comfort

5.84 A thermal comfort assessment must be carried out for all relevant spaces, to ensure the indoor environment maintains thermal comfort and avoids overheating. Thermal modelling is to be undertaken using a DSM, which should consider the following:

- thermal modelling of each space taking account of different systems serving the spaces
- thermal modelling of each space taking into account the building envelope, orientation and type of construction, e.g. impact of thermal mass, size and location of windows

- review of thermal zoning strategies to ensure adequate system controls are in place to cater for varying heating and cooling loads as well as occupant control where applicable
- design for future thermal comfort, based on future climate scenarios.

5.85 The required thermal modelling approach and criteria must be applied where relevant:

- fully conditioned spaces: in line with BS EN ISO 7730:2005, which considers PMV – PPD (predicted mean vote – predicted percentage of dissatisfied) and establishes different categories of the indoor environment. By assuming certain values for these parameters, a range of thermally comfortable temperatures can be established (see BS EN 15251: 2007)
- naturally ventilated or mixed mode spaces: in line with CIBSE TM52 and CIBSE TM59 for appropriate spaces; all criteria to be targeted where relevant
- BREEAM criteria.

5.86 Note, HTM 03-01, which all projects must comply with, also recommends indoor air temperatures from 18°C to 28°C in general wards, and 18°C to 25°C for more sensitive areas, such as birthing and recovery rooms.

Clinical Equipment Requirements

5.87 Unregulated loads will also cover clinical equipment, which are generally significantly more energy-intensive compared to non-clinical equipment. During design development, a feasibility study is required to assess opportunities for energy savings and heat recovery from key clinical equipment, to drive down energy demands across the project. Key processes and equipment that this should cover, but not be limited to, include:

- Imaging equipment (Hybrid MRI/CT/PET-CT etc.)
- Medical Devices
- Ventilators
- Decontamination equipment
- Medical Gas Plant
- Anaesthetic Gas Use
- Renal Dialysis
- Sterilizers
- Autoclaves
- Decontamination equipment
- Laboratory equipment
- Patient devices – low carbon medical inhalers
- Pharmaceutical equipment, e.g. cold storage.

Energy Limits

5.88 Within the *Operational Compliance Tool* and Table 16 below, approximate Energy Limits are provided for unregulated loads for each space-type based on different bounds for equipment usage. However, Design Teams are not expected to comply to these limits, they are provided as a guide to inform conversations with suppliers and clinical teams and consequential modelling to refine the expected values.

5.89 However, although clinical requirements can differ, when averaged across the internal departmental floorplates, as a backstop, equipment energy loads should not exceed the following[9] without exceptional circumstances:

- Medium Tech: 80 W/m^2
- High Tech: 100 W/m^2

5.90 Expected unregulated loads should be cross-checked against these values.

Energy efficiency measures for clinical equipment

5.91 With regard to clinical equipment energy efficiency measures, the following must be considered where appropriate to the project:

- The feasibility of cooling large clinical equipment with water and waste heat recovery from the equipment; by cooling large medical equipment with water there is an opportunity to recover heat that may be utilised in a central heating system (heat pump based), hot water system or as part of a potential ambient loop network across the site or building. Additional pipe runs required for heat recovery purposes must be minimised by considering locating spaces with clinical equipment near to spaces where recovered heat can be utilised; therefore it would be appropriate to consider these space adjacencies at RIBA 1 and 2.
- The feasibility of creating a separate water-cooling loop for large clinical equipment; this loop may be able to operate at higher temperatures and be less prone to variations that commonly occur in larger cooling loops as a result of normal space temperature control fluctuations. It should be noted that maintaining a separate larger water-cooling loop will still provide the advantage of being able to utilise temperature and or pressure reset strategies.
- For large imaging equipment, including CTs and MRIs served by air-cooled systems, equipment power use should be linked to the controls of the cooling system serving the space, to fully account for unoccupied periods. Reducing airflow, for example via a variable-air-volume (VAV) system, to only that needed to keep the equipment in its desired operating temperature and humidity range, can eliminate reheat and excess air, significantly reducing energy consumption.

Non-clinical Equipment Requirements

5.92 Energy efficiency should be considered when specifying all equipment by the Project Team (likely a Trust responsibility) and the following must be accounted for in the specification, particularly for non-clinical equipment:

9 ERIC data 2020.

- Specify low energy equipment:
  - EnergyStar® or similar certified equipment should be specified.
  - The use of laptops instead of workstations should be considered where feasible, as these are more energy efficient.
- Install controls:
  - Where appropriate, equipment such as computers should be installed with power-saving modes during unoccupied hours.
  - Timer switches with an "off" setting during unoccupied hours should be considered for equipment such as coffee-makers and other small appliances.
  - Where equipment is not required to be on during unoccupied hours, consider using a switched power distribution unit to reduce parasitic loads.

Signpost:

ASHRAE Advanced Energy Design Guide (AEDG) for large hospitals provides a wide range of energy efficiency measures for both clinical and non-clinical unregulated loads

Metering, Monitoring and Controls Requirements

Energy Metering

5.93 Meters are to be selected, installed and commissioned to provide the data needed for the effective monitoring of all key equipment and spaces within the building(s) as described in Table 12. This includes data needed for the operational verification of the Energy Limits determined for all relevant space-types and for the whole building. Sub-metering is to be provided on each floorplate with department and large-scale users separately metered and integrated with the BMS systems, with suitable interoperable systems for data sharing, to allow for full monitoring of operational efficiency. Unregulated and regulated loads must be capable of being separately monitored. Meters must provide consumption by end-use with a minimum breakdown as follows:

- fans
- pumps
- large medical equipment
- lifts
- catering facilities and equipment and
- other special uses, e.g. server rooms.

5.94 A more detailed table of expectations can be found in Table 12.

Signpost: Metering and monitoring requirements and best practice, see:

Building Regulations as well as any local regulations (i.e. "Be Seen" in the GLA), HTM, HBN, CIBSE TM39 and BREEAM New Construction 2018.

NABERS Metering and Consumption Rules, December 2020

Energy Monitoring

5.95 Data exchange is key in allowing a study of the building's performance and the opportunity to identify and mitigate against potential issues early on. Set up of data, including naming and schematics, as well as process for harvesting and storing should be clear to implement.

HVAC Controls

5.96 Particularly given the high airside energy requirements for clinical space-types, designing a robust HVAC control strategy will be key to significantly reducing heating, cooling and auxiliary energy requirements. The following control strategies are to be implemented where appropriate as part of the HVAC design:

- **Supply air and water temperature reset:** the cooling and heating load is expected to vary daily and seasonally. The ability to control the supply air temperature for a variable-air-volume system based on cooling demand and reset it to a higher temperature (for example, when the building is not at peak cooling load) can lead to significant energy savings. Design implications should be considered such as sizing of terminal units when servicing multiple zones with non-coincidental peak loads so that these can be met with air warmer than the design temperature. The same temperature reset principle should be applied for the chilled water temperature.
- **Heat Exchanger Controls:** all air handling units (AHUs) should be capable of enabling variable airflow across the heat recovery sections with the inclusion of summer bypass to optimise the usage of the heat exchangers. This can significantly reduce cooling and heating loads.
- **Low occupancy and unoccupied mode:** design should allow for modulation of the air volumes to floor plates and rooms based on the demand and use of the space. Where cluster systems, separate ventilation zones or single patient rooms are used, systems should be able to control airflow to these spaces to limit unnecessary energy usage.
- **Temperature set-points:** operational set-points should consider the use of the spaces and the potential to move towards the summer upper or winter lower conditions to reduce the energy usage while still remaining within acceptable limits. The opportunity for seasonal variation on temperature set-points are limited but may be appropriate in some areas with less sedentary occupants.

Lighting Controls

5.97 Daylight controls should be integrated as part of the daylight strategy. A full lighting control strategy with occupancy sensing should be applied to ensure the use of artificial lighting is minimised. Sensors must have low parasitic power and time switches for sensors, especially when on all the time. Daylight linking should be used in all areas where this is compatible with the space use, so that the minimum daylight level is achieved. See the User Guide for additional guidance.

Table 12 Metering, monitoring and controls

Metering		Monitoring
Heating and Cooling	**Ventilation**	• Open source data • Connection to BMS • Collection at half hourly intervals, in line with data set up • Central repository for data with a minimum of 18 months' data storage • Retainment of data for a five-year period • Disclosure of data within NHS database for future benchmarking • Align monitored data with POE study if carried out
• Primary Heating and Cooling circuits • Primary DHW circuits • Heating to each floor/department, major user and space cluster • Cooling to each floor/department, major user and space cluster • DHW energy usage to each floor/department, major user and space cluster	• Airflow to each floor/department, major user and space cluster • Airflow from AH • Airflow of specialist ventilation systems. Should these serve multiple levels or areas then this must include each floor/department, major user and space cluster as appropriate	
Electricity	**Water**	
• Main incoming high voltage supply(s) to building(s) • Main low voltage switchboard(s) • Plant room usage • External lighting • Lighting to each floor/department, major user and space cluster • Individual electric vehicle charging points • Individual vertical transportation systems • Small power to each circuit on floor/department, major user and space cluster • Electrical sub-metering	• Main incoming water supply to building(s) • CWS volume usage to each floor/department, major user and space cluster • DHW volume usage to each floor/department, major user and space cluster	
Indoor conditions (recommended)	**External conditions (recommended)**	
• Carbon dioxide CO_2 parts per million (ppm) in each space • Temperature and relative humidity of each floor/department, major user and space cluster • Indoor air quality of volatile organic compounds	• Air quality, including particulate matter, nitrogen dioxide and sulphur dioxide (especially where natural ventilation is used in urban environments) • Relative humidity and temperature	

5.98 The indoor and external conditions are included in this table for the benefit of real time operation and optimisation of building serving systems and have benefits for patient and staff experience through improved internal environmental conditions.

Step 2: Space-type Energy Limit and Performance Targets

5.99 Step 2 focuses on Energy Limits and PTs for specific space-types, as summarised in Figure 24. The space-type categories are defined within Table 1 in the User Guide.

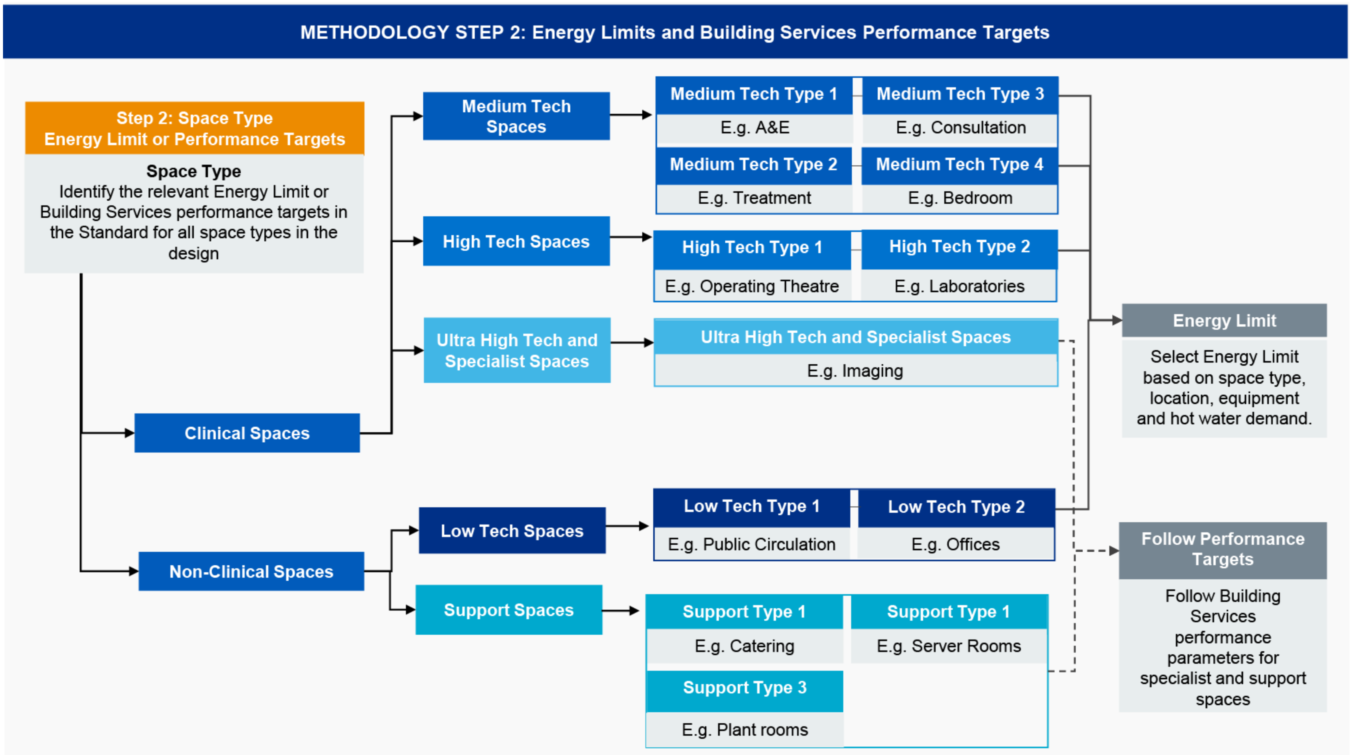
5.100 Twelve categories of space-types are defined, including seven clinical and five non-clinical, based primarily on the occupancy profiles and fresh air ventilation rates, as well as equipment load. All the areas in the design, at department level, should be matched to the most suitable space-type technology category as described in the User Guide and assigned either an Energy Limit or BSPT.

Space-type technology categories

5.101 The space-type technology categories, which are presented in more detail in the User Guide, provide assumptions within each space regarding occupancy schedules, ventilation rates and equipment loads. These space-type technology categories are to be used by the Design Team to describe as closely as possible respective spaces in their brief. The figures assigned to each space within the User Guide are indicative only and should only be used as guidance in cases where bespoke information cannot be obtained at early design stages only. Design Teams must be using bespoke inputs relevant to the building design and operation of the building when this becomes available, for the respective items.

5.102 Figure 24 provides a summary of what compliance requirements are applied to each space category as part of the NHS Operational Energy Compliance methodology.

Figure 24 Operational Energy Compliance Methodology



5.103 Due to the level of variance and uncertainty around the design for DHW in healthcare buildings, for the purposes of compliance with the operational energy element of the Standard, DHW is excluded in the DSM for clinical spaces for which compliance with an Energy Limit is required. Best efficiency of delivery and minimisation of losses is expected to be achieved through adhering to the whole building PTs relating to DHW. DHW Energy Limit must nevertheless be reported for reference in the *OE&C Compliance Tool* under Tab 7.0.

5.104 A detailed description of each of the space-types within each category and the associated Energy Limits or targets are provided in each of the relevant sections.

Mental health units

5.105 It has been identified that most of the typical spaces included in mental health units, including facilities for Child and Adolescent Mental Health Services (CAMHS), as well as low-tech spaces within Community Healthcare Centres can be matched to one of the space-type categories of the Standard, and they can be assessed for compliance in the same way as any primary or secondary healthcare building. However, as in the HBNs, a preference is set towards natural ventilation strategies where possible. It is expected that these buildings, where naturally ventilated, will perform better than the provided energy limits within the operational carbon element of the Standard. No separate approach is deemed necessary.

Energy limits

5.106 The space categories addressed through compliance with Energy Limits in the Standard are described in the following subsections and are listed below.

1. Low-tech space-types
2. Medium-tech space-types
3. High-tech space-types.

Low-tech space-types

5.107 Low-tech space-types are non-clinical spaces with low equipment requirement and uses such as office spaces, inclusive of all circulation strictly associated with that space. The Standard includes two Energy Limits for two different low-tech space-types. The Energy Limits include DHW and equipment and there is no adjustment according to the corridor area of each matched space. The Energy Limit for the respective spaces in the brief will be calculated using the *OE&C Compliance Tool*, by specifying the space category (see Table 13).

Table 13 Low-tech space-types – detailed descriptions and energy limits

Low-tech Space-type categories		
Space-type Category	Low-Tech Type 1	Low-Tech Type 2
Description	Non-clinical conditioned circulation spaces with low equipment requirement not associated with a department such as reception spaces, stair cores or large waiting rooms.	Non-clinical spaces with low equipment requirement such as office, teaching spaces, eat/drink areas, gyms inclusive of all circulation strictly associated with that space.
Associated Energy Limit	35kWh/m²/year	70kWh/m²/year

Signpost to achieve low carbon design and performance see the following guidance:

1. LETI Climate Emergency Design Guide - for offices and other low technology spaces
2. UKGBC Net zero carbon: energy performance targets for offices
3. NABERS UK

Medium- and high-tech space-types

5.108 Medium- and high-tech space-types (see Tables 14 and 15) cover clinical areas that have medium and high internal gains in terms of equipment loads, such as patient rooms, wards and consultation room, operating theatres, and laboratories. Each medium and high-tech department included in the design should be matched with a relevant space category described in the Standard to identify the Energy Limit. The Energy Limit for the respective spaces in the brief will be calculated using the *OE&C Compliance Tool*, by specifying the space category, location zone, and equipment gain.

- The calculation of the Energy Limit **excludes** the following;
  - DHW energy
  - Equipment energy
  - Energy required for humidity control
  - High efficiency particulate air (HEPA) (or other) filters in the ventilation system.

5.109 DHW is not included in the compliance with the operational energy element of the Standard and unregulated energy is reported for reference only. However, the assumptions in delivering the Energy Limits in the Standard have included two bands of inputs for DHW and equipment, specifically high or low DHW demand and high or low equipment load, for each of the space categories in the Standard. It is important that these are properly checked when matching the brief to the space categories of the Standard so that the derived Energy Limits for reference are best suited to the actual requirements of the spaces addressed.

5.110 The provided Space-type Energy Limits also account for variations in the building's location within the UK. For simplification while covering sufficiently the different weather characteristics across the UK, four location zones are available for selection in the *OE&C Compliance Tool*. The location zone selection will affect the Energy Limits derived. Nonetheless, for the modelled building demonstrating compliance with the operational energy element of the Standard, the closest match to the actual location of the proposed building is to be used, selecting one of the current CIBSE TRY weather files. The location zones have been defined in Figure 25. Additionally, it is of note that the Energy Limits for each space category can be adjusted based on the circulation area they include. This is to be done using the *OE&C Compliance Tool* and assigning circulation percentage from 20% to 40%, at 5% increments.

Figure 25 OE&C Compliance Tool Location Zones

Location Zone A

Characterises locations in England with a higher cooling load when compared to other locations.

Degree Days
CDD10 **> 1100**
HDD18 **< 2700**

TRY weather files that match this location: London.

Location Zone B

Characterises locations in England with balanced heating and cooling loads when compared to other locations.

Degree Days
CDD10 **700 - 1100**
HDD18 **2700 – 3100**

TRY weather files that match these locations: Birmingham, Cardiff, Leeds, Manchester, Norwich, Nottingham, and Southampton.

Location Zone C

Characterises locations in England with a higher heating load when compared to other locations.

Degree Days
CDD10 **< 700**
HDD18 **> 3100**

TRY weather files that match this location: Newcastle.

Location Zone D

Characterises locations in England with a lower heating load and an average cooling load when compared to other locations.

Degree Days
CDD10 **700 - 1100**
HDD18 **< 2700**

TRY weather files that match this location: Plymouth.

Table 14 Medium-Tech Regulated Energy Limits across location zones

Medium-tech Regulated Energy Limits		
Space Type	**Location**	**Regulated Energy Limit (kWh/m²/year)***
Medium-Tech Type 1	A	95
	B	95
	C	96
	D	94
Medium-Tech Type 2	A	46
	B	46
	C	46
	D	44
Medium-Tech Type 3	A	41
	B	40
	C	39
	D	39
Medium-Tech Type 4	A	53
	B	52
	C	50
	D	50

* Note: values are based on a 30% circulation percentage. Values presented are based on high equipment usage loads for ease.

Table 15 High-Tech Regulated Energy Limits across location zones

High-tech Regulated Energy Limits		
Space Type	Location	Regulated Energy (kWh/m²/year)*
High-tech Type 1	A	165
	B	159
	C	153
	D	155
High-tech Type 2	A	80
	B	78
	C	76
	D	75

* Note: values are based on a 30% circulation percentage. Values presented are based on high equipment usage loads for ease.

5.111 Note that energy for equipment and DHW is provided in the tool for reference purposes but is not included in the reporting for compliance with the operational energy element of the Standard (under Tab 7.0 in the *OE&C Compliance Tool*).

Table 16 Unregulated Energy across space-types (guidance only)

Space Type	Unregulated energy across medium- and high-tech space-types (guidance only)			
	Equipment usage (W/m²)	Unregulated Energy (kWh/m²/year)*	Equipment usage (W/m²)	Unregulated Energy (kWh/m²/year)*
	Low		High	
Medium Tech Type 1	10	52	19	80
Medium Tech Type 2	10	27	19	42
Medium Tech Type 3	10	26	19	41
Medium Tech Type 4	10	46	22	98
High Tech Type 1	43	162	60	225
High Tech Type 2	22	79	50	177

* Note: values are based on a 30% circulation percentage. Design Teams need to approximate equipment usage which then derives the regulated energy usage.

5.112 Domestic hot water demands have been split out from the regulated energy limits due to a lack of convergence across sources of data (Part-L, ASHRAE, CIBSE and IHEEM) for domestic hot water loads for different spaces, due to limited sub-metering on existing estates. It also can vary significantly depending on clinical characteristics.

Table 17 Domestic hot water energy usage across space-types (guidance only)

Domestic hot water (DHW) energy usage across space-types (guidance only)		
Space Type	Total DHW (kWh/m²/year)* Low	Total DHW (kWh/m²/year)* High
Medium Tech Type 1	3	8
Medium Tech Type 2	2	4
Medium Tech Type 3	2	4
Medium Tech Type 4	17	26
High Tech Type 1	8	9
High Tech Type 2	3	5
* Note: values are based on a 30% circulation percentage. Design Teams should derive their expectations for domestic hot water usage and derive an energy usage.		

5.113 Detailed internal conditions for each NHS Net Zero Building Standard space type are included in Tables 18 and 19 below. These assumptions have been provided so that the Design Team can match the spaces in their brief with one of the NHS Net Zero Building Standard space types. The detailed internal conditions can also be used as benchmarks for early-stage analyses. Internal conditions should be tailored to each project and all spaces should be compliant with the HTM documents.

Table 18 Medium-tech Space-types – Detailed internal conditions

	Medium-tech space-type categories			
Space-type category	Medium-Tech Type 1	Medium-Tech Type 2	Medium-Tech Type 3	Medium-Tech Type 4
Description	Clinical spaces containing consulting/ exam/ treatment work areas and critical care areas which are occupied 24 hours a day.	Clinical spaces containing treatment work areas which are occupied during the day only.	Clinical spaces containing consulting work areas which are occupied during the day only.	Clinical spaces containing beds ranging from single bedrooms to multiple patient units in wards. This space-type includes bed and sanitary facilities, and patient support facilities and are occupied 24 hours a day.
Space Occupied Schedule	24/7	7 am to 8 pm	7 am to 8 pm	24/7
Ventilation	10 ach	10 ach	6 ach	6 ach
Lighting (W/m²)	7.7	7.7	7.7	7.7
Lux	500	500	500	300
Daylight Control	No	No	No	Yes
Occupant Light Control	No	No	No	No
Equipment (low/high) (W/m²)	10/19	10/19	10/19	10/22
Occupancy (ppl/m²)	0.07	0.07	0.07	0.175
Setpoints heating/cooling	21/25	21/25	21/25	20/26
Hot Water Demand (high/low) (l/d/m²)	0.21/1.05	0.21/0.525	0.21/0.525	2.18/3.46

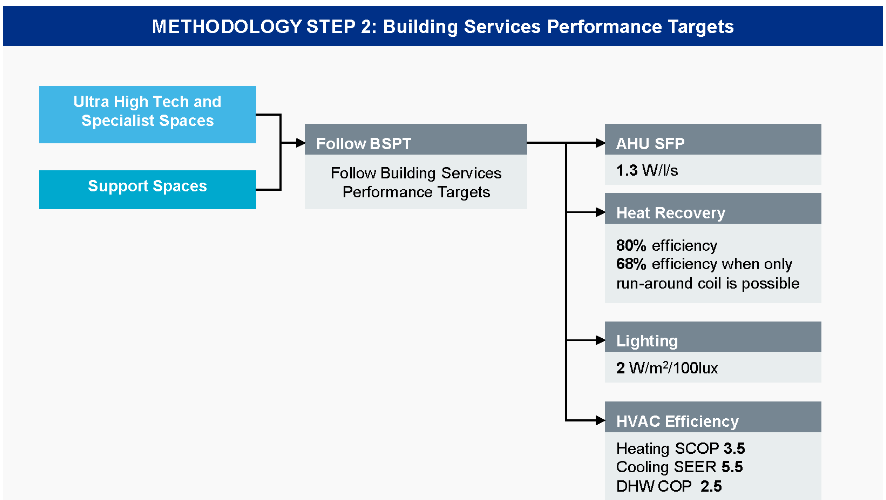
Table 19 High-tech Space-types – Detailed internal conditions

	High-Tech Space-Type Categories	
Space-type category	**High-Tech Type 1**	**High-Tech Type 2**
Description	Clinical spaces including the main operating theatre and any operating theatre ancillary spaces such as anaesthetic, scrub and preparation rooms which are occupied during the day only. This category excludes hybrid theatres. * *Ventilation and lux level requirement values have been averaged out over a standard operating room layout which includes the theatre, scrub, prep and anaesthetic rooms. Refer to the HTM 03-01 Standard layout 1 (Two-corridor conventional operating suite with "lay-up" prep). Internal conditions for each room should be compliant with HTM 03-01.*	Clinical spaces including most types of high-tech general hospital laboratories. This space-type does not include low-tech laboratories. This space-type includes both the benches work areas and any areas used for support equipment which are occupied during the day only.
Space Occupied Schedule	7 am to 10 pm	7 am to 8 pm
Ventilation	21 ach*	10 ach
Lighting (W/m²)	13	10
Lux	760*	500
Daylight Control	No	Yes
Occupant Light Control	No	No
Equipment (low/high) (W/m²)	43/60	22/50
Occupancy (ppl/m²)	0.125	0.08
Setpoints heating/ cooling	20/22	21/25
Hot Water Demand (high/low) (l/d/m²)	1.06/1.255	0.33/0.66

Building Services Performance Targets (BSPTs)

5.114 Spaces that are identified as Ultra-High Tech, Specialist and Support space-types should comply with the BSPT in Figure 26 and are described in the next section.

Figure 26 Building Services Performance Targets (BSPT)



5.115 Plant and duct, selections and sizing must enable the ventilation systems to achieve Specific Fan Powers (SFP) of 1.3 W/l/s or lower for all main ventilation plant.

5.116 For spaces that are using the minimum BSPT, a minimum of 80% efficiency of heat recovery is required. For other spaces, best practice heat recovery should be used in line with the following minimum efficiencies:

- Sensible Energy Wheels: 85%.
- Plate Heat Exchangers: 80%.
- Run-Around Coils: 68%.

5.117 An SFP of 1.3 W/l/s excludes the use of HEPA (or equivalent) filters and includes heat recovery. If a HEPA filter (or equivalent) is included in the ventilation system design, the increase to the SFP required for a filter and the type of filter are required as derogations in the *OE&C Compliance Tool*.

Ultra-high-tech, Specialist and Support Space-types

5.118 Ultra-high-tech, Specialist and Support space-types are not included under the Low, Medium and High-Tech space-types. The ultra-high tech and specialist are clinical space-types that have very high equipment loads or specialist requirements such as burn units and imaging departments. Support spaces are non-clinical spaces that have very high equipment loads or specialist requirements such as server rooms and kitchens and large unconditioned spaces such as plant rooms (see Table 20).

Table 20 Ultra-high-tech/Specialist and Support Space-types – Detailed descriptions and applicable targets

Space-type category	Ultra-high-tech/Specialist and Support Spaces			
	Ultra-high-tech and Specialist	Support Type 1	Support Type 2	Support Type 3
Description	Clinical spaces that have very high equipment loads or specialist requirements such as containment labs, diagnostic and imaging.	Non-clinical spaces that are high load, conditioned and ventilated spaces such as catering.	Server rooms.	Large unconditioned non-clinical spaces such as plant rooms, large stores and waste facilities.
Associated Targets	BSPTs	BSPTs	BSPTs (if applicable)	BSPTs (if applicable)

5.119 Where support spaces are expected to have low energy demand, like large unconditioned spaces assumed under Support Type 3, it is important to ensure that any applicable BSPTs are still adhered to (often lighting) and that the spaces are addressed through the BMS and included in the metering and monitoring framework set out.

Additional process for refurbishment projects

5.120 Alongside the main process dictated within Figure 11, the following adapted process diagram – Figure 27 for operational energy and carbon compliance – should be followed for major refurbishment projects to comply with the Standard.

5.121 As discussed in Section 3, maximising refurbishment opportunities are one of the best ways for a Trust to act on mitigating climate change – significantly reducing the upfront carbon associated with providing new or changing healthcare services in the short to medium term. Embodied carbon benefits and drawbacks associated with refurbishment are provided within Section 5.

Case Studies – Zero Carbon London, November 2020

This document includes numerous case studies for retrofit, re-used buildings and fit-outs.

ASHRAE's new HQ - a retrofit aligned with net zero carbon

Situated in Atlanta, Georgia, USA, a major office refurbishment for ASHRAE's new Headquarters. With an aspiration to exceed the provisions of its own indoor air quality standards and to deliver a maximum demand-side energy use intensity (EUI) of 67.5kWhm^2 per year, aligned with the society's zero energy office building standards.

Figure 27 Adaptation to process diagram for major refurbishment projects

Stage	Participant Activities	Information capture and reporting
RIBA 0-1	**Establish Project Brief** **Use pre-design considerations (at SOC)** to maximise reuse of buildings where possible. Ensure that key targets for achieving net zero operational carbon and making informed whole life carbon decisions are included within the design brief.	**Same** - capture project information within Compliance Tool
RIBA 0-1	Use **NHS Net Zero Capital Planning Tool** to help optimise investment decisions and understand quantum of investment required across different aspects of the energy hierarchy.	N/A
RIBA 0-1	**Establish Energy and Carbon Limits** Carbon limits can be derived using the compliance tools, however, it is expected that they should be adjusted following more detailed building appraisal at latter design stages.	Baseline carbon and energy limits should be captured within Compliance tools as a target for project teams

RIBA 2-4 (Collaboration required across design stages)	**Design activities:**
	• Assessment of existing building conditions to create a gap analysis of various performance parameters.
	  • Using latest HTM compliance and all performance targets within Standard e.g. envelope U-values, HVAC efficiencies, metering and BMS.
	  • Assess inter-storey heights and other building and site constraints
	  • Assessments for source capacities of building services
	  • Benchmark energy usage per space type / system if current submetering allows.
	• Undertake other assessments including thermal comfort and daylight analysis to identify any further health and wellbeing issues.
	• Assess feasibility study of bridging these performance gaps across the design through refurbishment, i.e. making the building compliant to HTMs and NHS Net Zero Building Standard. Optimise PTs for the design based on technical and commercial viability (may be iterative with modelling below).
		Follow the process and requirements as per the Standard.
		
		Capture design decisions in the Design Register. Update throughout the design stages.

RIBA 2-4 (Collaboration required across design stages)	**Energy and carbon modelling:** • Undertake energy and carbon modelling as per requirements in the Standard to assess compliance with departmental energy limits and performance targets. • Establish project bespoke departmental energy limits using best possible building and HVAC performance targets, if performance targets cannot be met based on building constraints. • Assess renewables opportunities for building based on orientation and massing modelling. • Refine modelling across the design stages as per the Standard.	**Derogation process where applicable:** - Reasons why PTs or energy limits cannot be met and the impact this has on the design - Where energy limits cannot be met, evidence must be provided that all other PTs have been complied with, or derogations need to be provided for these values also
RIBA 2-4 (Collaboration required across design stages)	**Update Energy & Carbon Strategy / Design Report to capture performance and design decisions.** *Formal compliance will be checked as part of OBC and FBC submissions.*	
RIBA 5-7	**Design activities and reporting requirements as per requirements within the main process diagram within the Standard**	

Continuous feedback across the capital investment programme and project lifecycles, to share lessons learnt and drive collective learning across all parts of whole life carbon. Learning and data collection across projects will be used to update the Standard to achieve targets for net zero.

6 Delivery stages and reporting

Introduction

6.1 This section outlines requirements and processes that will help any asset on its journey towards achieving net zero carbon across its lifecycle. Figure 28 shows a summary of the key activities needed across the lifecycle to support this.

6.2 Achieving net zero carbon and successful project delivery requires a close collaboration between the Client Team(s) and the Project Team, especially where the scale of change is so radical comparative to historical practice. The Teams must follow the activities and sequence set out in this section to achieve the desired performance outcomes; compliance requires a combined effort between the Client Team(s) and the Project Team.

6.3 To support high performing buildings, increased focus and investment in planning and optioneering early within the design stages is required. Early design efforts in the project programme are less costly and less disruptive than implementing the same changes at later stages of the design.

6.4 This section also provides wider sustainability considerations to enable not only low carbon but more broadly sustainable solutions, where possible aligning to existing accreditations, standards and policy.

Compliance

6.5 This section summarises the reporting requirements to demonstrate compliance.

6.6 Three tools have been provided as outlined below and must be used as the principal reporting mechanism:

1. **Design Management Tool** – provided specifically for the Net Zero Carbon (NZC) Coordinator to manage the delivery of the net zero carbon requirements.
2. **Whole Life Carbon (WLC) Compliance Tool** – provided to demonstrate compliance against Upfront Carbon Limits and whole life carbon reporting.
3. **Operational Energy and Carbon (OE&C) Compliance Tool** – provided to demonstrate compliance against operational Energy Limits, Performance Targets and provides a space allocation tab that is required to determine requirements for both upfront carbon and operational energy.

6.7 The tools must be used to demonstrate compliance against the following key requirements of the Standard:

1. **Management** – the management team must set and manage the brief, which is fundamental to setting the Carbon and Energy Limits. The *OE&C Tool* must be used to break down the schedule of accommodation into space-type technology categories at department level where possible and must be updated as and when the brief changes. The Trust must ensure a NZC Coordinator is appointed from within the Project Team, who should be principally responsible for compliance to the requirements of the Standard.
2. **Setting Limits** – the Upfront Carbon Limits, Operational Energy Limits and PTs must be set using the Compliance Tools and communicated to the Project Team by the Client Team, with help from the NZC Coordinator where applicable. The limit setting process is automated in the tools such that the limits can be set easily. Limits at the earliest project stages are established to set an indicative benchmark to optimise against. Limits must be updated throughout the project in response to significant changes of the brief and levels of detail/certainty within early assumptions on areas and space-types.
3. **Design Activities** – the Project Team must demonstrate that the design activities required in the Standard have been undertaken and record actions against them in the *Design Management Tool*, which must be overseen and reported by the NZC Coordinator.
4. **Operational Energy Assessment** – DSM must be undertaken using detailed HVAC modelling to calculate and report the expected energy consumption to compare against the Energy Limits derived from the *OE&C Compliance Tool*. The reporting must also include compliance to the whole building PT's, BSPTs, and Energy and Carbon Strategy related items. A second DSM model should be derived that includes all energy consumption sources and spaces within the building for purposes of comparing in-use metering and monitoring data. See DSM modelling checklist within the user guide for more information on this.
5. **Whole Life Carbon Assessment** – calculations must be undertaken by the Project Team for all Tier 1 and Tier 2 elements for the full lifecycle and reported using the *WLC Compliance Tool*. Whole building embodied carbon reporting forms the basis of compliance against Upfront Carbon Limits.
6. **Meeting Upfront Carbon Limits** – the Project Team must demonstrate that the Upfront Carbon in Tier 1 elements does not exceed the Upfront Carbon Limit assigned, providing assurance of quantity modelling and extraction and transparency of carbon calculation assumptions using the *WLC Compliance Tool*.

6.8 The matrix in Figure 28 summarises the requirements through the design process, as well as external reporting requirements at the OBC, FBC and Handover stages to demonstrate compliance.

6.9 Within Figure 28, it is assumed the following:

1. Pre-design stage is encompassing of RIBA 0–1 and SOC. This is typically outside the formal scope of the Standard, but its principles and objectives can be used to help influence decision-making at this stage.

2. Business Case Stages are where compliance is checked formally by parties outside of the Project Team – the requirements and evidence for compliance are shown within the table as pale blue rows.
3. RIBA stages show activities that are needed by the Project Team to support compliance with the Standard (white rows).
4. It is assumed that OBC aligns with the end of RIBA 2.
5. It is assumed that FBC aligns with RIBA "4a" – as a responsibility of the Design Team before Contractor design proportions.
6. Carbon and energy compliance, design developments within RIBA 4b are typically captured as part of the post FBC activities, alongside other construction activities.
7. Verification of design values and building performance, will sit across both handover (RIBA 6) and in-use (RIBA 7) depending on the requirement.

Management activities

6.10 To oversee design activities and the compliance process for the Standard, management activities (aligned to the BREEAM methodology) are pertinent to ensure that the outcomes of the Standard are met. These management activities have been split into two main groups of responsibility; those of 1) the Client (Trust) and 2) the Net Zero Carbon (NZC) Coordinator.

6.11 While the requirements to assess and approve compliance are aligned to the business case stages, management activities should be active in supporting the Project Team (design and construction) throughout the RIBA stages.

Client (Trust) roles

6.12 The Client should be responsible for coordinating the governance, commercial and technical inputs into business case approvals across the Project Team. This must include ensuring that the activities and reporting requirements of the Standard are fully understood by the Project Team and included in project scope and costing documents.

6.13 The Client should be responsible for ensuring the objectives, outputs and requirements of the Standard are clearly articulated in tender and specification documents, relevant to the project's procurement stage(s) and various parties.

Continuous improvement

6.14 Throughout the project lifecycle there is an expectation for continuous improvement across the capital programme for the NHS. To achieve this alongside capturing information from reporting at business case stages, there needs to be feedback from the Project Team into NHS England regarding lessons learnt and key assumptions. This will be used to inform further iterations of the Standard and its appendices in the future.

Figure 28 Summary of Compliance for the Standard – *this has also been provided as a stand-alone PDF for ease of use*

Requirement	1. Management Activities		2. Setting Limits & Performance Targets		3. Design Activities	4. Operational Energy and Carbon Assessment		5. Whole Life Cycle Carbon Assessment	6. Meeting Upfront Carbon Limits
Sub Requirement	**Client Project Team (Trust)**	**Net Zero Carbon (NZC) Coordinator**	**Upfront Carbon**	**Operational Energy**		**Modelling**	**Energy Sources**		
Reporting Mechanism	OE&C Compliance Tool Tab 1.0 Space Allocation	Design Management Tool Tab 1.0 Summary, Tab 2.0 Checklist and 3.0 Design Register	WLC Compliance Tool Tab 1.0 Project Information	OE&C Compliance Tool Tab 2.0 Whole Building PTs and 3.0 Compliance Requirements	Design Management Tool Tab 3.0 Design Register	OE&C Compliance Tool Tab 4.0 Energy Limit Compliance, 5.0 Building Services PT Compliance, 6.0 Derogations log, 7.0 Energy Use Reporting	OE&C Compliance Tool Tab 6.0 Derogations Log, 8.0 Energy Strategy Reporting	WLC Compliance Tool Tab 2.0 OBC, 2.1 FBC, 2.2 Handover	WLC Compliance Tool Tab 3.0 WLC Summary and 4.0 Assumptions
Pre-design	The compliance tools should be used to aid option appraisal and setting a low carbon brief	The nominated representative (e.g. advisors) shall use the tools and previous experience of schemes to inform option selection	Indicative Upfront Carbon estimations for options appraisal shall be derived using Tab 1.0 of the tool	Indicative energy (and carbon) intensity for options appraisal shall be derived based on rules of thumb from the energy limits and associated magnitudes of development.	No Requirements.	No Requirements	Engagement with the Local Authority Area in respect to local opportunities/requirements related to zero carbon energy sources should be carried out, including heat and energy network connection requirements. Involvement of Specialist(s) as necessary.	No Requirements	No Requirements.
Design brief / preparation	The Brief shall be set. The Space Allocation Tab (1.0) shall be used to determine the classification of spaces at high level, in reference to block schematics or proposed space split. Design to appoint NZC Coordinator.	The nominated representative e.g. NZC Coordinator shall undertake Items 1-7 in Tab 2.0 (Checklist) ensuring limits and targets are correctly set and shared with the design team.	The WLC Compliance Tool Project information Tab 1.0 must be completed using the Output from the OE&C Compliance Tool Space Allocation Tab 1.0. The limits will be automatically developed based on the inputs.	Energy limits calculated in Tab 3.0 based on the brief as entered in Tab 1.0. Whole building PTs are calculated in Tab 2.0. Tab 3.0 will identify the spaces for which compliance with building services PT's is required.		Ensure Design Energy Limits in Tab 4.0 and Building Services PTs in Tab 5.0 are established	No Requirements	Copy the Upfront Carbon Limits from the Project Information Tab 1.0 to the inputs in Tab 2.0.	
RIBA 2	A review of the impact of changes on the brief and energy limits is required. Space Allocation (Tab 1.0) to be updated as necessary - Delegation of updating Tab 1.0 to the NZC Coordinator or design team is acceptable.	The NZC Coordinator shall ensure limits are amended as required, recorded in Tab 1.0 (Summary) and communicated to the design team. The NZC Coordinator to regularly update the Design Register (Tab 3.0)	The limits shall be reviewed following changes to the brief and updated if necessary. The NZC Coordinator must record changes in the Design Management Tool Tab 1 (Summary) to capture the effect and reasoning.		Undertake design activities as required in the Design Management Tool Design Register Tab 3.0. Boxes are greyed out and locked where not required at this stage.	Undertake high level DSM and report on Design Energy Limits in Tab 4.0. Input design values against expected values for Building Services PTs Tab 5.0. Complete Derogations log, if required, in Tab 6.0. Output Energy Use Reporting Tab 7.0.	Establish the building's energy strategy using the energy and heat hierarchy, ensuring that decarbonisation pathways align with NHS E/I target dates. Complete Derogations log, if required, in Tab 6.0.	Undertake WLC Assessment in Tab 2.0. Quantity estimations are acceptable, with guidance provided in the commentary column. Simplified approaches to carbon calculations are accepted, e.g. mid level calculation for building services, and lift up factors. Assumptions and estimations used should be clearly stated in the commentary column, replacing the guidance in the register.	Progress against the limits shall be tracked throughout the design stage to ensure compliance can be demonstrated at OBC.
Outline Business Case - Compliance	The Trust shall review the evidence submitted and ensure compliance has been achieved. Derogations must be provided where limits are exceeded with sufficient justification.	Demonstration of compliance is the responsibility of the NZC Coordinator - compiling the relevant reporting tabs from the Compliance Tools, as specified in the Design management Tool Checklist (Tab 2.0) Items 9-15.	The WLC Compliance Tool Project Information Tab shall be reported to provide carbon limits used.	The OE&C Compliance Tool Tab 2.0 & 3.0 shall be reported to provide energy limits and performance targets used.	Compliance shall be demonstrated through submitting the Design Register output in the Design Management Tool, alongside any supporting information e.g. results of optioneering studies. Actions shall be reported against all activities required at RIBA 2.	Prepare and submit the Energy Use Reporting Tab 7.0, and Derogations Tab 6.0 if applicable, based on concept design. Where derogations have been identified, justified reasons and quantified impacts must be provided.	Prepare and submit the Energy Strategy Reporting Tab 8.0 and Derogations Tab 6.0 if applicable, based on concept design. Where derogations have been identified, justified reasons and quantified impacts must be provided. Report all planned energy sources and their carbon intensities, including feasibility study of the Decarbonisation Strategy, that includes achievement dates for NZC and alignment to broader Estate decarbonisation plans where applicable.	Compliance shall be demonstrated through submitting the WLC Compliance Tool Tab 2.0. This shall also be reported to the relevant database as requested by the Client.	Compliance shall be demonstrated through submitting the WLC Compliance Tool Tab 3.0 and 4.0. Derogations must be raised if the limit is exceeded - this is only possible on grounds set out in Section 6.3.
RIBA 3 and 4a - Spatial Coordination and Technical Design	Whilst managing change, a review of the impact of changes on the brief and energy limits is required. Space Allocation (Tab 1.0) to be updated as necessary - Delegation of updating Tab 1.0 to the NZC Coordinator or design team is acceptable.	The NZC Coordinator shall ensure limits are amended as required, recorded in Tab 1.0 (Summary) and communicated to the design team. The NZCC shall ensure the Design Register (Tab 3.0) is regularly updated to capture design activities against the requirements of the Standard.	The limits shall be reviewed following changes to the brief and updated if necessary. When updated, the NZC Coordinator shall record this in the relevant tab to capture the effect and reason of the change.		Undertake design activities as required in the Design Management Tool Design Register. Boxes are greyed out and locked where not required at this stage	Undertake sub-hourly DSM, coupling solar shading, daylight control strategies, HVAC plant and bulk airflow network, to develop the design to ensure compliance to technical requirements listed within the Standard. Use FM and contractor engagement to update design assumptions.	Further refine energy strategy, gathering evidence that technologies are compliant with the Standard, including further details on decarbonisation plan(s), energy generation and demands management technologies.	Update assessment using tab 2.1, replacing assumptions and estimations with known quantities, EPD information and supplier information where possible.	Progress against the limits shall be tracked throughout the design stages to ensure compliance can be demonstrated at FBC.
Full Business Case - Compliance	The Trust shall review the evidence submitted and ensure compliance has been achieved. Derogations must be provided where limits or other performance targets are exceeded with sufficient justification.	Demonstration of compliance is the responsibility of the NZC Coordinator - compiling the relevant reports from all of the Tool tabs, as specified in the Design management Tool Checklist (Tab 2.0) Items 9-15.	The WLC Compliance Tool Project Information Tab shall be reported to provide carbon limits used.	The OE&C Compliance Tool Tab 2 & 3 shall be reported to provide energy limits and performance targets used.	Compliance shall be demonstrated through submitting the Design Register output in the Design Management Tool, alongside any supporting information e.g. results of optimisation studies. Actions shall be reported against all activities required at RIBA 3&4.	Prepare and submit the Reporting tabs 7.0 and 8.0 and Derogations log (Tab 6.0), if applicable. Where derogations have been identified, justified reasons and quantified impacts must be provided.		Compliance shall be demonstrated through submitting the WLC Compliance Tool Tab 2.1. This shall also be reported to the relevant database as requested by the Client.	Compliance shall be demonstrated through submitting the WLC Compliance Tool Tab 3.0 and 4.0. Derogations must be raised if the limit is exceeded - this is only possible on grounds set out in Section 6.3.
RIBA 4b - Technical Design (typically contractor detailing)	Limits shall be stated as mandatory requirements in tender documentation and carbon reduction opportunities should be requested. This must form part of the procurement scoring.	The NZC Coordinator shall ensure limits are amended as required and communicated to the construction team. The NZC Coordinator shall ensure the Design Register is shared with the Contractor.	The limit shall become the calculated value submitted at FBC, following acceptance of derogations.		Actions shall be updated as required until the detailed design is finalised. The register tab shall be shared with the Contractor during tendering to allow carbon reduction opportunities to be proposed.	Undertake RIBA 4 sub-hourly DSM, coupling solar shading, daylight control strategies, HVAC plant and bulk airflow network, to further develop/amend the design, with quoted manufacturer specific inputs to ensure planned energy strategy and operational energy limits will be complied with at handover. Metering arrangement, as set out by HVAC, lighting and controls team, to be reflected in the DSM. Include evidence that the modelling assumptions reflect the latest known operational conditions of the building and are reflective of final product specifications.		Continue to update assessment, finalising design calculations in Tab 2.1 and updating following Contractor comments.	The Contractor may challenge any assumptions or quantities provided by the design team and carbon calculations updated as required.
RIBA 5 - Construction	Embodied carbon and energy performance shall be integrated within requirements for Responsible Sourcing of construction products.		The limits shall be accepted by the Contractor prior to appointment.		As part of continued improvement, the Contractor shall submit carbon reduction proposals as part of the tender response using the design information presented. Updates shall be added to the Design Register by the design team.	Undertake: 1) Quality Assurance inspections related to Operational Energy performance such as fabric installation inspections and evidencing 2) Programme of physical testing: fabric integrity / plant operational tests / natural light / thermal comfort / indoor air quality. 3) Full commissioning of building services in line with control strategies, setpoints, required flow rates, as in DSM. 4) FM strategy and building user guides related to Operational Energy systems 'in use', review and sign off		Tab 2.2 shall be developed using accurate, as-built information. EPDs shall be provided for all products supplied, transport emissions provided, and on-site waste rates tracked. Site emissions shall be tracked and attributed where possible to elements, otherwise lump sums may be reported.	Progress against the limits shall be tracked throughout the construction stage to ensure compliance can be demonstrated at Handover.
RIBA 6 - Handover & Post-Construction Verification	The Trust shall review the evidence submitted and ensure compliance has been achieved. Derogations must be provided where limits are exceeded with sufficient justification.	Demonstration of compliance is the responsibility of the NZC Coordinator - compiling the relevant reports from all of the Tool tabs, as specified in the Design management Tool Checklist (Tab 2.0) Items 9-15.	No Requirements	The OE&C Compliance Tool Tab 2 & 3 shall be reported to provide energy limits and performance targets used.	Compliance shall be demonstrated through submitting the Design Register. Evidence of carbon savings should be presented.	Prepare As-Built revision of the DSM with actual specification including commissioning test outputs used. Compare performance against final As-Designed DSM. FM strategy, full description of operation and building user guides to assist with handover and ensure energy limits are complied to in operation. Compliance via submission of Reporting tabs Tabs 7.0 and 8.0 and Derogations Log Tab 6.0, as per handover conditions.	Collate evidence that the As-Built / Installed technologies comply with the Project's Energy Strategy.	Compliance shall be demonstrated through submitting the WLC Compliance Tool Tab 2.2. This shall also be reported to the relevant database as requested by the Client.	Compliance shall be demonstrated through submitting the WLC Compliance Tool Tab 3.0 and 4.0. Assumptions shall be replaced with actual as-measured data in Tab 4.0. Derogations must be raised if the limit is exceeded - this is only possible on grounds set out in Section 6.3.
RIBA 7 - In Use	Trust to review process and prepare a short summary of lessons learned, supporting future knowledge share and continuous improvement.	NZC Coordinator to ensure all relevant reports are shared with Central NHS and industry databases as required, and lessons learnt are captured to feed into the development of future versions of the Standard. NZC Coordinator to log changes made within initial operation as carried out in the Operational Energy and Carbon Assessment.	Monitoring and Verification Plan must be enacted to monitor building outcomes across the energy and carbon limits and performance targets. An investigation for non-compliance must be undertaken if applicable and a Corrective Action Plan formed where necessary with continued conversation between the Client and Project Team. In-use monitoring will be ongoing and feed into ongoing Estate Management and optimisation.		Contractor and project team review process and prepare a short summary of lessons learned (including benefits of applying circular economy principles), supporting future knowledge share and continuous improvement.	Follow Monitoring & Verification Plan to verify performance over the first year of operation by comparing on a monthly basis the As-Built DSM against the final As-Designed DSM to identify any areas of poor performance and plan and instruct mitigations. Continue monitoring for 3 years as per the requirements of the Standard.	Collate evidence from monitoring that installed technologies, as well as connections to any local network or existing estate infrastructure, where relevant, comply with the Project's Energy Strategy and the systems are operating at their assumed efficiencies. Update on track of decarbonisation plans.	Summary of unknowns and missing information to be provided in a short report to identify key areas of focus for future projects	Summary tab with results at each stage to be reported back to central NHS to inform future development of the Standard.

RIBA 0-1 – pre-design stage and establishing design brief

6.15 At RIBA 0–1 (pre-design) stage, it is critical that the Client understands the various parameters that critically influence the carbon intensity of the scheme and uses this to help inform decision-making (see paragraphs 3.3–3.6 for more information).

6.16 At design brief stage, the Client must establish baseline Carbon Limits and PTs for the scheme, using the *Operational Energy and Carbon Compliance Tool – Tab 1.0 Space Allocation*. The Client must ensure that this is reflective of the level of information of the scheme and is continually reviewed and developed throughout the design stages – updating the space allocation and relevant limit setting tabs in the respective tools may be delegated to the NZC Coordinator upon appointment.

6.17 The Client must also establish the project requirements and state what additional processes must be followed to support the Standard, such as the Government Soft Landings Framework and BREEAM, ensuring this is captured within design brief(s) and scopes of services.

Throughout design stages

6.18 Throughout the design process, it is the Client's role to review critical design information and decisions made regarding carbon and energy performance, including documentation provided for compliance. The Client must review and seek to understand any derogations from the Standard as well as the reasoning and impact of that design decision using information presented by the design team, recognising the risk this might present at business case approval stage(s).

6.19 The Client Team(s) must ensure that there is engagement with the Project Team regarding operational characteristics of the facilities, so that energy modelling is reflective of best knowledge and reduces the number of assumptions.

6.20 The management team must facilitate conversations across the Client, Clinical and Project Team(s) regarding decision-making for adaptability to establish the correct design brief and schedule of accommodation used to create project specific Energy and Carbon Limits.

Construction stages

6.21 As the project passes from design to construction, the Client must incorporate clear construction team specifications to tender documents, ensuring the envisioned future outcomes. Critical items that must be included are:

1. Ensure that Operational Energy and Upfront Carbon Limits and other PTs are included as mandatory requirements in the construction tender package.
2. Invite embodied carbon saving opportunities to be proposed in tender responses and weighted appropriately in procurement scoring to incentive innovation and low carbon solutions.
3. Incorporate requirements in contractors' prelims to recalculate the energy model if design items are changed or value engineered and to demonstrate that the

"as-built" project meets agreed Operational Energy and Upfront Carbon Limits and other PTs.

4. Ensure that as-built upfront carbon is monitored and reported including construction emissions.
5. The Client must ensure that there are allocated individuals managing quality within construction and are establishing a M&V Plan for the project.

In-use stages

6.22 Following handover of the building there will be continued Client requirements into operation for the continued monitoring and verification of the building's performance. This is likely to sit with the estate and operations team, rather than the Client Project Team as it will extend throughout the building's lifetime.

6.23 The Client is required to help facilitate and engage with formal Post-Project Completion Evaluation throughout the three-year monitoring and verification period (Project Team responsibility).

6.24 Once the building is in operation and beyond the formal POE phase, the Trust Operations and Estates team will be responsible for the ongoing in-use monitoring of the building and patient and staff satisfaction. Key actions and activities will need to be continued that were established as part of the handover process, especially regarding energy and carbon monitoring. This should integrate with facilities management and Estate Management Plans to refine building performance practices (behavioural and technical).

6.25 In-use reporting should feed into the Built Environment Carbon database, Healthcare Without Harm, as well as NHS central asset performance monitoring requirements, e.g. ERIC.

Net Zero Carbon Coordinator Role

6.26 As introduced within the Operational energy compliance Section, the Net Zero Carbon Coordinator ("NZC Coordinator") role has been introduced in the Standard to manage the design process regarding net zero carbon performance and create a critical link between the Client/Trust and the Project Team.

6.27 The NZC Coordinator must be appointed by the Client and is likely to be someone from within the Design Team, although it does not have to be. The role may be filled by different people across the project lifecycle based on varying levels of detail within the design (similar to the Principal Designer role within Construction, Design and Management Regulations 2015). The role should be filled by a suitably qualified professional with the following characteristics and qualifications:

- current relevant experience working within a multi-disciplinary healthcare design team
- demonstrate industry knowledge of the key components and characteristics of both operational energy and whole life cycle carbon performance, as well as the design decisions that affect high performance

- an excellent communicator who can translate difficult technical requirements and outcomes across different disciplines, and be an integrator within the project team and to other internal and external stakeholders
- does not need to be a technical specialist that has ability within carbon and energy assessments, e.g. detailed operational energy modelling (as these design activities can be done by others within the design team), interface with the Project Team is therefore essential.

6.28 The NZC Coordinator should understand the design activities required of differing disciplines and outcomes of the Standard across all future stages, informed in part by review and usage of the Compliance Tools.

6.29 The *NZC Design Management Tool* has been provided to assist the Coordinator to manage the design and compliance process outlined in this section. The tool must be reviewed on a regular basis (recommended to be a minimum of monthly) and updated where applicable based upon:

- any significant changes to the project brief that may affect Operational and Upfront Carbon Limits. The qualitative change should be tracked using the *NZC Design Management Tool – Tab 1.0 Summary*, capturing any key decisions or outstanding information following design activities.
- Capture quantitative changes to the project brief by: (Note: the limits can go down as well as up over the design process).
  - Ensuring the space allocations within the *Operational Energy and Carbon Compliance Tool – 2 … Tab 1.0 Space Allocation* are updated with the new space requirements.
  - Ensuring the summary of key project information is input into the *Whole Life Carbon Compliance Tool – Tab 1.0 Project Information* to also reflect changes to the Upfront Carbon Limit .

6.30 Design activities and decisions against requirements of the Standard – the NZC Coordinator should record key actions in the *Design Management Tool – Tab 3.0 Design Register Tab*. Regular whole Project Team meetings should be used to ensure a collaborative approach to the design activities.

6.31 Additionally, the following responsibilities are required of the NZC Coordinator:

- Act as an advocate for NZC performance within the Design Team, helping ensure the Project Team is engaged in all aspects of NZC design, including facilitate Project Team workshops and collaboration to achieve the desired outcomes.
- Capture key design decisions made throughout the project lifecycle that impact the operational energy and carbon, and embodied carbon performance across the lifecycle of the asset, capturing this within the *Design Management Tool* – Tab 3.0 Design Register.
- Ensure Energy and Carbon Limits and PTs are set and communicated to the Design Team, and that the Design Team are on track against the limits through design

stages to enable successful compliance at relevant business case stages. This should be tracked using the *Design Management Tool* – Tab 2.0 Checklist.

- Facilitate necessary stakeholder engagement across all requirements in this section, drawing together Client, Design Team, Contractor(s), Facilities Management, and wider stakeholders to achieve the objectives of this Standard.
- Oversee, capture, and report all required tabs of the *WLC* and *OE&C Compliance Tools* alongside relevant evidence.
- Where derogations are proposed by the Design Team, work to understand their rationale and impacts across the scheme's lifecycle; working with the Design Team to establish what is a reasonable alternative level of performance.
- Finalise requirements with potential contractors and subcontractors around Carbon and Energy Limits, managing any challenges of assumptions and final Carbon and Energy Limits due to derogations and change, asking for options for improvement and including carbon questions on tender return forms.
- Continue to manage *Design Management Tool* – Tab 3.0 Design Register through the Construction stage, ensuring all information is captured as required for formal verification and reporting.
- Ensure the Project Teams are report carbon assessments as required to the relevant industry databases (Built Environment Carbon Database and Healthcare Without Harm).
- Assist the Client in capturing and sharing lessons learnt across with the Trust, other Professional Bodies and Supply Chain to enable continuous improvement services.

Setting Carbon and Energy Limits

Upfront carbon

6.32 Refer to the User Guide for a detailed step by step process for how to derive project specific Upfront Carbon Limits and use the Compliance Tools. This process uses the *OE&C Compliance Tool – Tab 1.0 Space Allocation*. The summary information required for setting Upfront Carbon Limits is provided as an output in this tab and simply requires copying across to the *WLC Compliance Tool – Tab 1.0 Project Information*.

6.33 The limits are first established following SOC stage – these are the limits set for OBC Compliance. The limits must be reviewed and set for FBC following completion of OBC, with a greater level of detail of space allocation expected to improve the accuracy of the limits.

6.34 The limits must be monitored by the NZC Coordinator throughout the RIBA stages to ensure the limits are updated and shared when the brief changes.

6.35 The Upfront Carbon Limits must be adjusted following approval of derogations at FBC stage to match the design outputs, these will form the limits for the Construction stage.

6.36 These updated limits must be reviewed and accepted by the Contractor prior to appointment. The NZC Coordinator must manage this process to ensure the limits for the construction stage are fair and reasonable based on the design submittal.

Operational energy

6.37 Refer to the User Guide for a detailed step by step process for how to use the Compliance Tools and derive project specific Operational Energy Limits and PTs. These User Guides include how information flows within the tools and what each tab is used for.

6.38 The Energy Limits and PTs are established following the SOC stage and must be monitored by the NZC Coordinator through the RIBA stages to ensure the limits are updated and shared when the brief changes.

6.39 At early stages, when spatial planning is at basic level, block schematics or percentage split of building by department should be used to calculate high-level whole building Energy Limits, which should be refined through the design as certainty of the spatial configuration increases.

Monitoring and Verification (M&V) Plan

6.40 Critical to verifying the project's performance across various technical aspects of the Standard (operational energy and carbon and upfront carbon) is a requirement to establish a Monitoring & Verification Plan (M&V Plan). This must establish project specific plans, processes and responsibilities to monitor and verify across handover and over the first three years of performance.

6.41 The Government Soft Landings Framework is an established process for delivering this, see Chapter 3 for more information, however, for projects not using this scheme, this requirement should be established within the project activities.

6.42 The M&V Plan should be considered as early as RIBA 2, to help refine the metering and monitoring strategy for the building and informed by specific building outcomes that need verification. The M&V Plan should then be refined across the detailed design stages and embedded within the construction contract and handover procurement processes.

6.43 The M&V Plan should be integrated with the digital estate strategy and intelligent building management, ensuring continuous monitoring of building performance and automated optimisation where possible. It is aspiration that ongoing monitoring and optimisation be undertaken based upon occupant satisfaction and feedback alongside more technical parameters such as energy, temperature, lighting and occupancy.

Design activities

6.44 *The Design Management Tool – Tab 3.0 Design Register* must be used to capture key design decisions and actions associated with requirements in Sections 4 and 5 for both operational energy and embodied carbon. The register is modelled on a design risk register (i.e. CDM Register), such that decisions are captured and revisited at each stage, ensuring alignment of strategy and tracking of carbon impacts through the design stages.

The activities must be undertaken in a collaborative way by the Project Team, and recorded by the NZC Coordinator, with some activities only required at certain stages.

6.45 The register must be shared when tendering to enable contractors to assess and outline carbon reduction opportunities as part of their tender responses, which must be used as a metric to score tender responses.

6.46 The register must be updated through the construction stage to capture key actions.

Operational Energy

6.47 The *OE&C Compliance Tool* must be used to assist design development and ensure compliance to the Standard. It must be used iteratively by the Design Team to review progress and help influence the design to ensure compliance at business case stages.

6.48 The use of DSM is a requirement to allow assessment operational energy within design stages. Using appropriate input data at each design stage to create as accurate an energy model.

6.49 The whole building Energy Limits and BSPTs in the Standard depend on the space allocation, therefore they must be calculated at every RIBA Stage and when significant layout changes affect the space allocation. Before DSM is carried out at each stage the Energy Limits and BSPTs must be calculated using the *OE&C Compliance Tool*.

6.50 DSM outputs reported in the relevant tabs alongside design assumptions within the Energy and Carbon Strategy. Beyond being a platform for demonstrating compliance for a proposed building, a key purpose of the tool is to help set up a consistent NHS building benchmarking database to help drive collective improvement.

6.51 At no stage must the DSM be carried out within the software's Building Regulations Part L mode (e.g. VE Compliance in IES VE or UK Building Regulations 2013 Studio in EDSL Tas).

6.52 As demonstrated within the electricity and heat source usage hierarchies, peak demand, flexibility, and storage across energy sources are key elements that must be considered within the design, depending on site and demand profile characteristics. The measures implemented must be reported in Tab 8.0 of the *OE&C Compliance Tool*.

6.53 Parameters relating to generating capacity and characteristics, such as photovoltaics (PV) nominal module efficiency and array size, must be reported to check for consistency across schemes.

6.54 Additionally, as part of schemes, peak demand across energy sources and flexibility are key elements that must be carefully designed for and reported in Tab 8.0 of the *OE&C Compliance Tool*. Only the renewable energy attributed directly to the building and systems noted under the "Be Green" steps of the hierarchy must be reported to remove any duplication.

Early design stages

Modelling

6.55 Early phase 3D modelling (parametric is strongly encouraged) should be carried out during early design stages to shape initial architectural concept forms and optimum building orientation. Solar exposure modelling and façade characteristics, including glazing ratio and shading optioneering and optimisation should be undertaken to avoid risk of excessive cooling demand.

6.56 At early design stages, schematics should be used, identifying level and area of each department, or likely percentage split. This level of information, along with estimates of equipment usage is sufficient to dictate the Energy Limits for the first DSM, using *OE&C Compliance Tool – Tab 1.0 Space Allocation and 3.0 Compliance Requirements*, with *Tab 2.0 Whole Building Performance Targets* also applicable. Guidance on internal conditions is provided within the Standard to assist Project Teams in collating early-stage inputs where it is not feasible to acquire project specific information. CIBSE TM54 methodology is to be followed, with detailed HVAC modelling being optional at this stage, but advised to reduce the risk of significant deviation in outputs from the DSM between RIBA Stages 2 and 3. Results from the first DSM are to be captured in the *OE&C Compliance Tool – Tabs 7.0 Energy Use Reporting and 8.0 Energy Strategy Reporting*.

Energy Sources

6.57 The Energy and Carbon Strategy is to be established at SOC, following an energy options appraisal to derive the most suitable option in line with the Standard. Any planning opportunities and limitations that may influence the potential of the proposed building to align with the Heat or Electricity Sources Usage Hierarchy and the Energy Limits and/or the BSPTs must be identified and explored in detail by the Project Team. The Project Team must ensure sufficient information is available to set out the Energy and Carbon Strategy in line with the requirements of the Standard, and with the derogations should these be needed.

6.58 The decision on energy sources needs to be justified in line with the hierarchies set out in the Standard. Where due to local opportunities or requirements, Priority 02 is deemed as the most appropriate option, full details of the local network or other source should be obtained and reported, including carbon factors and capacity. Similarly, full details of the existing infrastructure energy sources, efficiencies and spare capacity should be obtained and reported where Priority 03 is followed. Evidence backed justifications should be logged in of the *OE&C Compliance Tool – Tab 6.0 Derogations Log*.

6.59 Decarbonisation strategies for all energy sources must be established and included within the Energy and Carbon Strategy.

Detailed design Stages

Modelling

6.60 A new revision of the *OE&C Compliance Tool* should be created. *Tab 3.0 Compliance Requirements* should be revisited based on revised *Tab 1.0 Space Allocation* to reflect the development of the design and any changes to the brief.

6.61 From RIBA Stage 3 onwards all DSM must be performed using detailed HVAC modelling, e.g. Apache HVAC in IES VE or Tas Systems in EDSL Tas, or other industry recognised DSM software compliant with ASHRAE Standard 140. Sizing and efficiencies should be informed by the bespoke inputs to each space for optimum operation. Modelling of controls for each control strategy must be included in the detailed HVAC modelling.

6.62 The whole building energy model should be analysed through sub-hourly DSM, coupling solar shading, daylight control strategies, HVAC plant and bulk airflow network. The DSM must be carried out to CIBSE TM 54 approach, or similar.

6.63 To accurately capture the utilisation of natural light and the impact it will have on artificial lighting, energy-consumption-detailed daylight analysis should be included where appropriate. As a minimum, the model should be able capture the reduction in electrical load and gains due to daylighting sensors where present.

6.64 The metering arrangement must be confirmed by the HVAC, lighting, and controls team, then reflected in the DSM, to identify which zones are to be controlled together for HVAC and lighting controls. Results from the detailed design stage DSM are to be captured in the reporting tabs of the *OE&C Compliance Tool*.

6.65 Any anticipated risks associated with achieving compliance, in particular with the BSPTs, must be resolved by RIBA Stage 4, using detailed modelling of the systems and up-to-date inputs from manufacturers. Equally, opportunities to enhance the energy performance of the building should be identified and tested via DSM at this stage.

6.66 During detailed design stages, Project Teams must estimate and communicate the margins of error from the DSM. This ensures areas with higher levels of uncertainty are identified and can be mitigated by obtaining the suitable level of information required from manufacturers, or Contractors.

Energy sources

6.67 Energy Source Decarbonisation Plans with supporting evidence must be reported where applicable in the Energy and Carbon Strategy aligned with FBC submission. All details of proposed energy generation solutions must be reported, along with calculated energy generation figures in the *OE&C Compliance Tool*.

Construction and handover stages

6.68 During construction, commissioning and verification should be undertaken to ensure specifications are as per the RIBA Stage 4 design, including performance specification of fabric, building services and metering and monitoring. Where the Project Team identifies that any such deviation poses a risk of failing compliance, further analysis of their impact as well as updates of the DSM are required.

6.69 Enhanced commissioning must be included within all handover processes as it has high importance and value to new healthcare facilities due to the complexity of building services systems. Additional calibration that is needed to ensure that whole systems are working together and successfully under different normal and infrequent scenarios.

6.70 Key items to be addressed during the construction and handover stage should include the following:

- Appointment of an independent Commissioning Manager (not involved in the Project Team and able to independently verify the work carried out by Project Team members), who is responsible for:
  - undertaking design reviews and giving advice on suitability for ease of commissioning
  - providing commissioning management input to construction programming and during installation stages
  - management of commissioning, performance testing and handover or post-handover stages.
- Design Commissioning Plan to support the design, construction, and eventual operation of a project that meets the project requirements for energy, water, indoor environmental quality, and durability, as well as best practice access provision for operation and maintenance.
- Ensure commissioning and testing is fully completed, witnessed and passed. This must include building services and controls, demand response, data-logging and building fabric thermal performance and airtightness. The “as-installed” control strategies, set-points, commissioned flow rates, metering, etc. must be in line with the energy model.
  - Training of Estates team in energy management and measurement and in delivering training to building users.
  - Where the energy source(s) is external to the Trust’s control (e.g. a privately run district heat network), all as-built confirmed evidence of the source’s capacity, efficiency and carbon factors should be reported. These should be reported during use also as part of the continued verification process.
- Additional items may be added by the Project/Client Team as part of a broader scope and/or Government Soft Landings process.

In-Use Stage (verification)

6.71 The following requirements must be established within the in-use stage of the building, i.e. post-handover. These items are to be expected to verify operational energy performance

- The M&V Plan should be enacted over the first three years post-handover of building performance and a verified performance outcome report must be provided (submitted to BRE to align with BREEAM requirements where applicable), including:
  - comparison of the metered data to the as-designed final DSM to identify and prevent deviations beyond an acceptable margin
  - conducting physical testing as appropriate to confirm natural light, thermal comfort, indoor air quality and adaptability and resilience performance within the building

  - monitoring and reporting operational emissions, including emissions and carbon factors from off-site sources or sources operated by a private organisation. Comparisons with detailed design stage carbon and energy predictions must be reported including any offsetting investment requirements and off-site renewable energy purchases. Reporting of this data through NHS Estate requirements e.g. ERIC. Used on an ongoing basis as part of the Trust's Green Plan where applicable.
- Where applicable, the DSM should be updated with monitoring data, including actual building usage patterns, with facilities management to be notified of discrepancies, including:
  - Ensure dual focus of improving accuracy of energy usage profiles as well as increasing optimisation of the building's operation.
  - Continue to fine tune controls and performance of the actual building through identification of any significant deviations between actual building and calibrated model, to ensure that operation is maintained at the expected requirements.
  - Utilise DSM to plan mitigations if required.
- Establish a corrective action plan and investigate non-conformances where applicable based on PTs and energy usage.
- Provide an audit trail of any changes made within initial operation and information about the impact of those changes, advise what changes have had to be incorporated and confirm that their impacts have been identified to the Client, operators, and users.
- Capture and share lessons across with the Trust, services sector and peers, reporting through NHS England and other systems.

Signpost:

Independent Monitoring and Verification (M&V) to International Standards – IPMVP, ISO 50015:2014 and Investor Confidence Project (ICP) Quality Assurance Program.

Whole Life Carbon Assessment

6.72 Assessment and reporting of WLC must be undertaken through each RIBA stage for all elements in Tier 1 and Tier 2. The use of the assessment in design activities (e.g. optioneering) should ensure that, as well as reporting carbon at the business case stages, carbon modelling itself becomes a decision-making tool through the design process.

6.73 It is important that each element of the scope is reported against at each design stage, with estimation required at early stages to provide an allowance and ensure carbon does not increase at later stages due to omissions at early stages. The calculation may be undertaken using any available in-house, freely available or subscription-based tools, but must be reported in the template provided. The assessment must be continuously updated through the RIBA stages, and submitted at business case stages to demonstrate compliance, and at practical completion to record the actual emissions using as-built data.

6.74 Increasing data collection within the Standard will help drive best practice across the built environment. Therefore, at each stage of compliance the reporting outputs must be reported to relevant industry databases.

6.75 Key industry guidance should be used where appropriate, principally it is recommended that the following are adopted:

1. BS EN 15978:2011 – Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method
2. RICS: Whole Life Carbon Assessment for the Built Environment
3. IStructE: How to Calculate Embodied Carbon
4. CIBSE: TM65 Embodied Carbon in Building Services: A calculation methodology.

Early design stages

6.76 Baseline assumptions used for developing the Upfront Carbon Limits, are provided as default values for Tier 1 elements in the *WLC Compliance Tool – Tab 4.0 Carbon Assumptions Table*, and should be used by the Project Team in absence of more accurate information. Further, key assumptions as required for estimation of quantities at early stages are provided in the commentary column of *Tabs 2.0 WLC Reporting, 2.1 OBC – WLC Reporting and 2.2 FBC – WLC Reporting*.

6.77 The overriding principle of the baseline assumptions is consideration of the industry implications of material selection, avoiding manipulation of assessments using best-case assumptions which has negative impacts on an industry level, increasing the likelihood of a performance gap at the Construction stage when procuring these materials may not be possible. Refer to IStructE article 'Seeing the Bigger Picture – Industry emissions, your project, and the performance gap'.

6.78 Using standard factors at early stages also allows designs to be compared against limits, simple comparisons and benchmarking of different healthcare schemes. Departure from these should be avoided without robust reasoning, and it is essential that Carbon Limits are not simply met by making unrealistic best-case assumptions on carbon factors, without considering wider implications.

6.79 The first WLC assessment required to be externally reported for compliance is at OBC stage using *WLC Compliance Tool – Tab 2.0 WLC Reporting*.

Detailed design stages

6.80 As designs develop and material specifications are known, the project may have a greater level of information regarding the sourcing of materials. If project specific data is known it should be used as part of the embodied carbon calculation at this stage, and if not, then assumptions used in early stages should be assessed for suitability and used as required.

6.81 While the designer may specify a product and justifiably use the EPD for carbon calculations, it is common that products are changed in the construction stages owing to commercial reasons, with a possibility that a higher carbon product may be specified than assumed by the designer. Therefore, designers should consider the range of products available on the market and ensure this risk is mitigated through early engagement with the supply chain and representative data used in carbon calculations.

6.82 It is recommended that the following list is used for UK applicable EPDs alongside recommendations providing in the IStructE Guide (referenced above): Environmental Product Declarations (EPD) for UK products - The Alliance for Sustainable Building Products (aspb.org.uk).

6.83 The WLC assessment externally reported for compliance at FBC stage must be completed using *WLC Compliance Tool – Tab 2.1 OBC – WLC Reporting*.

Construction and handover stage

6.84 The as-built information should be used to record and report as-built upfront carbon emissions for all elements in *WLC Compliance Tool – Tab 2.2 FBC – WLC Reporting*. The project Design Team (principally the NZC Coordinator) must maintain responsibility for recording and reporting through the construction stage, working closely with the Contractor and the management team.

6.85 The following checklist should be used for monitoring upfront carbon impacts during the construction stage:

- Review alternative products and material selections proposed by the Contractor against technical and performance standards and against the WLC requirements.
- Resource efficiency, i.e. waste quantity and activity source per material should be recorded.
- Construction process carbon emissions should be recorded for all site activities in a granular way (split by key elements e.g. foundations, retention system, floors, etc.) as provided in subheadings in the WLC Reporting Tab 2.2 FBC – WLC Reporting).
- Confirm that at least 75% of plant and equipment on site is electrically powered.
- Quantify any embodied carbon reduction savings over and above the limit requirements.
- Implement monitoring and regular reporting regime throughout construction process stage of:
  - site transport
  - resource consumption against each building element (superstructure/substructure/façade/internal finishing categories and MEP).
- Carry out benchmark inspections for general quality, construction quality, including in-situ thermal performance tests, thermographic and airtightness testing.
- Stage B and C assumptions must be updated according to supplier specifications.

In-use stage

6.86 The operational and estates team must monitor embodied carbon in-use and update the *WLC Compliance Tool – Tab 2.2 FBC – WLC Reporting* with actual values through the design life. Key lessons must be reported back to NHS England e.g. where significant Stage B emissions are recorded to inform decision-making.

Operational carbon

6.87 The following expectations must be used for carbon factors to calculate and report operational emissions for new buildings within the Energy and Carbon Strategy and for inclusion within WLC assessments. The guidance below reflects different energy sources and appropriate carbon factors.

6.88 Expected operational carbon emissions must be reported under the following expected breakdowns.

- total annual direct CO_2e emissions from self-generation and consumption
- total annual direct CO_2e emissions from combustion of fuels (e.g. CHP or on-site fossil fuels) per fuel type:
  - used for primary energy (i.e. non-backup)
  - used for backup purposes across site (e.g. generators)
- total annual indirect CO_2e emissions from imported electricity
- total annual indirect CO_2e emissions from off-site sources (all other energy sources, e.g. heat networks) per fuel type.

6.89 The carbon emissions must be reported at the expected year of handover, as well as the base year 2020 for comparative purposes (using BEIS's electricity carbon factor of 0.233 $kgCO_2e/kWh$). The carbon emission values reported at the expected year of handover must be based on expected carbon factors, in line with guidance in paragraph 6.92.

6.90 Tab 9.0 Carbon Emissions Factor (in the *OE&C Compliance Tool*) includes a carbon emissions calculation for a period of 60 years which is required to conduct a WLC assessment. The calculation requires input for the energy consumption result per fuel type extracted from the full DSM (energy and carbon modelling employing detailed HVAC). This value is then multiplied by the carbon factors per fuel type for each projected year, starting at the expected handover year. See below for guidance on carbon factors to be used for the calculation of operational carbon.

6.91 The following guidance and expectations must be used for carbon factors to calculate and report operational emissions for new buildings within the Energy and Carbon Strategy. The guidance below reflects different energy sources and therefore appropriate carbon factors.

6.92 These reports will be used to help inform offsetting magnitudes and compare schemes across the programme.

1. **Annual emissions for Building Regulations and handover predications:**

- During design development, Design Teams must use the latest annual CO_2e emissions based on the BEIS GHG reporting factors for Scope 2[10] while clearly stating the year of emissions factors used (they are updated annually). This must be the basis assuming the Trust has REGO contract for electricity, and assuming no additionality. Also, the annual emissions upon handover must also be reported against a baseline year of 2020 using an electricity carbon factor of 0.233 $kgCO_2e/kWh$ for comparative benefit across projects.
- Energy consumption of the building must account for generation on site that has been used to supply the building (e.g. PV, wind etc.) as per Be Green hierarchy. Care must be taken to ensure double counting across the estate does not occur.
- Where renewable energy sources are provided to the building and additionality of this can be demonstrated from off-site renewable energy sources, the carbon factors associated with this source must be used based on expected demand. Clear demonstrations and certificates of this energy source must be provided from the supplier/provider.
- If applicable, where other on-site sources of electricity are used that have higher carbon factors than grid electricity (e.g. CHP) these predicted carbon factors for the year of handover must be used to show representational emissions for the building in operation, used to help inform offsetting magnitudes.

2. **Lifetime predictions:**

- As part of a life cycle assessment and within decarbonisation pathway(s) within the Energy and Carbon Strategy the following carbon factors must be used.
- For grid electricity, as well as REGO based electricity sources that do not demonstrate additionality, the BEIS grid decarbonisation trajectory[11] must be used, starting upon year of handover.
- Alternatively, where renewable energy additionality can be demonstrated, the lifetime carbon factors of this energy source must be used. Clear demonstrations and certificates of this energy source must be provided from the supplier/provider.
- If applicable, where other on-site sources of electricity are used that have higher carbon factors than grid electricity (e.g. CHP) these must be used to show representational emissions for the building in operation.

Meeting the Upfront Carbon Limit

6.93 The *WLC Compliance Tool – Tab 3.0 Upfront Carbon Reporting* provides a summary taken from the WLC assessment to report Upfront Carbon for Tier 1 elements against the Carbon Limit. This tab must be published at the business case stages to demonstrate compliance, with derogations required where the limits are justifiably exceeded. Refer to derogations section below for more information.

10 BEIS Green House gas Reporting: conversation factors for 2020, https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020

11 BEIS trajectory electricity factors, https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal, File: Data tables 1 to 19: supporting the toolkit and the guidance.

6.94 Alongside this, the Project Team must report the modelling checklist and carbon assumptions table in the *WLC Compliance Tool – Tab 4.0 Carbon Assumptions Table*. Further information is provided below.

Modelling checklist

6.95 Material quantities are typically captured in building information modelling (BIM) models, which places a high importance on the quality of modelling to ensure quantities are accurate. It is essential that the project is set up at inception to ensure the quality of modelling is sufficient to enable accurate carbon calculations.

6.96 The modelling checklist included in *WLC Compliance Tool – Tab 4.0 Carbon Assumptions Table* ensures a minimum level of quality assurance on the quantities used for the calculation. This must be used as a minimum standard, in addition to internal processes (e.g. BIM Execution Plans).

6.97 Further, the level of detail of models through the design stages will increase, and therefore the quantities modelled increases. This has the impact of carbon appearing to increase through the design stages, through the expansion of scope of the modelling. To mitigate this risk, the WLC Reporting tabs provide elemental granular breakdowns and commentary to ensure allowances are made at early stages for all elements to mitigate this risk. This is particularly important for Tier 1 elements to ensure limits are met at FBC as well as OBC.

Calculation assumptions

6.98 In developing the Standard, the most important requirement received in the consultation process was that calculations are undertaken in a robust and consistent way. To this end, *WLC Compliance Tool – Tab 4.0 Carbon Assumptions Table* also provides a mechanism to ensure Project Teams report carbon assumptions.

6.99 The carbon assumptions must be stated for all Tier 1 elements as a minimum. Additional reporting of key assumptions for other elements is advised to aid industry knowledge and standardisation of approaches, helping to introduce more elements into Tier 1 when the Standard is revised.

Derogation process

6.100 It is understood that meeting the Upfront Carbon Limits and operational Energy Limits and PTs may not be possible for a small number of valid reasons, and thus a strict derogation process is outlined below to account for these reasons. Beyond the technical reasons specified below, any relevant national operational or strategic considerations will be taken into account as part of the business case process led by the DHSC and NHSE Joint Investment Committee.

Upfront carbon

Early-stage conservatism

6.101 It is accepted that structural designs are conservative in nature at early design stages due to uncertainty and lack of time to rationalise and optimise the design. It is therefore possible that carbon calculations are higher at early stages than later in the design development as optimisation of designs is undertaken.

6.102 Evidence must be provided to support the derogation, e.g. for a steel design the average utilisation of members may be used to demonstrate carbon reduction potential through optimisation.

6.103 The requirement is the following:

✓ **A derogation may be raised if the Upfront Carbon Limit is exceeded due to structural design conservatisms at OBC stage only. Detail must be provided on the approach the Project Team will take to optimise the designs, alongside evidence.**

Ground conditions

6.104 The ground conditions have a significant impact on foundation solutions, and it is unreasonable to expect designers to meet the carbon limit if the foundation system is significantly more carbon intensive than what would be expected of a typical site.

6.105 In the first instance, it is recommended that more extensive optioneering studies to those proposed already in the Standard are undertaken, combining the superstructure and substructure solutions to achieve the lowest carbon outcome. This may best be achieved by minimising the building mass as much as possible to unlock foundation savings.

6.106 Further, derogations may be raised where the Project Team, despite this additional activity, cannot meet the limit due to the carbon intensity of the foundation system.

6.107 The requirement is the following:

✓ **A derogation must be raised with evidence provided to demonstrate the additional optioneering studies of combined superstructure and substructure elements, and clearly showing that the limit is exceeded due to the unavoidable carbon intensity of the substructure.**

Whole life benefits

6.108 There is a clear benefit to using an approach that aims for the lowest WLC solution and striving for this will create the best outcomes. However, future events present significant uncertainty such that adding carbon upfront for perceived whole life benefits carries a risk of those benefits not being realised, leading to increased total emissions.

6.109 Nevertheless, the Standard advocates that where WLC benefits can be demonstrated by the designer, Upfront Carbon Limits may be exceeded.

6.110 The requirement is the following:

✓ **A derogation must be raised with evidence provided to demonstrate that a reduction in whole life emissions justifies exceeding Upfront Carbon Limits, even accounting for uncertainty of future events.**

Circular economy

6.111 Similarly, there is a clear benefit to creating infrastructure that can be re-used in the future to reduce the requirements for new materials. While the general strategy is to increase durability and extension of design life (reducing the need to demolish the building), there may be instances where short term buildings are required and the design life is shorter. In this instance, the focus should shift towards embedding re-useability and circular economy principles into the design. This may require more upfront carbon but can be justified on a circular economy basis (Module D benefits) and therefore is an accepted derogation from the Carbon Limits required in the Standard. Note also, circular economy principles should be prioritised for external car parking facilities linked to the main buildings.

6.112 The requirement is the following:

✓ **A derogation must be raised with evidence provided to demonstrate that circular economy benefits (Module D emissions) justify exceeding Upfront Carbon Limits, even accounting for uncertainty of future events.**

Carbon factor assumptions

6.113 A table of assumptions and recommendations has been included to aid consistent carbon calculations and reporting. This links where possible to current best practice industry guidance. However, it is accepted that as this is a developing area, data will evolve over time, and improvements in our knowledge will improve assumptions and calculations over time.

6.114 To this end, it is accepted that Carbon Limits may not be met if more conservative assumptions are made to those used when developed the limits.

6.115 The requirement is the following:

✓ **A derogation must be raised with evidence provided to demonstrate the additional carbon associated with more conservative assumptions is the cause of the design exceeding the limit.**

Construction Stage changes

6.116 Carbon impacts must be quantified against change orders during the construction period and compiled by the NZC Coordinator. If the result of changes is a net increase, this must be reported as a derogation at handover

6.117 The requirement is the following:

✓ **A derogation must be raised if Client changes during the construction stage result in a net increase in carbon impact.**

Operational carbon

Fabric performance

6.118 A set of fabric PTs capturing external walls, ground and exposed floors, roofs and windows, as well as air permeability, has been determined for primary and secondary care buildings respectively, accounting for the fact that in primary healthcare buildings very high-performance fabric is both reasonably achievable and more impactful on energy efficiency. Both sets of fabric PTs reflect an ambitious level of performance, significantly improved compared to both Building Regulations Part L2A and The Future Buildings Standard consultation, but without being unattainable from current mainstream industry.

6.119 The requirement is the following:

✓ **A derogation must be raised with evidence provided to demonstrate why any fabric element has been specified and/or constructed to a non-compliant fabric performance level. It is expected that a failure to comply could potentially be challenging only in refurbishment projects.**

Energy Limit

6.120 For the following NHS Net Zero Building Standard Space Categories an Energy Limit expressed in kWh/m2 per year has been determined and set for regulated energy: Medium-Tech Type 1, 2, 3, 4, High-Tech Type 1 and 2, Low-Tech Type 1 and 2 and Support Type 2. The regulated Energy Limits are expected to be met for the respective areas identified in the proposed building's schedule of accommodation and the area weighted average regulated Energy Limit for the whole building must not exceed the target value calculated in the tool. Additionally, the DHW Energy Limits and unregulated Energy Limits must be reported. The Energy Limits have been determined assuming efficient electric systems, i.e. air source/ground source heat pumps and chillers.

6.121 The requirement is the following:

✓ **A derogation must be raised with evidence provided to demonstrate why the whole building's regulated Energy Limit, as calculated in the tool, has not been complied with. It is expected that new buildings, served by efficient electric systems such as air/ground source heat pumps and chillers will comply with the regulated Energy Limits calculated for them.**

Building services

6.122 PTs have been determined and set for space heating, space cooling, DHW, ventilation and lighting for the NHS Net Zero Building Standard Space Categories for which Energy Limits have not been determined. The BSPTs are ambitious and detailed HVAC modelling in the DSM is deemed necessary to best model demand and system response. The BSPTs differ between primary and secondary healthcare building types. For heat recovery, different efficiencies are included to account for different system types as required. For AHUs, filtering requirements are addressed where present.

6.123 The requirement is the following:

✓ **A derogation must be raised with evidence provided to demonstrate why any of the BSPTs, as determined in the tool, have not been complied with. The tool highlights any NHS space category where the design/as-built BSPTs are not compliant with the respective value calculated in the tool and prompts for derogation. Any non-compliance at space category level must be captured in the derogation required for non-compliance at whole building level, where that is the case. Specifically, for AHU SFP non-compliance, the derogation must declare:**

1. **Whether the non-compliance is due to HEPA filtering requirements or similar, and the impact on the SFP due to each filter**
2. **Other reason for non-compliance.**

Renewable energy (PV)

6.124 Any on-site or off-site PV array must have an efficiency of at least 19% to ensure they are installed in suitable locations. It is not expected that any benefit of less efficient PV modules will outweigh the carbon intensity of their production, especially when their relatively short lifespan is taken into consideration. A feasibility study must be produced to demonstrate how PV installation can be maximised on the building and on site, to the PTs set.

6.125 The requirement is the following:

✓ **A derogation must be raised with evidence provided to demonstrate why the target efficiency has not been achieved.**

Energy source

6.126 The Energy Limits and BSPTs set out in the Standard have been derived assuming efficient electric systems, i.e., air source/ground source heat pumps and chillers. It is expected that deviation from these parameters will impact on the commitment of the Trust to deliver a building that complies with these set targets. However, it is accepted that in some cases it may not be feasible to deliver in line with Priority 01 of the Heat Sources Hierarchy temporarily or altogether, due to existing infrastructure constraints and local or regional approaches to decarbonisation. In such cases, three derogations must be raised as described below:

6.127 The requirement is the following:

✓ **Three derogations must be raised with evidence provided to demonstrate:**

- **That a decision to align with Priority 02 is expected to deliver benefits to the wider community by enabling the locally identified pathway to decarbonisation**
- **That a decision to align with Priority 03 is feasible within any spare capacity of the existing estate infrastructure, without any requirement for it to be increased and**
- **That a decision to align with Priority 03 can only be supported if there is a clearly identified time frame for the decarbonisation of the existing estate infrastructure, which is in line with the Trust's Green Plan and NHS targets for decarbonisation.**

Metering and monitoring

6.128 The Energy Limits and BSPTs, as well as PV performance, must be verified in use. Appropriate metering and monitoring provision, outlined in the Standard, must be set out and put in place to enable the production of evidence of the building's performance in terms of Energy Limits and BSPTs.

6.129 The requirement is the following:

✓ **A derogation must be raised with evidence provided to demonstrate why compliance with any of the required targets has not been verified in use.**

Broader sustainability considerations

6.130 As summarised within Chapters 1–3, the Standard focuses on NZC; however, it is important that this is considered within the broader reach of sustainability and ensures that designs are not aligned with NZC at the peril of other patient and environmental outcomes.

6.131 It is recognised that a significant amount of existing policy, certification(s) and requirements exist in the industry. The Standard has been developed with these in mind, aiming to align as closely as possible and be mindful of future works that were known at the time of authoring.

6.132 This section of the Standard provides an overview of how broader sustainability considerations should be considered within the design process. This is split into three key components:

1. additional activities and design considerations within the design process
2. alignment with existing expectations and accreditations e.g., BREEAM New Construction
3. alignment and additional activities through The Government Soft Landing (GSL) Framework.

- These existing processes and frameworks should be used to assist the delivery of the outcomes and requirements within the Standard, for example aligning with BREEAM credits methodologies and key activities within the GSL Framework. Figure 12 summarises the key alignments and how these are likely to be mutually beneficial.
- Internationally, there has been more case studies demonstrating the benefits of sustainable and healthy design, such as the one below.

Case Study - Khoo Teck Puat Hospital:

The Khoo Teck Puat Hospital in Singapore is the winner of the first-ever Stephen R. Kellert Biophilic Design Award.

Incorporates biophilic elements into the hospital design for better patient experience. Designed around utilising natural ventilation and lighting.

Additional activities and wider considerations

6.133 As part of the broader sustainability requirements for a scheme the following should be embedded into any project requirements and process to achieve holistic sustainability and mitigate unintended consequences:

- user health and wellbeing:
  - thermal comfort
  - light and views, including natural light
  - air quality
  - acoustics – interior acoustics and noise pollution reduction; and
  - impact of fire
- biodiversity and green space/landscape
- active travel and sustainable transportation
- water management, consumption, resilience, and quality:
  - flood and surface water management and resilience
  - efficient indoor water consumption and use reduction, via monitoring, quality management, efficient equipment, and leakage detection
- waste:
  - construction waste management and diversion from landfill
  - operational waste and recycling.

6.134 Generally, the elements above should be considered at the earliest opportunity within the design and business case process, appraising a site for its various opportunities and constraints. It is acknowledged that these elements are related to design generally rather than carbon specifically but to achieve low carbon outcomes whilst improving health outcomes it is important to holistically apply this thinking to all aspects of the project. Assessments and modelling should then form the basis of design development, giving numerical feedback on performance across these aspects of performance, or at minimum how options have been appraised.

6.135 Quality monitoring and commissioning should also look to verify these aspects of performance where applicable, to integrate with the broader sustainability strategy for the building and help inform lessons learnt across the programme.

6.136 High-level guidance is provided for additional considerations below, noting that a significant set of requirements exist within BREEAM, HTMs and other policies or sources of best practice, so the Standard does not replicate this information.

Thermal comfort

6.137 As discussed in Section 5, thermal comfort must be carefully considered due to the potential for overheating from highly serviced and occupied spaces. Also, under climate change scenarios, it is likely that there will be an increased requirement for passive cooling. Where possible, mechanical cooling should be minimised (reduced) as far as possible to meet thermal comfort criteria, as well as reduce energy demands.

6.138 Passive approaches must be used to help mitigate this, to reduce overheating, such as building form, shading, orientation, and natural ventilation pathway analysis should be undertaken at early stages to inform design. Façade optimisation should also be used to maximise performance across various parameters.

6.139 Within technical design, thermal controls and sensors are critical items alongside operational training and management routines to help ensure that the building operates as designed, reduce energy demands and ensure thermal comfort, see HTM 03-01 for more information as well as the following documents.

Signpost:

CIBSE AM11 – Building Energy and Performance Modelling, considering an appropriate CIBSE Future Climate Weather Scenario file.

CIBSE TM52: The Limits of Thermal Comfort: Avoiding Overheating in European Buildings

CIBSE TM59 - Modelling and Analysis Guide (in residential buildings)

Lighting and views

6.140 As discussed in Section 5, natural light is another critical aspect that significantly impacts the health and wellbeing of occupants within spaces. However, it is a key area within the design and must be considered alongside energy efficiency and thermal comfort.

6.141 BREEAM and WELL Building Standard requirements may not be most applicable for healthcare facilities due to the characteristics of the spaces as well as clinical adjacency requirements, therefore it should be up to the Design and Client Teams to decide on the best metrics for the space that they are designing and how this may vary across the schedule of accommodation. Design should optimise and validate performance against these various aspects of natural light; visual comfort, glare control, daylighting, internal and external lighting levels, zoning and control and views out.

Adaptability and resilience

6.142 An Adaptability Strategy is a core deliverable as part of the design strategy and must be produced alongside the Estate Management Team where applicable to establish appropriate elements of the design to embed adaptability and flexibility.

6.143 Sensitivity of design for changing climatic factors should also be assessed, including increased rainfall and flood risk, surface run-off and increased wind speeds to ensure that this does not have an impact on the resilience of the facility where it is critical.

Air quality

6.144 These requirements are additional to those already prevalent within healthcare design regarding infection control.

6.145 Air quality should be assessed and its short and longer-term impacts on the design reviewed for patient wellbeing. For example, city centre air quality may not be a long-term issue due to the decarbonisation of transportation.

6.146 Factors that impact internal air quality through operation, such as sources of volatile organic compounds (VOCs) should also be assessed in context of building energy, especially for staff that may be exposed for much longer periods than patients or visitors. This includes but is not limited to; cleaning products, materials and medical products/ procedures and medical gases.

6.147 CO_2 limits through occupancy of spaces should also be monitored, as this can directly impact occupant wellbeing; a target of minimising CO_2 levels to <900 CO_2 ppm is a benchmark for best practice across the built environment.

Alignment with BREEAM

6.148 BREEAM New Construction is an existing set of requirements and methodologies to deliver more sustainable buildings. Numerous of the credit areas and methodologies should be complimentary for reducing the carbon and energy intensity of a building. For all major new buildings, achieving BREEAM Excellent is a mandatory requirement alongside this Standard as well as BREEAM Very Good for refurbishment projects.

6.149 The following credits are likely to be achieved fully or partially achieved through compliance with this Standard, but additional work may be required and should be checked with the BREEAM advisor:

BREEAM credit	Compliance
MAN03	Via programme of physical testing of fabric integrity/ plant operational tests to ensure responsible construction practices requirements. Whenever possible, ensure the appointment of a clerk of works that is responsible for quality checks.
MAN04	Through planning of targeted commissioning activities and provision of controls operating descriptions for all engineering systems and an updated plan for commissioning, training, and handover. Additionally, creation of risk register and confirm responsibility for managing Contractor prelims during construction and commissioning.
MAN05	Via provision of an update of what will be required for aftercare and the scope of the engagement required from all parties, as well as provide an updated plan for removal and replacement of plant.
HEA01	Dynamic simulation models (DSM) used to ensure Visual Comfort, Glare Control, Daylighting, Internal and external lighting levels – Zoning and Control and View Out guidelines are met.
HEA02	Via an Indoor Environmental Quality Report that ensures indoor air quality, IAQ Plan and Ventilation guidelines are met. Development of a materials tracker to identify compliance of wet applied products, furniture, architectural and interior products with HEA02 requirements, alongside Emissions from Construction Products.
HEA04	Achieved through use of DSM model outputs showing agreed operational parameters, and specification of thermal comfort controls within the design.
ENE01	Via the reduction of energy demands and provision of renewable generation on site.
ENE02	Via the monitoring of energy usage.

BREEAM credit	Compliance
ENE04	Achieved through minimising operational carbon at the design stage.
ENE05–08	Credits met through energy efficiency in cold storage, transportation and laboratory systems, and equipment requirements.
MAT01	Largely achieved through requirements for optimisation of embodied carbon.
MAT02	Construction products are specified to have EPDs, achieving a total EPD points score of at least 20.
MAT03	Construction products responsibly sourced.
MAT05	Achieved through conducting physical testing to check whether resilience and durability measures have been incorporated into the building.
WST01	Achieved via whole Project Team effort for reduction of waste at the design stage and during construction activities.
WST05	Met through conducting a climate change adaptation strategy appraisal updates during and providing updates during Technical Design demonstrating how the recommendations or solutions proposed at Concept Design have been implemented where practical and cost effective.
POL01	Achieved through compliance with refrigerants requirements, using system specified with a Direct Effect Lifecycle CO_2 (DELC) of ≤750 $kgCO_2e/kW$.

Alignment to Government Soft Landings

6.150 The GSL Framework is not a mandatory process for all projects that the Standard is applicable to, but it can be very helpful to deliver the outcomes of the Standard. The GSL covers the following components:

- soft landings
- enhanced commissioning
- performance validation
- Post Occupancy Evaluation (POE).

6.151 The benefits and purpose of implementing this framework are to assist with seamless operational start up, reduce the performance gap, reduce operational costs, and help support the training and development of the building operators, as well as capture building performance and user satisfaction/feedback.

Rule of Thumb:

Many case studies can be seen where the success of the building is typically dependent on the management and operational practices rather than the technology within it. Therefore ensuring that the building operators know the importance and practicalities of the various building systems is essential for ensuring buildings operate with as low an operational energy demand as possible.

6.152 Early planning for a successful handover and operation is essential. Therefore, the requirements start the considerations for soft landings and system commissioning at RIBA Stage 2 including identification of a Soft Landings Champion who is responsible for integrating GSL as part of the project lifecycle.

6.153 It is expected that the typical GSL process is used throughout the RIBA stages, and project stage processes. Reporting and deliverables are to be in line with the GSL Standard Framework. However, as part of this process, GSL should also be used to help identify project bespoke measures, systems and plans based on the project brief and other aspects of the estate and operations.

6.154 The NZC Coordinator and Soft Landings Champion should work closely with their collaboration being mutually beneficial. For example, Soft Landings Champions should have the following responsibilities throughout the RIBA stages:

1. Represent the needs of the users, occupiers, visitors, and facilities managers.
2. Actively engage with the users to ensure their needs are input into all stages of the project.
3. Actively engage with the Project Team to ensure these needs are considered at all stages of the brief, design, construction, handover and in-use support.
4. Ensure communication with the Client regarding design decisions.
5. Support the Project Manager in developing and implementing the Aftercare Plan and POE studies.
6. Design Commissioning Plan to support the design, construction, and eventual operation of a project that meets the project requirements for energy, water, indoor environmental quality, and durability, as well as best practice access provision for operation and maintenance.
7. Prepare a schedule of commissioning and testing in accordance with current Building Regulations, BSRIA and CIBSE guidelines and other best practice standards as appropriate.
8. Demonstrate how any operating constraints have been advised to the planning authority and operators/owners.

Soft landings, POE and aftercare

6.155 As part of the GSL, there are further and more extensive requirements for training and aftercare for building users and formal POE. These are recommended activities that typically should form part of this process.

- Training and aftercare as part of soft landings, covering management and maintenance strategies:
  - Ensure building users are trained and understand all building systems.
  - Soft opening and testing as part of POE process.
  - The Trust’s Energy Manager especially should be trained in using BMS and reporting systems.
- Confirm the performance of the facility is monitored and evaluated via the POE methodology for the extended aftercare period.

- BIM models and information should be transferred to the Estates Teams to assist with ongoing operation and maintenance.
- Organise an annual POE for the first three years of occupation (optional alignment with BREEAM requirements).
- Confirm lessons learnt are captured with any feedback from operational stakeholders.

Annex 1 – Glossary

Term	Abbreviation	Definition
Additionality (renewable energy)		That is, the extent to which something happens as a result of an intervention that would not have occurred in its absence.
Air Source Heat Pump	ASHP	A low carbon heating solution that absorbs heat from the outside air to heat space and/or water. A liquid is used to transfer the heat, and as heat outputs are greater than electricity inputs, they provide a low carbon heating solution.
Department for Business, Energy and Industrial Strategy	BEIS	This is the UK Government's Department for Business, Energy and Industrial Strategy.
Be Lean		The first stage of the energy hierarchy, focusing on reducing energy demands within the building.
Be Clean		The second stage of the energy hierarchy, achieving efficient supply of energy and heating to the site, using local resources (such as waste heat).
Be Green		The third stage of the energy hierarchy, using renewable energy sources that prioritise energy generation close to point of use e.g. on-site renewable energy generation.
Be Seen		Referring to the understanding and visibility of actual operational energy performance. This requires monitoring and reporting of the actual operational energy performance after construction.
Biomass/ bioenergy		"Biomass" is material of biological origin excluding material embedded in geological and/or fossilised formations, with bioenergy being the energy produced by living organisms.
Building elements		Building elements are the basic elements which make up a building e.g. foundations, roof, walls and columns.
Building management systems	BMS	This is an IT system that operates a building and can be responsible for monitoring and optimising its subsystems.
Building Research Establishment Environmental Assessment Methodology	BREEAM	A method of assessing, rating, and certifying the sustainability of buildings. It focuses on: Energy, Land use and ecology, Water, Health and wellbeing, Pollution, Transport, Materials, Waste and Management.

Term	Abbreviation	Definition
Carbon		Total carbon dioxide equivalent (CO_2e).
Circular Economy		The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products if possible, rather than a traditional linear model of materials going to waste.
Carbon capture, utilisation, and storage	CCUS	This is a process of capturing carbon dioxide before it enters the atmosphere, transporting it and storing it (carbon sequestration) ready for reuse
Carbon factor		The carbon factor is the amount of equivalent carbon dioxide (CO_2e) released per kilowatt hour of electricity (generated and distributed) and can be related both to the energy used directly by NHS trusts (scope 1 & 2 carbon), and to the energy used to manufacture and transport construction materials (scope 3 carbon).
Carbon sequestration		Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. A fundamental element of achieving net zero carbon emissions.
Chartered Institution of Building Services Engineers	CIBSE	An international professional association and global network of building services engineers that provides support and guidance to engineers. It works to set the standards for best practice and drives internationally recognised Guidance and Codes for the industry. It is a full member of the Construction Industry Council and licenced by the Engineering Council.
"Clean" energy		Clean energy is energy that comes from renewable, zero operational emission sources that do not pollute the atmosphere when used.
Climate Change Conference of Parties	COP	The United Nations supreme decision-making body of the convention on climate change to.
Construction, Design and Management	CDM	The primary set of UK regulations for managing the health, safety and welfare of construction projects.
Direct Effect Lifecycle CO_2e or Global Warming Potential	DELC or GWP	A measure of the effect of global warming arising from emissions of refrigerant gases from the equipment to the atmosphere over its lifetime (units: $kgCO_2e$).
Domestic hot water	DHW	Water used, in any type of building, for domestic purposes, including hand washing sanitation and personal hygiene
Embodied Carbon		The total amount of CO_2e emitted associated with the materials, production and construction processes throughout the whole life cycle of an asset (Modules A1–A5, B1–B5, C1–C4).
Energy Modelling		Energy Modelling is a specialist activity that forecasts the operational energy use of a building based upon its design and an understanding of how the building is intended to be used. It applies dynamic simulation and detailed heating, ventilation and air conditioning (HVAC) analysis to determine the impact of both internal and external influences upon the indoor environment and the energy consumed by systems to meet control set-points.

Term	Abbreviation	Definition
Energy hierarchy		The energy hierarchy was produced by the Greater London Authority to inform the design, construction and operation of new buildings, with stage one being of highest priority, and four the least.
Estates Return Information Collection	ERIC	A mandatory central data collection for estates and facilities services from the NHS in England.
Energy use intensity	EUI	The Energy Use Intensity (EUI) is a measure of the total energy consumed (kWh) in a building per floor area (m^2). It includes all of the energy consumed in the building, such as regulated energy and unregulated energy (expressed as kWh/m^2). The total amount of energy consumed (kwh) in a building per floor area (m^2) excluding on-site renewable energy generated (expressed as kWh/m2 (where is the – for renewable energy generation/year).
Greater London Authority	GLA	The GLA is the devolved regional government body of the London region.
Ground Source Heat Pump	GSHP	A low carbon heating system which transfers heat from the ground to heat space and/or water. A liquid is circulated between the ground and the heating system to transfer the heat, resulting in a low carbon emission heating technology.
Heat networks/ district heating		A heat network – sometimes called district heating when having a much greater range – is a piped distribution system that takes heat from a central source or number of distributed sources and delivers it to a variety of buildings.
Heating, ventilation, and air conditioning	HVAC	Heating, ventilation, and air conditioning systems control the temperature and ventilation within a space.
Kyoto Protocol		The Kyoto Protocol was an international treaty which extended the 1992 United Nations Framework Convention on Climate Change that commits state parties to reduce greenhouse gas emissions, based on the scientific consensus that global warming is occurring and that human-made CO_2 emissions are driving it.
Internal air quality		Internal air quality describes how polluted the air people breathe is in an internal space. When air quality is poor, pollutants in the air may be hazardous or impact wellbeing of building occupants.
London Energy Transformation Initiative	LETI	A self-governing network of built environment professionals from across the industry, voluntarily working together to drive the industry regarding action on climate change.
Lifecycle		This includes all the stages of a product's life from raw material extraction through to end-of-life disposal or recycling.
Lifecycle Assessment	LCA	A technique to assess environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling.
Limit		The total allowable value, in this instance related to energy and carbon.
Mechanical Ventilation with Heat Recovery	MVHR	Systems that mechanically ventilate a space and provide heating and/ or cooling by reusing energy from incoming air.

Term	Abbreviation	Definition
Modern Methods of Construction	MMC	Is a methodology to evolve construction from traditional ways of working to those that increase value across the supply chain.
Module A, B, C, D emissions		These are emissions which are produced during the lifecycle of a product or building.
Net zero carbon	NZC	All carbon emissions are reduced in line with the Paris Agreement 1.5°C trajectory, with residual emissions offset through carbon removals or avoided emissions.
Net Zero Operational Carbon		Net Zero Operational Carbon is achieved when the total amount of carbon and other greenhouse gas (GHG) emissions associated with the building's operational energy [on an annual basis] is zero.
Operational carbon – Energy		"Operational Carbon – Energy" (Module B6) are the GHG emissions arising from all energy consumed by an asset in-use, over its life cycle.
Operational carbon – Water		"Operational Carbon – Water" (Module B7) are those GHG emissions arising from water supply and wastewater treatment for an asset in-use, over its life cycle.
Operational Energy Limits		This Standard includes operational Energy Limits in the energy usage intensities, expressed in kWh/m^2 of gross internal floor area per year that covers all energy use of the building (typically supplied through its fiscal meters), including loads currently unregulated by Building Standards.
Offsetting		Offsetting means emission reductions or removals achieved by one entity can be used to compensate (offset) emissions from another entity.
Performance Target	PT	The required performance level for specific building elements and systems, that are required to achieve energy and/or Carbon Limits. This includes envelope, energy efficiency, heating, lighting, ventilation and cooling systems.
Photovoltaics	PV	The direct conversion of light into electricity usually via photovoltaic panels or cells (commonly referred to as solar panels).
Post-occupancy evaluation	POE	Post-Occupancy Evaluation is the process of obtaining and reviewing feedback from a buildings user(s) on a building's performance during operation.
RACI matrix		A responsibility assignment matrix, also known as RACI matrix, describes the participation of various parties and roles in completing tasks or deliverables or parts of a process. A matrix showing those that have responsibility, accountability, must be consulted and informed (RACI).
Refurbishment		The definition of "refurbishment" encompasses a wide range of works to improve the performance, function and overall condition of an existing building or asset.
Renewable Energy Guarantee of Origin	REGO	A certification scheme that provides transparency to consumers about the proportion of purchased electricity that suppliers source from renewable energy generation.

Term	Abbreviation	Definition
Regulated energy		Building energy consumption resulting from the specified design of controlled, fixed building services and fittings, e.g. space heating, cooling, hot water, pumps, fans and lighting.
Renewable energy		Renewable energy is the term used to describe energy that occurs naturally and continuously in the environment, such as energy from the sun, wind, waves or tides.
Royal Institution of Chartered Surveyors	RICS	A professional body promoting and enforcing the highest international standards in the valuation, management and development of land, real estate, construction and infrastructure.
Seasonal Coefficient of Performance	SCOP	A measure of energy efficiency as an asset across a 12-consecutive-month period (as efficiency varies seasonally). The annual useful heat output is measured and divided by total electrical input.
Seasonal Energy Efficiency Ratio	SEER	The annual average of the output of cooling energy compared with the electrical energy input.
Scope 1, 2, 3 emissions		Scope 1: Direct emissions from owned or controlled sources Scope 2: Indirect emissions from the generation of purchased energy Scope 3: All other indirect emissions that occur in an organisation's value chain Emissions from all scopes are measured in CO_2e.
Space-types		Common areas within a healthcare building that undertake the same healthcare activity e.g., laboratories or operating theatres.
Space-type technology category		Space-type technology groups can be further broken down into categories based on defined building performance parameters – there are seven clinical and five non-clinical Space-Type Technology Categories. E.g. Medium Tech Type 1.
Space-type technology group		A healthcare building's space-types can be grouped by technology level (low, medium, high, ultra-high or support) based on common performance parameters.
Technology Readiness Level	TRL	Technology Readiness Levels is a method used to assess the maturity level of a particular technology.
Thermal gain		Thermal gain refers to heat energy absorbed from an outside source resulting in a warming of a particular space. Internal heat gains, can also be generated from of equipment loads and occupation of spaces.
Thermal Mass		Thermal mass is the ability of a material to absorb, store and release heat. This is typically achieved through its ability to absorb unwanted heat during the day and then release it at night.
Tiers		The Standard has defined different "tiers" of building components which have different guidance and reporting requirements. Tier 1 components have: industry assessment methodology and relative maturity, robust sources of available data to inform carbon assessments and inform existing benchmarking. Tier 2 materials have not been given defined Carbon Limits due to a current lack of available data and maturity in use of calculation methodologies.
Traded emissions		The emissions that can be traded between countries, and their industries, to cover exceeding their permitted emissions under the Kyoto Protocol.

Term	Abbreviation	Definition
Unregulated energy		Unregulated energy loads are those energy demands from non-fixed building services and systems, also commonly known as equipment, process and plug loads.
Upfront carbon		“Upfront carbon” emissions are the emissions associated with materials and construction processes up to practical completion (Modules A1–A5). Upfront carbon excludes the biogenic carbon sequestered in the installed products at practical completion. This definition should be used when reporting the embodied carbon up to practical completion.
Variable air volume	VAV	Variable air volume systems, supply constant temperature air to an area while the volume of air varies as opposed to a conventional HVAC system which has constant volume and varies the air temperature.
Waste heat		The unused, excess heat produced by a process. This can be used as a resource when captured and reused for an alternative function.
WELL Building Standard	WELL	The WELL Building Standard is a performance-based system for measuring, certifying, and monitoring features of the built environment that impact human health and wellbeing, through air, water, nourishment, light, fitness, comfort, and mind.
Whole life carbon	WLC	The total sum of carbon emissions and related GHG emissions for all assets and removals, both operational and embodied over the lifecycle of an asset including its disposal (Modules: A1–A5 Upfront; B1–B7 In Use; C1–C4 End of Life). Overall Whole Life Carbon asset performance includes separately reporting the potential benefit from future energy recovery, reuse, and recycling (Module D).

Annex 2 – Supporting documents from industry

- Built Environment Carbon Database
- Delivering a 'Net Zero' National Health Service (October 2020).
- BEIS Industrial Decarbonisation Strategy (March 2021).
- CLC Guidance Document for PAS 2080 (2016).
- Government Energy White Paper - Powering our net zero future (December 2020).
- Greater London Assembly (GLA) Whole Lifecycle Carbon Assessments Guidance (2022).
- International Cost Management Standard (ICMS), Third Edition (November 2021.
- IPA work on WLC's, Gov's strategy for NZC Estate (2021).
- LETI Embodied Carbon Primer (January 2020).
- LETI Whole Life Carbon one-pager.
- LETI Embodied Carbon one-pager.
- LETI Embodied Carbon target alignment.
- LETI Carbon Definitions for the Built Environment, Buildings & Infrastructure (2021).
- LETI Climate Emergency Retrofit Guide (2021).
- LETI Client Guide (2021).
- National Grid Future Energy Scenarios (2021).
- NHS Client Brief on Net Zero (forthcoming).
- NHS Estates and Facilities Net Zero Delivery Plan (2021).
- NHS Health Technical Memoranda (HTMs) and Health Building Notes (HBNs).
- PAS 2060, Carbon neutrality (2014).
- PAS 2080, Carbon management in infrastructure (2016).
- RIBA 2030 Climate Challenge (2021).
- RIBA Embodied and whole life carbon assessment for architects (2019).

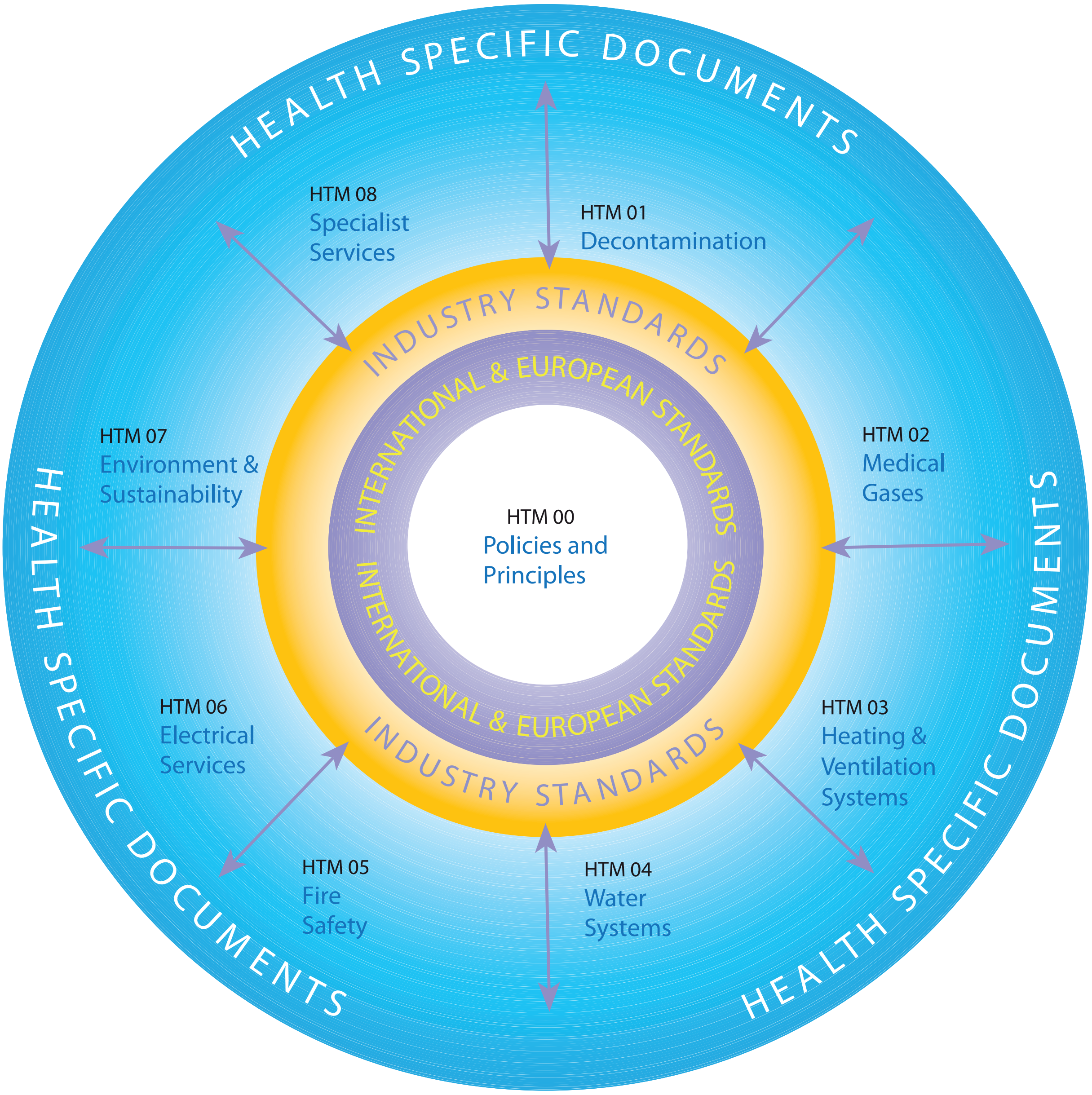
- RIBA Plan of Work (2020).
- RIBA Sustainable Outcomes Guide (2019).
- RIBA Plan for Use Guide (2021).
- RICS Whole Life Carbon Assessment for the Built Environment, Professional Statement (2017).
- CIBSE TM65: Embodied carbon in building services: A calculation methodology (2021).
- UK Governments Policies for the Sixth Budget and Net Zero, and the International Energy Agency's (IEA) Energy Technology Perspectives (2020).
- UK Green Building Council (UKGBC) Built Environment Whole Life Roadmap (2021).
- UKGBC Embodied carbon: developing a Client brief (2017).
- UKGBC Circular Economy Guidance for Construction Clients: how to practically apply circular economy principles at the project brief stage (2019).
- UKGBC Renewable Energy Procurement and Carbon Offsetting Guidance for Net Zero Carbon Buildings (2021).
- Procurement Policy Note – Taking Account of Social Value in the Award of Central Government Contracts (2020).
- The Social Value Model (2020).

There are also numerous forthcoming guidance, policy and process updates across the NHS, as well as across the broader built environment, that will affect components of this Standard. Those known about and expected to be significant are the following:

- NHS Estates Net Zero Capital Planning Tool (expected 2022).
- Changes as part of the Future Building Standard, including non-domestic Building Regulations Part L modelling and compliance (BRUKL).
- Guidance and best practice form the Construction Innovation Hub and other working parties within and in partnership with Government.
- Reporting requirements to align to the Green Book for Business Case preparation and submission.
- Updates to BREEAM New Construction 2018.
- BEIS Performance-based policy framework in large commercial and industrial buildings, proposed start date for phase 1 is April 2022, it is suggested other sectors of the non-domestic sector adopt this framework.

This Standard is not intended to deviate from the requirements set out within the NHS' Health Technical Memoranda (HTMs) and Healthcare Building Notes (HBNs). It has been written in order to comply with these, ensuring the drive for a net zero carbon future is addressed. It should be noted that the energy modelling undertaken to support the development of this Standard was compliant to the latest HTMs, including HTM-03. HTMs, as mapped below in Figure 29, and HBNs are undergoing frequent updates as part of a national programme and some of the methodology and content within them will change to reflect NHS ambitions for net zero estate.

Figure 29 Mapping of HTMs



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