Net Zero Design Standard

Building blocks of net zero design

The Net Zero Design Standard is critical to accelerate our transition to net zero across our housing, corporate and investment portfolios and realise our resilience goals.

Document Functionality

This document is designed as an interactive PDF to enhance the user experience. Throughout the document the reader is offered hyperlinks to relevant sections to enable a more seamless enriched experience and quickly find what they are looking for. It uses infographics throughout to minimise the need for text and gives an easy-to-understand overview of a topic. The document addresses accessibility requirements where possible. Please note that the table size is small and requires users to zoom in to see. Further guidance on functionality and the relevant symbols are presented on the right.

Click this symbol anywhere in the document to go to Chapter Summaries page with links to other parts of the document.

This symbol denotes text hyperlinks to relevant sections in the document

Use this symbol to go to the Interactive User Guide for Design Standards

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// Building Blocks for Net Zero

01. Why Climate Action, Why Now?

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A foreword from the City of London Corporations' (CoLC) Climate Action Programme Director outlining why the Design Standard has been developed.

The City of London Corporation has adopted a radical Climate Action Strategy, which breaks new ground and sets out how the organisation will achieve net zero, build climate resilience and champion sustainable growth, both in the UK and globally, over the next two decades.

Buildings and Infrastructure are responsible for 25% of the UK's greenhouse gas emissions. Therefore, how they design, refurbish, and develop new buildings is critical to delivering on the net zero and resilience goals. By introducing the Net Zero Design Standard, they intend to accelerate this transition across their housing, corporate and investment portfolios. The new Standard will complement the Housing Design standards, and the to be developed, Sustainability Supplementary Planning Guidance for the Square Mile and beyond.

This document sets out the Design Standard we have developed. The Standard looks across the whole life cycle of the development process and targets a longer-term focus on both cost and natural resource use efficiency. The Standard will provide designers and developers with consistency in the definition of good practice and greater clarity on the delivery of environmentally sound and cost-efficient buildings, facilities, and overall high sustainability performance across the asset life cycle.

Grace Rawnsley
Climate Action Programme Director

02. Introduction

> This chapter introduces the Climate Action Strategy (CAS), along with the CoLC's commitments and the part the whole organisation will play in achieving these.

INTRODUCTION

London is a world leader in climate action, the City of London Corporation (CoLC) are proud to have developed a radical Climate Action Strategy (CAS), which breaks new ground and sets out how they will embed climate action in everything that they do and work within the latest standards and advice. The CAS targets for the CoLC form the basis of these Design Standards, the implementation of these robust design standards across all property groups will be an essential mechanism to ensure that all works support the achievement of CAS targets. The Vision, Aims and Goals are:

Through the Climate Action Strategy, CoLC commits to achieving:

- Net zero by 2027 in CoLC's operations
- Net zero by 2040 across the CoLC's full value chain
- Net zero by 2040 in the Square Mile
- Climate resilience in buildings & public spaces

In the context of climate action, the City of London will support the achievement of net zero, build climate resilience and champion sustainable growth to create a truly sustainable City. This will be achieved via numerous commitments within their Corporate Plan 2018-23, which will drive their performance. The actions reflect ongoing work in supporting innovation and growth in the financial and professional services sector and relate to the first six years of the strategy. The strategy and action plan will then be refreshed for the next phase of implementation to achieve the City of London's 2040 goals.

Everyone within the Organisation and wider value chain has an important part to play in making this vision a reality. The organisation therefore recognises the scale of the challenge and the urgent need to realise sustainable outcomes that will assist the communities in thriving.

Our Vision

The City of London is **Responsible, Sustainable** and **Competitive**

Our aims

- To **support** the **achievement** of **net zero**
- To **build climate resilience**
- To champion **sustainable growth**

Our goals

For the City of London Corporation

City of London Corporation **scope 1 and 2 emissions are net zero by 2027** and **scope 3 emissions are net zero by 2040.**

The City of London Corporation and its assets **are resilient to climate change.**

The City of London Corporation supports UK and overseas organisations to **become climate responsible.**

For the Square Mile's fabric and function

The Square Mile's scope 1, 2 and 3 emissions (BASIC+ definition) **are net zero by 2040.**

The Square Mile's buildings, public spaces and infrastructure **are resilient to climate change.**

For society

People in the Square Mile and beyond **benefit from a clean, green and safe environment** and **job creation.**

SCOPE

This Design Standard (herein called 'the Standard') provides CoLC Project Managers (PM), Project Delivery Teams, Designers and other Stakeholders with consistent sustainability and resilience guidelines and expectations at all stages of future and new build developments and major refurbishments for CoLC's operational and investment portfolio.

Application of this Standard will mitigate risks of underperforming buildings and support CoLC to embed net zero requirements across new construction, planned refurbishments and/or replacing plant and systems at end of life – this will help ensure they are all 'net zero ready'. For the purpose of this Standard the definition of Net Zero is ensuring that both emissions from construction and operation are balanced by removal out of the atmosphere *(UKGBC, Net Zero Carbon buildings: A framework definition, April 2019).*

To focus their approach and ensure the developments are aligned to the City of London's Vision, they have introduced a set of outcomes which have underpinned the development of this Standard.

To ensure the outcomes are achieved, the Standard includes sustainability requirements, within six Design Standard Categories (Whole Life Carbon, Circular Economy, Materials, Resilience, Wellbeing, and Post Occupancy Evaluation (POE)), for integration at all stages of the asset lifecycle across CoLC's operational and investment portfolio. More information on the Design Standard Categories is found in the next section of this standard.

From a management perspective the asset lifecycle encompasses every stage from first identifying a need for the asset (new build or refurbishment) through to disposing of the asset once it has reached end of life. CoLC staff should also note that for planned stock changes, CoLC staff must check whether there are any initial targets in place, noting that any planned stock changes need to perform to contribute to the CoLC 2027 net zero targets as well. The four stages of an asset's life cycle are defined as follows for this Standard:

- **Planning and Procurement:** Establishing the requirements of an asset, based on the evaluation of existing assets, managing Capex and procurement, and acquiring the right goods and services. By aligning with the RIBA Stages, the Standard will inform PMs of the relevant requirements at each of the early life cycle stages and support them in informing the design to reach net zero and improve the asset. PMs should also make use of the CoLC Procurement Code and the Responsible Procurement Policy.

The POE category will also provide teams with lessons learnt for future projects.

- **Operation / In use:** Reviewing the performance of the building in operation against the design and acquisition decisions. Carrying out upgrades, repairs, compliance audits, and cost analysis based on the asset performance reviews. (The Whole Life Carbon and Wellbeing categories allow PMs to look at ways of improving working and living environments as well as enabling building to become more efficient in operation).

- **Maintenance (including improvement works):** Activities that help optimise the performance and extend the asset's lifespan, including servicing, repair and addressing critical failures (several categories including Materials and Resilience will inform PMs on relevant criteria required here, as well as signposting the Technology Standard where key technologies are discussed). See ➲**Appendix 1.**

- **Disposal / Decommissioning:** Effectively monitoring and controlling 'end-of-life' process when the asset needs to be disposed of, re-purposed, or recycled in line with the Circular Economy Principles. (The Standard details Circular Economy requirements enabling PMs to make informed decisions about the individual assets).

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03. Interactive User Guide & Structure

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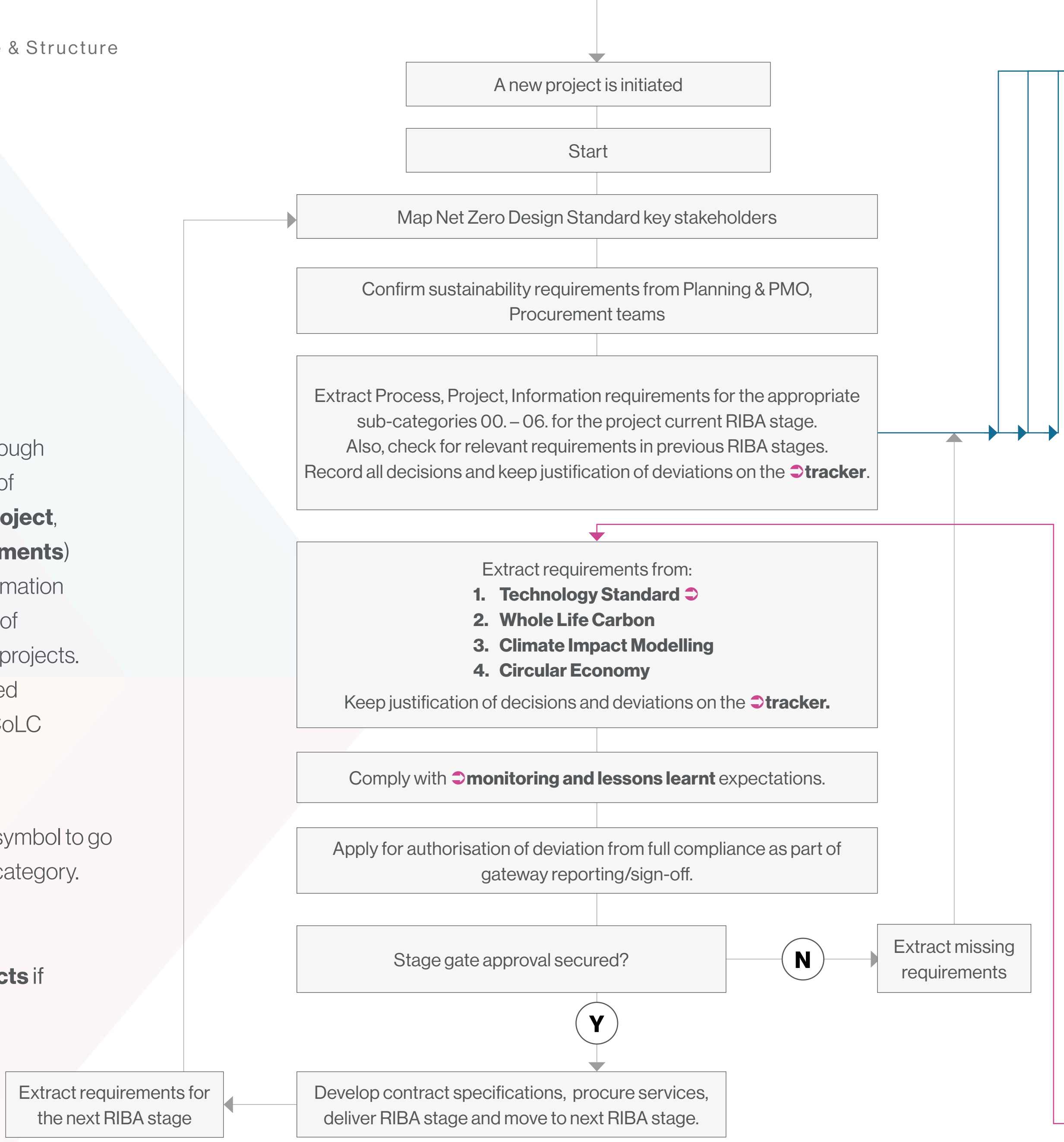
This chapter provides users with an interactive user guide to navigate around the Standard. Hyperlinks takes users to the key requirements which make up the main body of the document. It outlines the six main categories and sub-categories and the key sources that have been utilised to create the Standard.

The Interactive User Guide allows users to navigate through this Standard to find tables of requirements (**Process**, **Project**, and **Information Requirements**) which contain detailed information that will support integration of sustainability requirements projects. The requirements are aligned with the RIBA Stages and CoLC Gateways (Figure 1).

■ ● ◆ Click the relevant symbol to go into required sub-category.

Go to the **Useful contacts** if you have specific queries.



	PROCESS	PROJECT	INFORMATION
00. ACCREDITATION			
Sustainability rating	■	●	◆
01. WHOLE LIFE CARBON			
Whole life cycle carbon	■	●	◆
Embodied carbon Resource efficiency	■	●	◆
Operational carbon / energy	■	●	◆
LZC technologies	■	●	◆
Carbon reduction	■	●	◆
Energy Efficiency	■	●	◆
Minimise Pollution	■	●	◆
Minimise Carbon	■	●	◆
02. CIRCULAR ECONOMY			
Decommissioning	■	●	◆
Circular economy	■	●	◆
Resource efficiency	■	●	◆
03. MATERIALS			
Low impact materials	■	●	◆
Procurement of materials	■	●	◆
Material durability	■	●	◆
Modern methods of construction	■	●	◆
04. RESILIENCE			
Climate change adaptation	■	●	◆
Biodiversity, ecology, conservation	■	●	◆
Flood resilience	■	●	◆
Local air quality	■	●	◆
Passive design	■	●	◆
05. WELLBEING			
Community centric approach	■	●	◆
WELL type requirements	■	●	◆
Resource efficiency	■	●	◆
06. POST OCCUPANCY EVALUATION			
Energy and Water Monitoring	■	●	◆

The specific requirements for each Design Standard Category are presented in three tables throughout this document, as follows:

Process Requirements: defines key decision points aligned to RIBA stages and apply to a range of key stakeholders.

Project Requirements: includes information for each sustainability category to be reviewed and applied as applicable.

Information Requirements: details what needs to be recorded to evidence how the requirements have been applied.

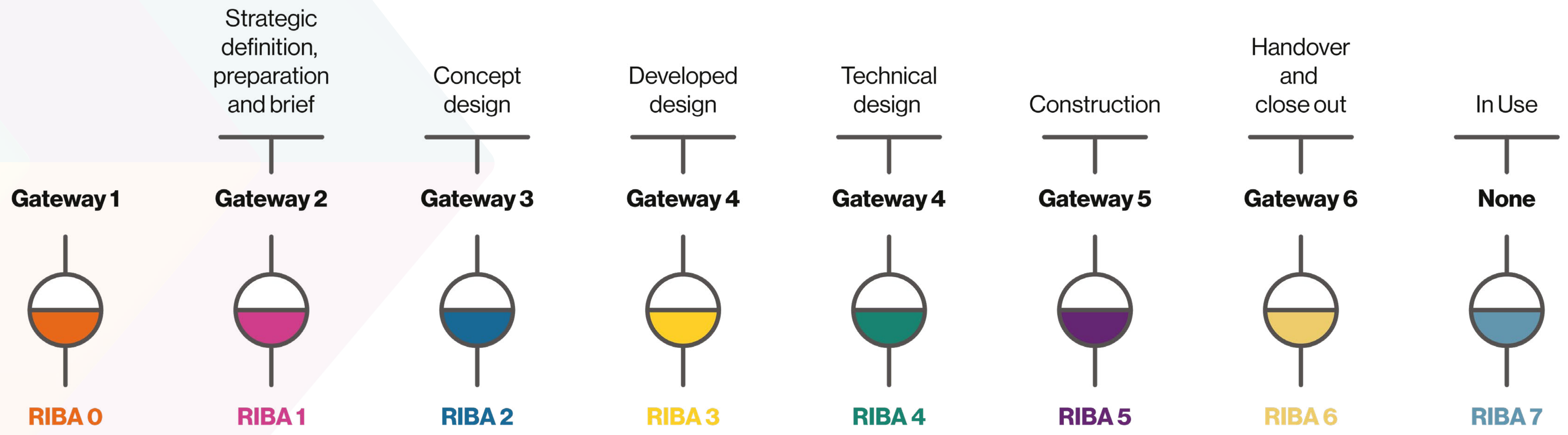


Figure 01 Standard alignment with RIBA Project Delivery Stages and City of London

DESIGN STANDARD CATEGORIES

The Standard offers specific requirements in six key sustainability themes (Whole Life Carbon, Circular Economy, Materials, Resilience, Wellbeing, and Post Occupancy Evaluation (POE) – please see Figure 2). These are further divided into Sub-Categories. The Technology Guide is provided in ➲**Appendix 1** to this Standard.

The sustainability requirements specified for each Design Standard Category, draw on a wide range of information sources, including:

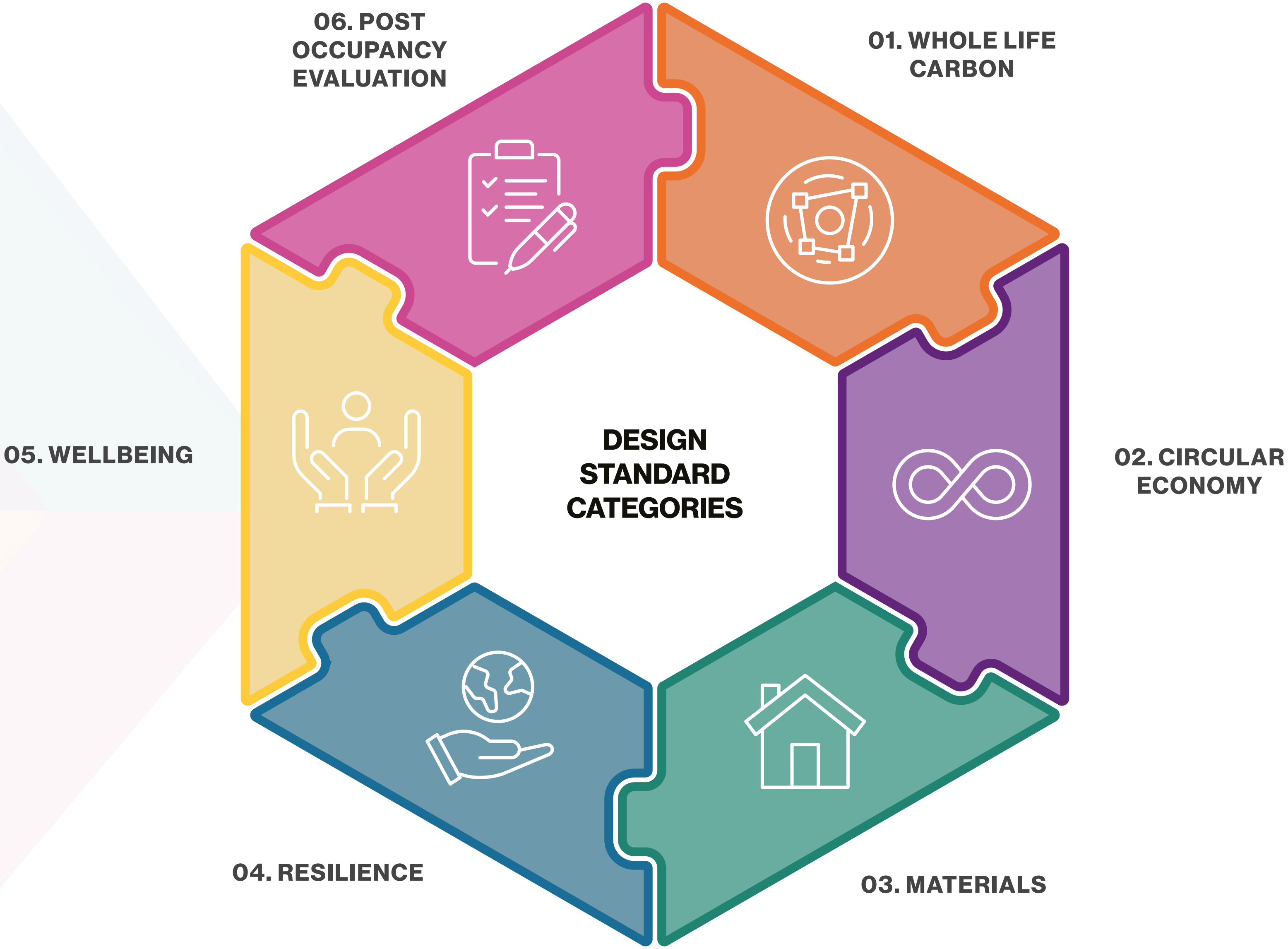
- National and international standards.
- Information developed as part of the wider Climate Action Programme.
- Existing CoLC policies, procedures, and other internal supporting documentation e.g. The Housing Design Standard, and Project Procedure – please see the ➲**References** for a full list of these.
- Studies commissioned by CoLC (e.g. Climate Impact Modelling, Whole Life Carbon Assessments).

The Technology Guide, which includes guidance on technology performance requirements and technology standards and is included as ➲**Appendix 1** of this Standard. Where this Standard refers to Technology requirements for the asset, please refer to this section.

Included at the end of this document is a full reference list, along with recommended further reading, are provided in ➲**Appendix 2** & ➲**3**.

As requirements will vary between projects and building types and classes, information is presented to enable users to select the requirements that are appropriate for each project.

Figure 02 Six Design Standard Categories



Accreditations

This section focusses on four key sustainability ratings/green building certifications: BREEAM, SKA, NABERS and Home Quality Mark. These have been selected as they are internationally recognised and have a science-based complement of validation and certification options. ➲**The Process Requirements** section provides details to support selection of the most appropriate sustainability rating for each project.

The scope of the six categories and associated sub-categories within the Standard are summarised below. It should be noted that not all the sub-categories will be relevant or applicable to every project and neither will all assets be able to achieve all the requirements and criteria. It will depend on the scope of works involved, asset and class type.

DESIGN CATEGORY 1. WHOLE LIFE CARBON

Whole Life Carbon (WLC) encompasses the total carbon emissions resulting from the extraction, transportation, and manufacturing of materials, as well as construction, operation, maintenance and demolition phases of a building over its entire lifecycle.

This includes both embodied carbon, and carbon emissions associated with operational energy from both regulated and unregulated energy use. A WLC approach seeks to identify overall the best combination of opportunities for reducing lifetime carbon emissions. Reducing carbon intensity by using life cycle carbon and cost assessment techniques will support the achievement of net zero. Applying a WLC approach to the project will help to identify carbon intense materials, equipment, and other activities both in construction and operation which can be addressed early and minimised – please see Figure 3 for a WLC process.

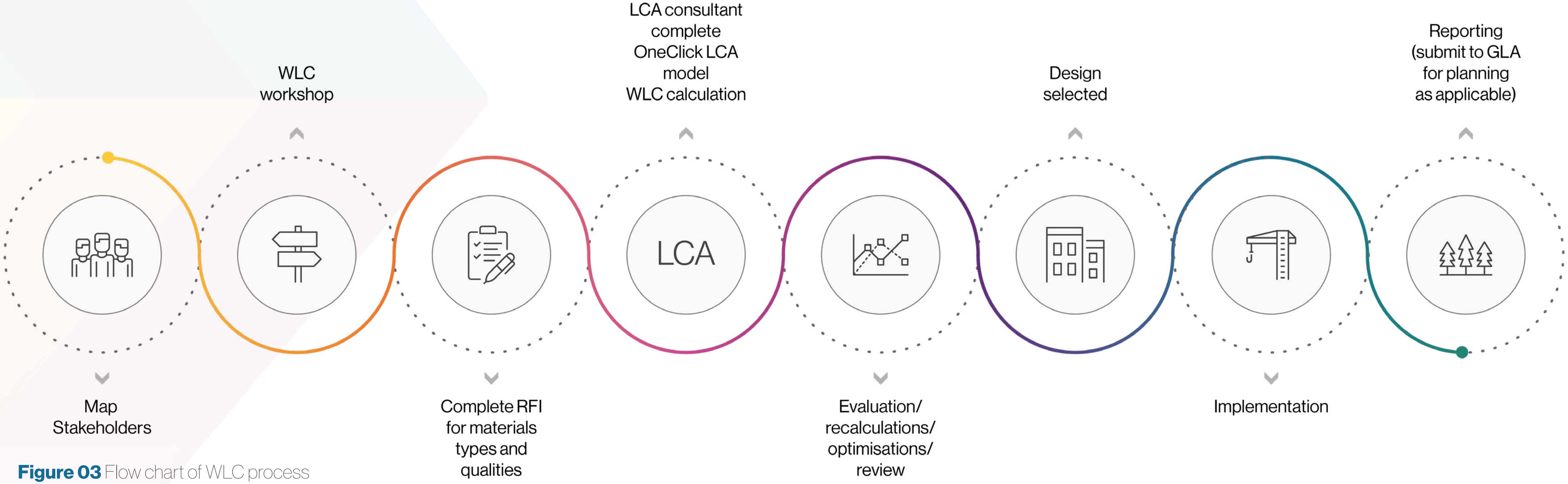


Figure 03 Flow chart of WLC process

The RICS professional statement: Whole Life Carbon Assessment for the Built Environment, released in 2017, should be followed for WLC assessments across the CoLC portfolio, fully considered and incorporated into the CoLC WLC Checklist. The methodology aims to standardise assessment and enhance consistency in outputs by providing guidance on implementing EN15978: Sustainability of Construction works.

Embodied and operational carbon emissions should be assessed across life cycle stages A1-C4 (Figure 4) for a lifecycle of 60 years. The emissions from the product stage (A1-A3), also known as cradle to gate, on average contributes the largest proportion of emissions to an embodied carbon assessment. This includes the raw material supply, transport and manufacturing required to produce a product. The LETI Climate Emergency Design Guide (2020) estimates that 80% of embodied emissions from small scale housing developments are attributed to A1-A3 stages, but only 48% in commercial office developments. In use stages B1-B5 are the next highest contributors to embodied carbon, including the maintenance and replacement of materials. Therefore, selecting the right material is key to lowering embodied carbon emissions across a development's life.

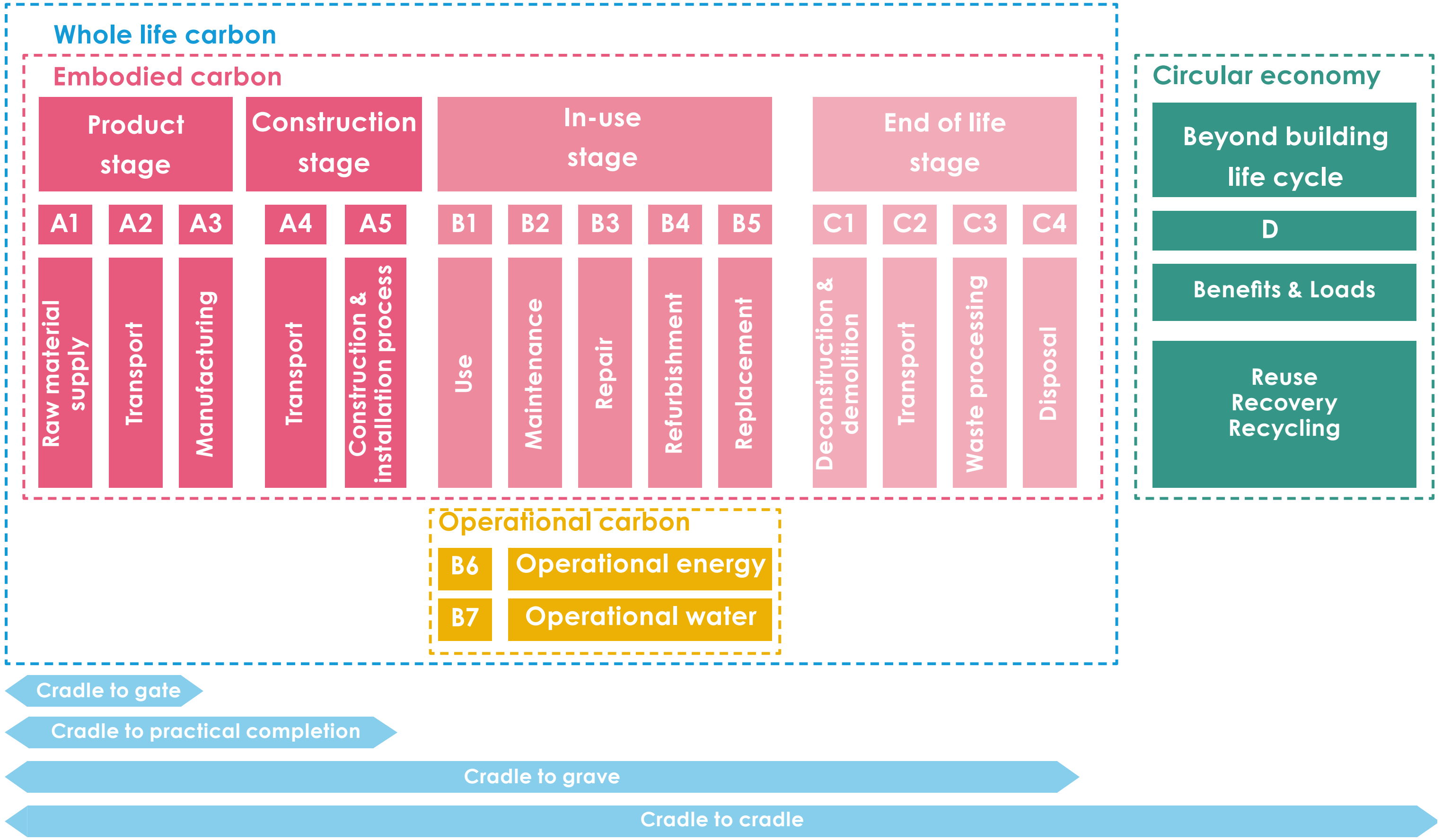


Figure 04 The EN 15978 life cycle boundaries, demonstrating the stages constituting a whole life carbon assessment (source: LETI Embodied Carbon Primer)

In this guidance, building elements that should be recorded are broken down according to the New Rules of Measurement classification system:

1. Substructure
2. Superstructure
3. Finishes
4. Fittings, furnishings and equipment (FF&E)
5. Building services/MEP
6. Prefabricated Buildings and Building Units
7. Work to Existing Building
8. External works

1a) Whole Life Carbon Assessment

The objective of a WLC assessment is the mitigation of the carbon impact of the built environment. WLC will enable a better understanding and consistent measurement of the WLC emissions of built projects. This in turn will allow result comparison, benchmarking and target setting to achieve Net Zero. Carrying out a WLC Assessment will provide carbon emissions data that can be targeted for reduction opportunities through the project stages, resulting in lower carbon impact through construction, during operation and at end of life of the asset.

CoLC have developed a ➲**WLC Assessment Checklist** to capture the WLC at each RIBA stage of the project. The analysis required to undertake an accurate and robust WLC assessment is complex and detailed, and PMs must review what information is required at each stage and utilise the checklist within the WLC tool. Production of a CoLC WLC Assessment will require use of a WLC related tool/software e.g., OneClick LCA software.

To gain a broader understanding of the CoLC approach to WLC on projects, please see the Whole Life Carbon Assessments undertaken by BDP [BDP, Whole Life Carbon Assessments, July 2022 doc ref COL-BDP-XX-XX-RP-Y-00001]. A portfolio of six sample CoLC live projects, including new build and refurbishments, offices and a café. The CoLC WLC Assessment checklist was then completed for each project. Optimisation scenarios were modelled to quantify £ per kgCO2e saving for each optimisation measure. Across the samples assessed by BDP, an average CO2e saving of 122.65 per m2 of development could be achieved if all optimisation measures were implemented. The cost savings range from £0 per kgCO2e (changing cooling set points of controls at Broad Street Place) to £214.60 per kgCO2e (triple glazed windows to lower g value at Eldon Street). The BDP report generated a menu of optimisation measures that can guide future projects to adopt measures that have low cost per kgCO2e saved (see section 1d for further details).

1b) Embodied Carbon

Embodied carbon comprises of all the GHG emissions associated with building construction, including those that arise from extracting, transporting, manufacturing, and installing building materials on site, as well as the operational and end-of-life emissions associated with those materials. *(McKinsey, Data to the rescue: Embodied carbon in buildings and the urgency of now article, September 2020).*

Upfront embodied carbon is emissions associated with the extraction and processing of materials, the energy and water consumption used by the factory in the production processes and constructing the building.

Best practice targets set out in the Project Requirements for embodied carbon should be met, and embodied carbon assessments should reflect all items listed in the project's Bill of Materials in accordance with the Circular Economy category.

A Life Cycle Assessment (LCA) tool such as OneClick LCA can be used to assess the embodied carbon for a project, allocating Environmental Product Declarations (EPDs) to material elements based on the proposed specification. EPDs are produced by product manufacturers and identify the carbon emissions of a product.

Embodied carbon should be assessed in line with BS 15978:2011 and the RICS Professional Statement, covering the following life cycle stages:

- A1-A3: Product Stage
- A4: Material transportation to site
- B4-B5: Replacement and maintenance
- C1-C4: End of Life

1c) Operational Carbon

The operational carbon emissions arising from the energy use of building-integrated systems as projected and/or measured throughout the life cycle of the project. (➲**RICS, Whole life carbon assessment for the built environment, 2017, P29**). A result of the energy consumed for the day-to-day operation of the building or structure and will usually include carbon emissions associated with heating, hot water, cooling, ventilation, and lighting systems, as well as those associated with cooking, equipment, and lifts (i.e., both regulated and unregulated energy uses).

1. **Regulated Energy:** Energy consumed by a building, associated with fixed installations for heating, hot water, cooling, ventilation, and lighting systems.
2. **Unregulated Energy:** Energy consumed by a building that is outside of the scope of Building Regulations, e.g., energy associated with equipment such as fridges, washing machines, TVs, computers, lifts, and cooking.

Operational carbon emissions are calculated based on CIBSE TM54 analysis, encompassing carbon emissions related to both the regulated and unregulated energy uses accumulated over the 60-year study period. A CIBSE TM54 analysis relies on detailed occupancy patterns and equipment, lifts, catering schedules (where applicable).

1d) Minimising Carbon

Minimising carbon is the use of less carbon-intense solutions to operate the same equipment and / or perform the same task to produce the same result. Carbon reduction measures can include reduction in both embodied and operational carbon. This category also includes, energy efficiency, and minimising pollution measures. Technical solutions to support the reduction of carbon can be found in ➲**Appendix 1**.

Modelling of scenarios should be completed early in the design process to optimise carbon reduction measures. In the report completed for CoLC by BDP [BDP, Whole Life Carbon Assessments, July 2022 doc ref COL-BDP-XX-XX-RP-Y-00001], four scenarios were modelled to quantify recommended carbon reduction measures:

3. **Baseline:** WLC impact resulting from the original design proposal.
4. **Optimised Operational Carbon Scenario:** WLC impact resulting from a combination of optimisation measures that aim to reduce operational carbon emissions.
5. **Optimised Embodied Carbon Scenario:** WLC impact resulting from a combination of optimisation measures that aim to reduce embodied carbon emissions.
6. **Optimised Operational and Embodied Carbon:** WLC impact resulting from a combination of optimisation measures that aim to reduce both operational and embodied carbon emissions.

The report outlined key measures that could be implemented to provide cost and carbon savings. The savings were presented in £ per kgCO2e saved.

Operational optimisation measures:

1. Improved HVAC and electrical efficiencies, prioritising natural and passive ventilation.
2. Improved lighting efficiency.
3. Selecting Photovoltaics with greater efficiencies.
4. Improved fabric insulation
5. Operational management, e.g. increasing cooling set point temperature.

Embodied optimisation measures:

1. Reuse existing structure where possible, either as is or reusing dismantled materials.
2. Reduce live load allowances to reduce the weight of the structure and the need for structural strengthening, thereby reducing the volume of material required.
3. Select materials with lower embodied carbon:
    a. Insulation, such as cellulose fibre insulation.
    b. Fermacell board instead of gypsum.
    c. Concrete with higher Ground Granulated Blast-furnace Slag (GGBS).
    d. Reclaimed steel, or where not feasible, EAF steel.
    e. Timber frame or CLT and steel with benefits of reduced weight and sequestering carbon.
4. Design for disassembly and reuse, for example using precast concrete elements. It is recommended that CoLC facilitate a circular economy across their portfolio, by repurposing materials from buildings undergoing change in other projects nearby.

Low and Zero Carbon (LZC) Technology

Using Low and Zero Carbon technologies to generate renewable energy results in the reduction of CO_2 emissions as well as the conservation of fossil fuels. These technologies are significantly more efficient than traditional solutions and emit less carbon in providing heating, cooling, or power.

Further information on the technologies and components to support the minimising of operational energy and the introduction of LZC technology can be found the Technology Guide in ➲**Appendix 1** of this Standard.

DESIGN CATEGORY 2. CIRCULAR ECONOMY

Circular Economy is characterised 'as an economy that is restorative and regenerative by design, and aims to keep products, components and materials at their highest level of utility and value at all times, distinguishing between technical and biological cycles' (Ellen McArthur Foundation).

The key considerations in the application of Circular Economy (CE) on projects are detailed in the CE the ➲**Project**, ➲**Process** and ➲**Information Requirements tables**.

For assets approaching the end of life, CE Principles should be applied to look at the options for reuse of the asset, refurbishment options and potential for reuse of materials, Post Occupancy Evaluations (POEs) may also support the process. A CE Statement is currently applicable for referable developments. However, for CoLC new developments and refurbishments, we see it as best practice that a Circular Economy Statement is developed with a level of detail proportionate to the scale of the development, and the CE Principles applied.

The Greater London Authority set out a vision of London transitioning to a circular economy in the ➲**Circular Economy Statements (2022)** and ➲**London Plan (2021)**.

- **The Environment Strategy** presents four strategic approaches – including 'Low Carbon Circular Economy', where 'A low carbon circular economy is one in which as much value as possible is extracted from resources, through their use and reuse, before they become waste...'
- **The London Plan 2021** promotes the adoption of circular economy (CE) principles in development, including designing out waste, designing for adaptability, design for longevity and design for disassembly, reuse, and recycling.

The Mayor of London's ➲**'Design for a Circular Economy Primer'** recognises the importance of the built environment's transition to the circular economy in addressing the challenge of the climate emergency and is intended to help support organisations in the built environment sector understand how they can embed circular economy principles into their projects and design processes.

For buildings, this means creating a regenerative built environment that prioritises retention and refurbishment over demolition and rebuilding. It means designing buildings that can be adapted, reconstructed, and deconstructed to extend their life and that allow components and materials to be salvaged for reuse or recycling. Designing buildings for a circular economy can increase their value by avoiding depreciation and can help to stave off obsolescence. It can even secure a positive residual value at end-of-life. In a circular economy, built environment assets are designed so that whole buildings, and materials, components and parts can be continually and easily recycled.

The ➲**Design for a Circular Economy Primer** provides a summary of circular economy principles and practice with guidance on project level circular economy strategy approach.

Technical guidance for the London Plan 2021 policy SI7, '➲**Reducing waste and supporting the circular economy**' outlines the direction of the technical guidance to follow.

CoLC are also developing their own CE Strategy, and this is currently a work in progress.

It is further understood City's Code of Practice for Deconstruction and Construction Sites 9th Edition 2019 is currently being updated and there will be further links to Circular Economy within this. It also stipulates that any project with a value of over £300k is required to produce a Site Waste Management Plan (SWMP) for new build, maintenance, and alteration or installation/removal of services (such as sewerage or water).

2a) Resource Efficiency

Resource efficiency is an aspect of the circular economy approach – and means 'doing more with less and delivering greater value with less input'. However, unlike the circular economy, resource efficiency does not necessarily challenge the linear 'take, make, use, dispose' model of consumption and production.

2b) Waste Reduction

As the largest user of materials and generator of waste in the economy, the built environment sector must take a lead in supporting the shift towards a circular economy. In London, the sector consumes 400 million tonnes of material each year and accounts for more than half of waste. More efficient use of resources and waste reduction has the potential to deliver a range of sustainability benefits.

2c) Decommissioning

The circular economy requires consideration of opportunities to keep products, components, and materials at their highest utility and value always. In the context of a building this includes consideration opportunities to retain utility through design approaches such as modular construction, design to allow future disassembly as well as retention of value through design to facilitate refurbishment, reuse, and recycling.

DESIGN CATEGORY 3. MATERIALS

This category provides guidance on ways to reduce the environmental and social impact of materials used on a project. It takes a 'cradle to cradle' approach to assess the impacts of materials used in the built environment. The issue focuses on material efficiency, environmental impact, responsible sourcing, and material durability. Materials and associated waste from these can increase a projects carbon emissions and contribute to global warming. The building and construction industry in 2021 accounted for over 34% of energy demand and c. 37% of energy and process-related CO_2 emissions. A reduction in material use, and smarter use of these materials, as well as those with low impact and an efficient life cycle will contribute to net zero targets and reducing the impact buildings have on the environment. PMs and the project team should also consider material reuse, and once available review the work by Hawkins Brown being instructed by CoLC which includes a materials selection matrix and design notes.

Material specification, selection, and consideration is integral to creating a sustainable building. It is highly dependent on contextual factors of the building, with several metrics playing a role in identifying the most suitable material of each building element. For example, there may be a need to review retention of existing materials and investigate alternative materials against the technical and performance standards, carbon requirements, and further, identify and factor in specific materials lifespans. Sustainable materials options are improving year on year, including the level and availability of EPDs. Material requirements are fully explored and explained in the Design Standard (sub)categories in accordance with the state-of-art industry standards.

To assist CoLC PMs and their architect/Project Delivery Team in making conscious sustainable material choices, it is recommended that low-impact material specifications are consulted when considering material options for all schemes. Below are links to current externally recognised low-impact material specifications.

- **➲RICS Professional Statement, 'Whole Life Carbon Assessment for the Built Environment' (whole life carbon assessment)**
- **➲ICE (Inventory of Carbon and Energy) Database (embodied energy and carbon database)**
- **➲LETI – Embodied Carbon Primer (whole life carbon assessment)**
- **➲BREEAM Green Guide to Specification (environmental impact of materials)**
- **➲SKA Rating Good Practice Measures (responsible sourcing)**

As a minimum, PMs should read through the different material specification methodologies in the links for further details. They should then discuss with their architect and project team the main project requirements for materials i.e., is carbon reduction most important, or responsible sourcing of materials, or both. This will help guide the project lead in making decisions on the relevant methodology to follow. They should also ensure they understand CoLC Procurement Policies and procedures and work closely with the Procurement team and architect for the project. It is not expected a PM will prepare or write a materials specification, but they should understand the different approaches and be able to discuss options with their architect who will prepare the materials specification for the project and contractor to follow. Materials specification is an evolving area and there will not be a 'one size fits all' approach as each project is individual and will have different material requirements and aspirations.

3a) Low Impact Materials

Low impact materials have the lowest whole life carbon impact while performing the function required. It may, however, be the case that higher embodied carbon materials are chosen due to their roles in reducing operational carbon over a building's lifetime. Projects should identify materials that can be re-used/recycled (demolition and refurbishment) and designing future buildings for disassembly and material re-use. Other considerations include selecting locally sourced, low-carbon and sustainable materials and a material efficiency and longevity review prior to selection.

3b) Procurement of Materials

Procurement of materials defines the relationship between the various parties in the process of researching, selecting, ordering, and paying for the materials required for construction of a building or structure. Initially this could include undertaking pre-demolition/pre-refurbishment audits to e.g., find opportunities for material re-use and introduce a sustainable procurement approach to procuring materials, including minimum expectations for materials. Further is the consideration of ethically sourced materials which means ensuring human rights and employment rights are both met to a high standard. Further information can be found in the ➲**CoLC Responsible Procurement Policy** and acts in accordance with the Procurement Code, highlighting the CoLCs commitment to identify areas of spend where there may be a high risk of poor working conditions, modern slavery, forced labour, human rights abuse, material sourcing from conflict-affected areas or negative impacts on security and crime. Human rights due diligence assessments will be carried out in the CoLC supply chain and there is continuous commitment to improvement, refection on existing and emerging legislation and guidance.

There will be an essential relationship with partner organisations such as the Ethical Trading Initiative and Electronics Watch to ensure the transparency of the mining and manufacturing of minerals used in the provisions of electric vehicles batteries and state-sponsored forced labour risks.

3c) Material Durability

Investing in sustainable and durable materials can help lessen the environmental impact and improve the building's lifecycle. At the design stage of the projects, aspects such as the adaptability/flexibility, disassembly, material resilience and exposure to premature end of life should be considered.

3d) Modern Methods of Construction (MMC)

Modern methods of construction employ innovative practices which spans off-site, near site and on-site pre-manufacturing, process improvements and technology applications, to minimise waste and energy usage. Some examples include modular offsite construction, creating panelled or cassette units in factories which can be assembled on site and the use of low impact materials. At the early stages of the project, consider opportunities to deploy MMC.

DESIGN CATEGORY 4. RESILIENCE

➲**The Intergovernmental Panel on Climate Change (IPCC) definition of resilience:** "Capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation".

The CoLC Climate Action Strategy (CAS) sets out how the CoLC will achieve net zero, build climate resilience and champion sustainable growth, both in the UK and globally.

Through the CoLC CAS workstreams including Resilient Buildings workstream which covers Climate Impact Modelling, Greener Streets and Cooling, CoLC are proactively considering and addressing action necessary to mitigate the worst climate change.

This Design Standard Category sets out the principles to be applied to achieve climate resilience, further information can be found in CoLC CAS, and CoLC Climate Impact Modelling documents.

For refurbishments and depending on the building type and works involved; consult the Buildings Resilience Plan initially to check if the building is included as a priority asset with proposed resilience intervention measures. Where assets are part of the Buildings Resilience Plan, include the intervention measures as part of the refurbishment, working with the relevant internal teams e.g., Asset Manager to ensure that resilience is fully encompassed. If they are not part of the Buildings Resilience Plans advice is to strongly consider including these within the scope as relevant.

For acquisitions, ensure that the due diligence followed has been designed to assess vulnerability to climate impacts. This will help to identify any necessary investment required to ensure that asset is well-adapted to changing climatic conditions.

It is recommended that a climate risk assessment is produced for all new developments and refurbishments, this will inform PMs on what is required to protect a building and tailor it to the asset type. Please refer to the Climate Impact Modelling work for further details.

4a) Climate Change Adaptation

Climate change adaptation is the approach of adjusting to actual or expected climate events to mitigate or moderate harm. The output of the Climate Impact Modelling work undertaken by CoLC showed insight into the anticipated impacts of heat stress and flooding on the Square Mile; enabling CoLC to put measures in place to better protect assets, the environment, and people from harm. Intervention measures include retrofitting and managing open spaces through permeable surfaces and increased tree planting, as well as solar shading, improved building fabrics and air tightness.

These measures can limit the hazards and associated climate risks from heat stress, fluvial and pluvial flooding, each of which could affect CoLC assets. Benefits of adopting a climate mitigation and adaptation approach when creating new developments or refurbishing existing building include, the opportunity to improve biodiversity and social value, increase the value and improve the space.

4b) Biodiversity, Ecology and Conservation

Biodiversity provides an opportunity for improved resilience to the impacts of climate change through measures such as Blue and Green Infrastructure. Future developments and refurbishments should contribute to local biodiversity, aligning with local and national government policies and adhering to species' protection status. The biodiversity impacts of potential interventions must be assessed and measured to ensure alignment between climate and biodiversity outcomes.

4c) Flood Resilience

Being prepared, ready to respond and able to cope with and recover from a flood event is known as 'Flood Resilience'. Resilience can be achieved through undertaking Flood Risk Assessments which will identify areas more vulnerable to flooding. Resilience measures such as flood defences and Sustainable Urban Drainage Systems (SUDS) can be introduced to mitigate and manage the effects of flooding. The climate impact modelling of the Square Mile illustrates the current and future heat stress and flooding projections, this data can inform decisions and interventions to protect the asset making it more resilient.

4d) Local Air Quality

Poor air quality is detrimental to human health and wellbeing. Harmful substances caused by gases such as Nitrous Oxide reacting with other gases and environmental factors, can have major health impacts such as affecting respiratory function and increasing instances of heart disease. CoLC is committed to reducing local air pollution through design and monitoring to improve air quality for occupants, visitors, and the local community. How air quality internally and externally and ventilation will be implemented, monitored, and managed for CoLC buildings should be a key consideration for all CoLC schemes.

4e) Passive Design

Passive design is design that works with the local climate to maintain a comfortable habitat within buildings. Passive design uses building layout, fabric, and form to reduce or remove mechanical cooling, heating, ventilation, and lighting demand.

DESIGN CATEGORY 5. WELLBEING

The relationship between human health, wellbeing, and the built environment are intertwined. This includes both physical and mental impacts of buildings on the wellbeing of occupants and users. CoLC is committed to providing a clean environment, access to nature, and celebrating responsible practices to improve wellbeing for all its building users. This category provides applicable features to elevate wellbeing for all and community engagement towards responsive, inclusive, and adaptable environment. Further information could be found in **CoLC CAS** and WELL V2 standard. Applying a wellbeing, people centric approach on new developments and refurbishments demonstrates CoLC's commitment to wellbeing. The relevant sub-categories are summarised on the right:

5a) Community Engagement

Community engagement is the process of working collaboratively with groups of people with a shared interest or situation to address issues affecting the wellbeing of those people. It may involve partnerships across stakeholders such as the public, councils and developers working together to reduce the vulnerability of their area to the impact of climate change through mitigation and adaptation, such as improving provision for recycling, energy management and protecting those vulnerable from increased temperatures and flooding, as well as ensuring and promoting ethical sourcing practices for both materials and labour. There are many opportunities throughout the lifecycle of the asset to engage with a plethora of stakeholders from the public, such as through consultations with suppliers and employees. The benefits of regular engagement will support the creation of assets that meet the needs of end users.

5b) WELL Type Requirements

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. The requirements are based around air, water, nourishment, light, fitness, comfort, and mind. They encourage a holistic approach to health and the built environment, addressing behaviour, operations, and design. An example of Air WELL requirements is to minimise the sources of indoor air pollution by aligning design with Particulate Matter and Volatile Substances standards. Taking a wellbeing approach to the development of an asset can help to ensure a healthy building with happier tenants.

DESIGN CATEGORY 6. POST OCCUPANCY EVALUATION (POE)

This category encourages a more holistic approach in managing the asset beyond handover. It is recommended that the Project Manager remain involved, this include developing post occupancy requirements prior to the project being completed, identifying the key areas to evaluate the performance of the building. Early engagement with the building manager/FM/tenant e.g., to gauge user experience and to understand whether the Net Zero Design ambition has been achieved in operation. The POE can help improve a buildings operation and occupants' comfort based on its outcomes. It can also be used to improve design and efficiency of future projects and will provide detailed lessons learnt for the CoLC team and year on year improvement for their assets. At a minimum it is recommended that a POE is undertaken annually. There are several different POE approaches that can be followed, including as part of the BREEAM Man 05 Aftercare credit requirements.

6a) Operational Carbon and Energy

Please see ➲**Design Category 1c**

6b) Embodied Carbon

Please see ➲**Design Category 1b**

6c) Energy and Water Monitoring

Energy and water monitoring systems can be installed within buildings to accurately measure both the energy and water usage of a site via sub metering systems and smart meters This information can then inform the Operations Manager whether the sites energy and water usage is within target or whether additional initiatives need to be introduced to minimise usage such as encouraging users to change their energy usage behaviours on site. Water monitoring systems are also able to identify leaks and can automatically shut off when a leak is identified to reduce water usage. CoLC uses a centralised system called "Team Sigma" to collect data for energy and water monitoring.

6d) Local Air Quality

Please see ➲**Design Category 4d**

04. Standard Requirements

"This chapter outlines who the Standard is aimed at, who should use it and when. It confirms the Standard should be used throughout the life cycle of a project and provides descriptions of the main user and stakeholders / project delivery team. It defines the reporting, assurance and sign-off process and offers guidance around filing structure, lessons learnt and continuous improvement and how the Standard will evolve and be updated. Lastly, there is a list of key contacts for help and assistance.

WHO SHOULD USE THE STANDARD

The Standards primary purpose is for use by CoLC Project Managers. It identifies the actions required and evidence that needs to be collected to demonstrate the requirements have been implemented. However, the information herein will also be of value to other CoLC stakeholders including the CoLC Chief Officers and Planning Team. Further information on how to use this Standard can be found here: **➲How to Use This Standard.**

This Standard is to be applied throughout the life cycle of the asset from design to end of life. To ensure the potential of the asset can be fully realised, key stakeholders and subject matter experts (SMEs), must be identified and engaged early. Figure 5 illustrates the key stakeholders within the Project Delivery Team and as presented in the **➲Project**, **➲Process**, and **➲Information Requirements** Tables which contains more detail on the role of each key stakeholder at each of the RIBA Stages.

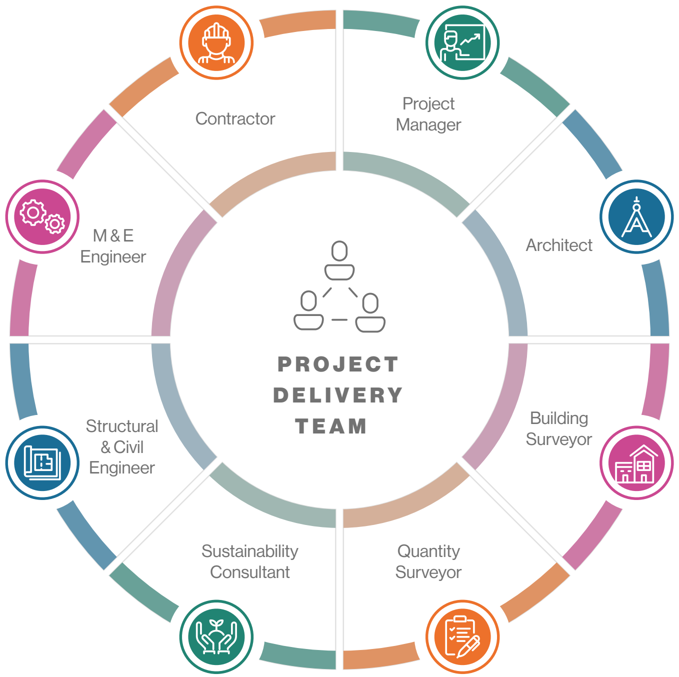


Figure 05 Net Zero Design Standard Project Delivery Team

Figure 06 Standard Defined Roles & Requirements

Project Manager

The CoLC Project Manager (PM) has a significant part to play in ensuring that the requirements of this Standard are met, this starts at RIBA Stage 0 and continues to the end of RIBA Stage 7.

At RIBA stages 0 and 1, the PM's role involves liaising with the Client Team/Project Management Office (PMO) and Senior Responsible Officer (SRO), who's role is to determine the viability of the project, costs and prepare the project brief. It is important that in advance of commencing RIBA stage 2 that the PM is satisfied that the project set up has been appropriately to enable successful delivery. The handover at this stage should include confirmation of sufficient funding and resources and that supplier contracts via discussions with Commercial Services are inclusive of the responsibilities in relation to meeting the requirements of the Standard, e.g., completing Whole Life Carbon Assessments.

Key to successful implementation is communication of the requirements to the Project Delivery Team at the start and working with the team at each stage of the project to ensure the Standard is followed, information is gathered and recorded consistently and timely; to demonstrate how the key areas are being addressed.

CoLC Project Managers must familiarise themselves with the Standard, including their role in meeting the requirements, this includes early and regular engagement with the relevant stakeholders at each stage (RIBA Stage (0-7) / Gateway (1-6)).

Project Delivery Team

The Project Delivery Team is appointed by the Project Manager and are shown in Figure 5. Each member has an active role in delivering key elements of this Standard, detailed in the ➲**Project**, ➲**Process** and ➲**Information Requirements** Tables.

Other Stakeholders identified as having a role in supporting the delivery of the Standard are noted below, these stakeholders should familiarise themselves with the requirements to support the PM and successful delivery of the project.

- CoLC Corporate Project Management Office (PMO)
- Senior Responsible Officer (SRO)
- Client Teams
- Commercial Services
- CoLC Members

Project Delivery Team & Key Stakeholders	Description what is required of each role to do to deliver sustainable buildings effectively
Architect / Designer	An organisation or individual, advised by specialist consultants and sub-contractors, whose business involves preparing or modifying designs for construction projects. Works with PM to drive design forward and assist the PM in the appointment of consultants at the right RIBA Stage. Review Standard requirements RIBA 0-6.
Building Surveyor	Provides a detailed evaluation of an asset's condition through extensive inspection. Works with the PM to inform works required on the asset and assist with any risk assessments required e.g., climate risk. Review Standard requirements RIBA 0-2.
Contractor	Builds / constructs or provides refurbishment works in the building. Employs or engages sub-contractors based on capability and availability and price. Interprets requirements of design team and may influence selection of products and design. Works with PM to ensure delivery of Standard criteria and achieve net zero. Review Standard requirements RIBA 4-7.
Fire Engineering	Applies scientific and engineering principles, and expert judgement, to protect people, property, and the environment from the destructive effects of fire.
Interior Design Services	Involved in the design or renovation of internal spaces, including structural alterations, furnishings, fixtures and fittings, lighting, and colour schemes. Works with PM to drive design forward and review Standard requirements RIBA 2-6.
M&E Engineer	Designs the Mechanical and Electrical components through integration, co-ordination and collaboration with consultants, contractors, and specialists. M&E ensures that their designs satisfy performance requirements and are safe and serviceable. Work with the PM to drive MEP design forward and ensure successful delivery of net zero. Review Standard requirements RIBA 0-6 including the Technology Guide in Appendix 1 utilising the BAT checklist.

Where Client Teams/SRO lead on initial stages of the Project (RIBA Stage 1 and 0), in advance of CoLC PM involvement, it is recommended that the Client Teams/SRO engage with the PM or Project Management Office at the start of this process as this will facilitate the smooth transition to implementation.

Project Delivery Team & Key Stakeholders	Description what is required of each role to do to deliver sustainable buildings effectively
PassivHaus Designer / Certifier	Consults delivery teams how to achieve the Passive House standard. Quality assurance is achieved through certification by a registered PassivHaus Certifier. Works with PM to ensure achievement of PassivHaus has a positive impact on the achievement of the net zero Standard.
Quantity Surveyor / Cost Consultant	Influences and guides the selection of building products. Early in the construction project they will give advice on costs, helping establish total spend for project completion. Works with PM closely to create cost plan and appoint consultants and review Standard requirements RIBA 0-2.
Structural & Civil Engineer	Responsible for foundations and general structures and associated infrastructure of a building. They monitor the progress of a project and inspect the work and advise contractors. With additional qualifications they become Structural Engineers who design the skeleton or structure of a building. Work with PM to ensure delivery of Standard criteria and achieve net zero. Review Standard requirements RIBA 0-4.
Sustainability Consultant	Assesses sustainability risks or needs of the building based on its location, policies and regulations and defines performance requirements. Prepares and completes any relevant accreditations and helps drive the delivery of the Standard to successful completion with the PM.
Transportation	Provides improved access to local amenities and to sustainable means of transport, i.e., public transport and other alternative transport solutions for building users. Encourages locations and solutions that support reductions in car journeys and, therefore, congestion and CO_2 emissions over the life of the building. Review relevant sub0categories within Standard and help towards successful completion.

WHEN TO USE THIS STANDARD

The Standard has been developed to embed sustainability and resilience across the CoLC Operational and Investment Building Assets (herein referred to as 'Assets' and 'Buildings'), providing a consistent approach and good design practices to:

- Be applied to CoLC new construction and major refurbishments.
- Be flexible enough to be applied across a broad range of buildings, using a range of delivery, operating and maintenance routes across CoLC.

The Standard will help to maximise the opportunities, minimise risk, cost and avoid retrofitting in the future by providing guidance on design decisions and technology choices. To be effective Standard implementation must occur at project inception, mobilisation of key stakeholders and early engagement of the Project Delivery Team will support early adoption.

Implementation of the Standard is aimed at all projects categorised below with full details in the ➲**Project,** ➲**Process,** and ➲**Information Requirements** Tables.

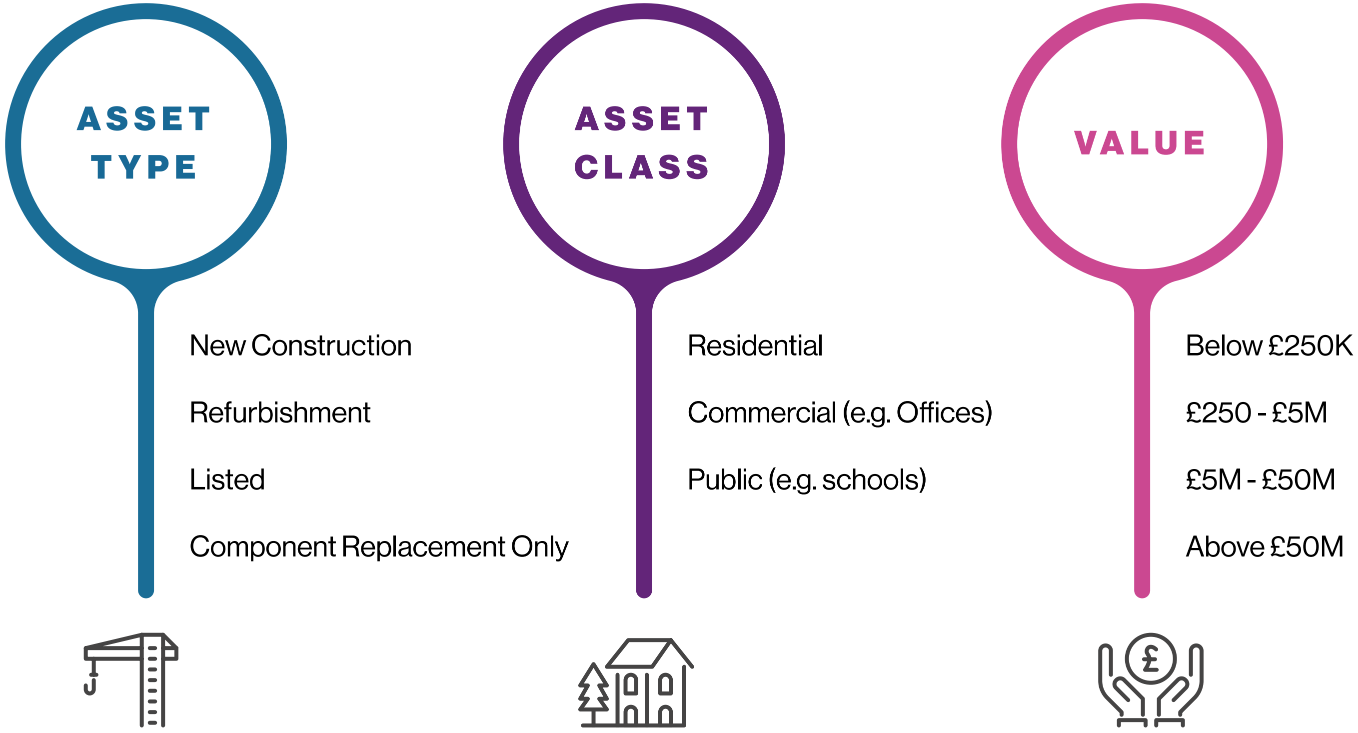


Figure 07 Mandatory implementation of listed categorised projects

HOW TO USE THIS STANDARD

At project initiation and regularly throughout the project stages, it is important that the CoLC PM engages with relevant CAS project workstreams and CoLC departments, building in reviews and references to the CoLC standards and procedures and other requirements e.g., Project Management Guidance, Planning, etc., this will ensure cohesion across the CoLC requirements.

The CoLC PM at the start of the project must engage with the Project Delivery Team and communicate the requirements and define how and when information will be recorded and shared with CoLC.

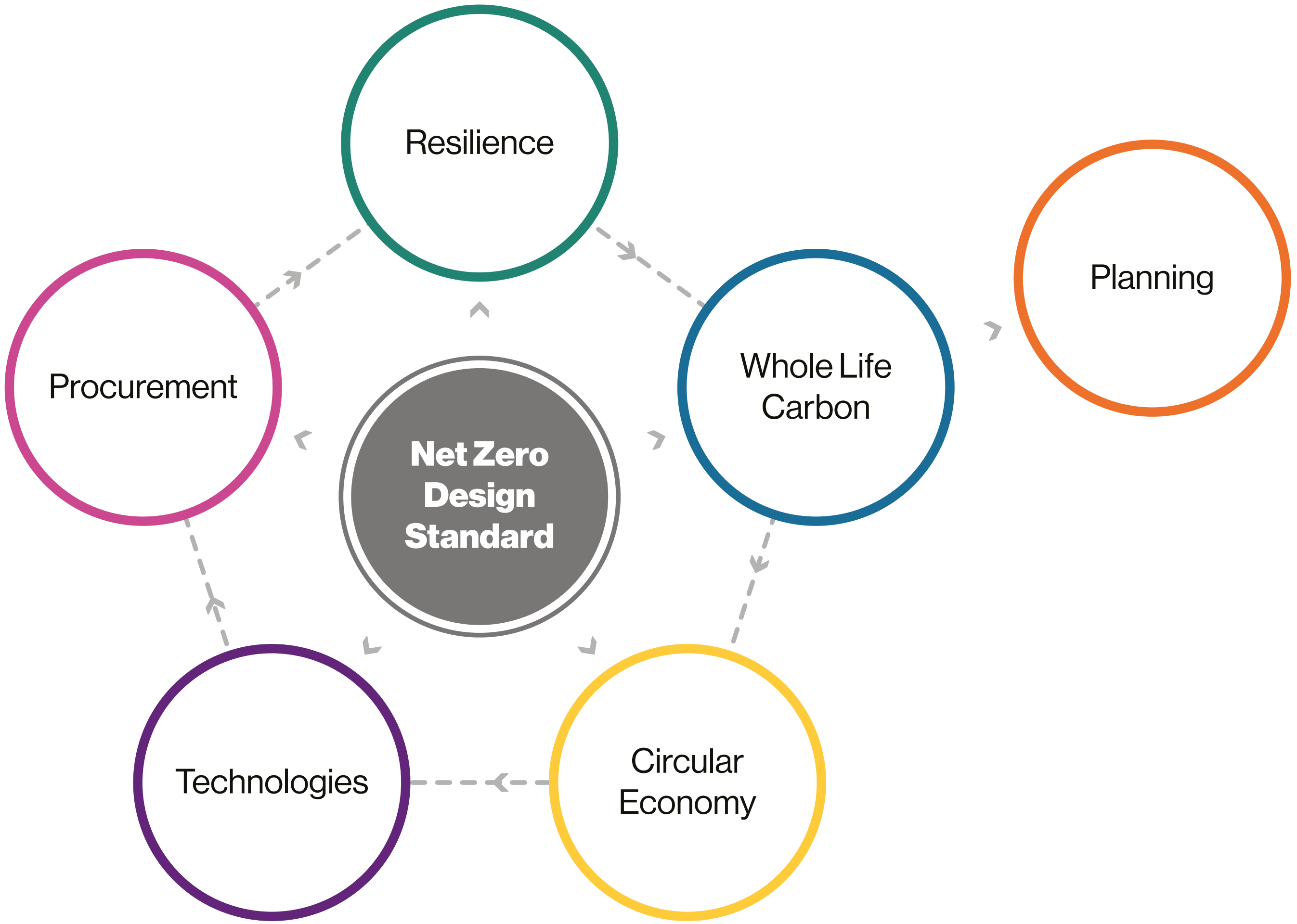


Figure 08 An illustration of the interdependencies with the Net Zero Design Standard

Interdependencies

The Standard provides users with an overview of and access to the tools and supporting information to embed sustainability on projects. The Standard is not intended for use in isolation, several key interdependencies have been identified as illustrated in Figure 8, as previously outlined above, early and continuous engagement with these teams within CoLC is essential. Key CoLC documents and processes as shown in Figure 9, should be reviewed in conjunction with the relevant section in the sustainability requirements.

A WLC Assessment tool is available for CoLC users on how to develop robust and consistent Whole Life Carbon Assessments for a range of building types. The analysis required to undertake an accurate and robust WLC assessment is complex and detailed, and PMs must review what information is required at each stage and utilise the checklist within the WLC tool.

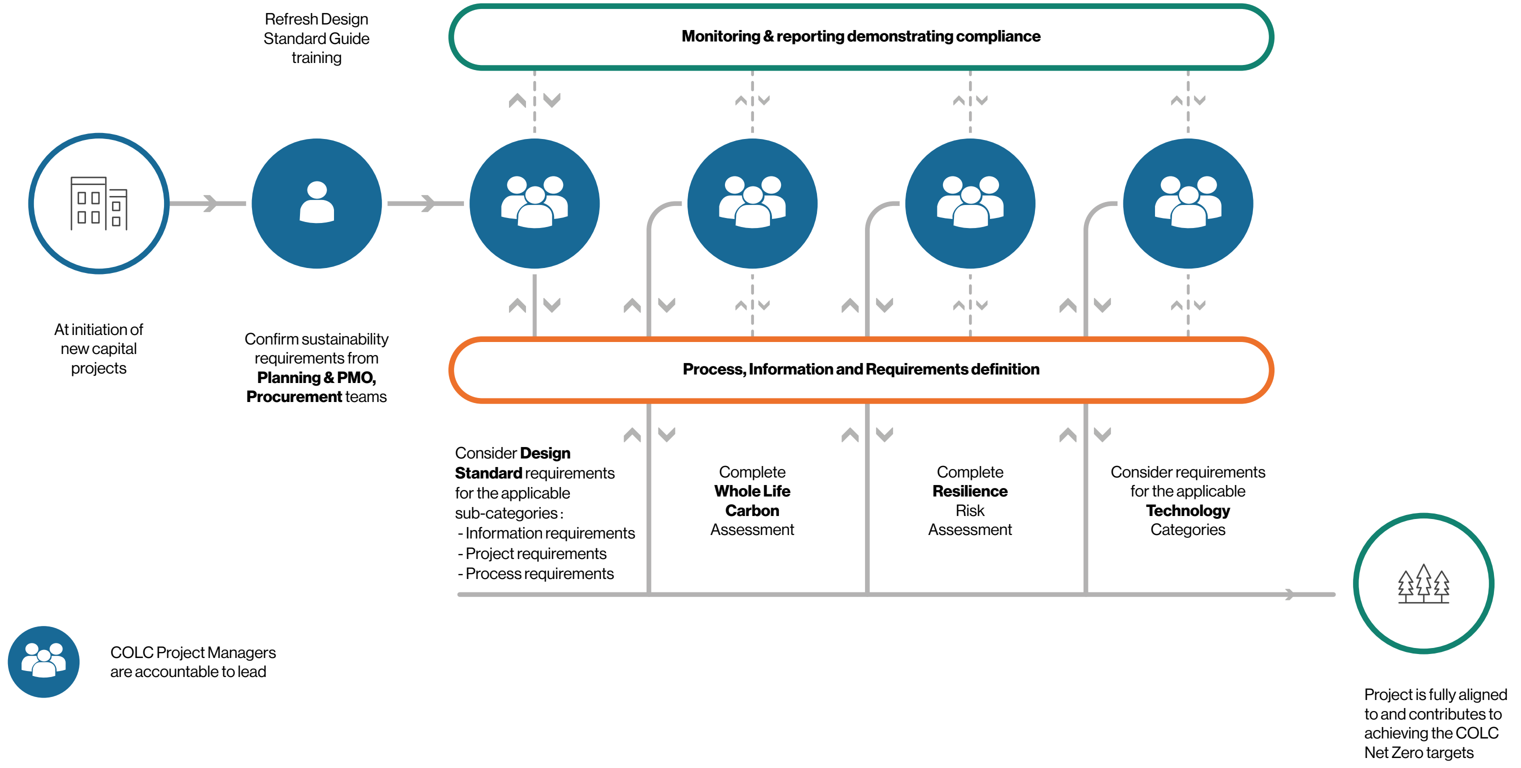


Figure 09 Process steps to gather sustainability requirements and align to CoLC targets

The Resilience or Climate Impact work involved risk modelling for CPG and IPG Assets on temperature and pluvial / fluvial flooding to identify high risks assets with the need for enhanced resilience and mitigation measures. The exercise, which is still in progress at the time of writing, aims to identify a set of proposed interventions and any constraints which need assessed and considered.

The Technology Guide which is an Appendix to this Design Guide offers a Best Available Technology selection tool (BAT) and covers categories including fabric, airtightness, HVAC (heating, ventilation, and air conditioning) systems, lighting, equipment, controls and components within the future maintenance, refurbishments, and construction of building projects. It provides guidance on the selection of equipment and technological solutions to support project managers and suppliers to specify the optimum technology in terms of performance, technical viability, lifetime costs and carbon emissions, considering both embodied and operational carbon.

The Carbon Options Guidance (which includes third party review of the options appraisal at pre-application stage) on Whole Lifecycle Carbon Optioneering is aimed at developers intending to build in the Square Mile. It provides guidance about how the planning process can encourage the development pathway towards net zero as set out in the CAS. This Standard is aligned with the methodology of the Carbon Options Guidance which in turn aligns closely with the GLA's Whole Life-Cycle Carbon Assessment Guidance. The purpose of the Carbon Options Guidance is to encourage the appraisal of development options for different degrees of major interventions in the commercial built environment as part of the pre-application process to ensure that planning application proposals for the Square Mile are designed with a maximum reduction of whole life-cycle carbon emissions and to drive best practice. This exercise should be clearly presented in the planning application documents.

Full (major) planning applications should aim to follow this guidance wherever possible as it offers a methodology to satisfy the requirements of the GLA's guidance on Whole Life-Cycle Carbon Assessments and Circular Economy Statements to fully explore and consider options for retaining buildings and structures. The methodology establishes the minimum data required at the pre-planning and planning stages, and the level of transparency to be disclosed to CoLC. A dashboard has been created to equip CoLC with easy, visual, and quantified information that is clear and benchmarkable, enabling an informed discussion between them and the Applicant party.

The Whole Life Carbon category has integrated the guidance stated in the Carbon Options Guidance, and GLA's new guidance on WLCA reporting (March 2022) accordingly. It is noted that this category will need to be updated as the market matures, and industry standards and assessment tools become more robust and reliable.

PROCESS, PROJECT, AND INFORMATION REQUIREMENTS

The Standard offers specific requirements for six Design Categories (Whole Life Carbon, Circular Economy, Materials, Resilience, Wellbeing, and Post Occupancy Evaluation (POE), which are presented in three tables herein, Process, Project, and Information Requirements Tables.

Each table should be reviewed in turn for each category and sub-category. The user should start with Process Requirements to understand what should be done when and by whom; secondly to the Project Requirements which details the set criteria to be achieved for net zero; and thirdly the Information Requirements which confirms the types of documentation and evidence to demonstrate compliance. Using the tables in this way will help ensure successful completion of the categories and that all requirements are met.

Process Requirements (Link to Table)

Process requirements summarises expectations around net zero key decisions which need to be taken throughout the delivery of new buildings, planned refurbishments, listed buildings, and/or replacement of building components and systems to ensure implementation of the information and project specific design requirements. Further, this section enables project delivery teams and PMs to identify additional stakeholders and milestones in line with the RIBA project stages of work. The requirements are presented and aligned to RIBA and CoLC Gateways to support the PMs and their project delivery teams in considering how and when these activities and works should be implemented throughout the project lifecycle.

Project Requirements (Link to Table)

Project requirements provides project managers (PMs), and their project delivery teams (designers, architects, engineers, etc.), with consistent project requirements and set criteria to apply to the delivery of new construction, planned refurbishments, Listed Buildings, and/or replacement of building components and systems at end of life. The aim is to achieve net zero carbon goals, ensure a high build performance and integrate these into current CoLC roles and responsibilities as set out in the CoLC Project Management Guide. The requirements are informed by available Industry Standards, Regulations, and guidance as well as existing CoLC documentation to ensure alignment and prevent contradictions. The project requirements not only act as a baseline of minimum requirements for net zero, but actively push project delivery teams to superior benchmarks and net zero buildings.

Information Requirements (Link to Table)

Information requirements outlines the reporting requirements to evidence how an individual project demonstrates their compliance to net zero. The information requirements are clearly set out corresponding to the above Project Requirements as well as aligning with CAS KPIs. Having set information requirements allows for quality control management and the ability for CoLC to actively measure and analyse a projects successful achievement of net zero.

DESIGN GUIDE - PROCESS REQUIREMENTS

Topics	Applicability					Strategic definition, preparation and brief	Concept design	Developed design	Technical design	Construction	Handover and close out	In Use	Considerations	Interdependencies				
	Value				Gateway 1	Gateway 2	Gateway 3	Gateway 4	Gateway 4	Gateway 5	Gateway 6	None	Stakeholders involved / instructed	CoLC				
Categories	below £250k	£250k - £5m	£5m - £50m	Above £5m	RIBA 0	RIBA 1	RIBA 2	RIBA 3	RIBA 4	RIBA 5	RIBA 6	RIBA 7		Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement
					✓	✓	✓	✓	✓	✓	✓	✓	Project Management					
					✓	✓							Client Senior Responsible Owner					
					✓	✓	✓						Building Surveying					
					✓	✓	✓	✓	✓	✓	✓	✓	Quantity Surveying					
						✓	✓	✓	✓	✓	✓		Architectural					
						✓	✓	✓	✓	✓	✓		Structural and Civil Engineering					
						✓	✓	✓	✓	✓	✓		Mechanical & Electrical Engineering					
							✓	✓	✓				Fire Engineering					
									✓	✓	✓	✓	Interior Design Services					
						✓	✓	✓					PassivHaus Design					
							✓	✓	✓				Transportation					
									✓	✓	✓	✓	Contractor					
Introduction and Accreditations																		
Sustainability rating		✓	✓	✓	1. PM: Project sustainability aspirations, objectives and certificate requirements to be identified and discussed with the client. 2. PM: Roles and responsibilities to be agreed and assigned within the project team. 3. PM: Sustainable innovation opportunities in design and construction to be identified. 4. PM: Sustainability objectives to be incorporated within the strategic brief. 5. PM to engage with planning officers (where application required), at pre-planning application stage, application stage and conditions stage - impac on timeframes and project specifications, and needs to be managed.	1. PM / consultant: Feedback from post occupancy evaluation, precedent review data, site surveys, and experience of facilities management team to state clear, deliverable and ambitious sustainability outcomes in project brief. 2. PM: Certification requirements to be clearly defined, including timetable for assessor appointments and early stage client actions. 3. PM appoint relevant licensed Assessors or sustainability consultants and BREEAM APs as appropriate. 4. PM to engage with planning officers (where application required), at pre-planning application stage, application stage and conditions stage - impact on timeframes and project specifications, and needs to be managed.	1. PM to align the Plan for Use Strategy with the Sustainability Strategy, Cost Plan, metering, site waste, and other project strategies. 2. PM consider benchmarking and quality assurance requirements in initial design work. 3. Architect and PM to incorporate lessons learnt from POE feedback and the review of precedents in developing architectural concept. 4. M&E to carry out sufficient energy and other modelling to test and refine the architectural concept, sustainability strategy and delivery of sustainability outcomes. 5. Architect to review architectural concept against the intended sustainability outcomes and report and mitigate any deviations. 6. PM to include a record of key design decisions in the stage report. 7. PM to engage with planning officers (where application required), at pre-planning application stage, application stage and conditions stage - impact on timeframes and project specifications, and needs to be managed.	1. Architect, M&E and Structures to undertake design studies and engineering analysis to test sustainability outcomes. 2. M&E (PM) to submit building regulations application and interim certification applications. 3. PM to integrate sustainability outcomes into spatially coordinated design aligned to stakeholder consultation feedback, incorporating lessons learnt from POE feedback and review of precedents, and record new lessons learnt. 4. PM to identify and update record of performance risks to inform Stage 4 tasks and deliverables and mitigate any deviation from sustainability outcomes. 5. PM with Procurement to embed requirements for POE in procurement strategy. 6. PM with Sustainability Consultant / Assessor to include a record of key decisions to deliver sustainability outcomes in stage report.	1. Architect, M&E and Structures to undertake technical design, including final specifications and material sourcing, to manufacture and construct building to achieve sustainability outcomes. 2. PM / Architect to coordinate design team and specialist subcontractors' manufacturing information, construction information and final specifications, embedding the target sustainability outcomes and plan for use strategy. 3. PM to update target commitments. 4. PM to include sustainability performance targets in tender information or employer's requirements and review tender returns or contractors proposals against sustainability outcomes. 5. Architect and M&E to mitigate or control as many building performance and climate change impact project risks as possible and identify management strategies for those that remain. 6. M&E with sustainability consultant / Assessor address sustainability outcomes targets and submit the building regulations application.	1. Contractor to manufacture, construct and commission the building to meet target sustainability outcomes. 2. Contractor to commission all equipment required to monitor sustainability outcomes. 3. Contractor to review construction stage changes, report and mitigate any deviation. 4. Contractor to compile construction stage information required for certification, and demonstrate compliance with sustainability outcomes. 5. Contractor to submit final information for statutory approval and certification, and performance in use verification. 6. PM and contractor to review and update the record of performance risks on site, and use it to identify and avoid defects. 7. Contractor to implement handover and aftercare 8. Contractor to compile asset information required for effective performance and management of building for building manual.	1. PM to hold a project performance session with the project team to gather views on process of embedding sustainability outcomes in briefing, design and construction and handover. 2. Contractor and Sustainability Consultant to provide induction and training of building users and facilities managers with reference to sustainability strategy. 3. PM to begin gathering feedback through light touch POE of sustainability outcomes in use.	1. PM to comply with in use planning conditions in relation to sustainability. 2. PM to use observations from light touch POE to fine tune and improve sustainable outcomes performance against the sustainability outcomes targets, and keep building manual up to date. 3. PM to undertake more detailed POE as required to test delivery of the in use sustainability outcomes. 4. PM to share feedback from lessons learnt with client, users, design and construction team members, and project stakeholders.	Intentionally left blank	N/A				
Whole life carbon																		
Whole life cycle carbon assessment	✓	✓	✓	✓	1. PM: WLC Carbon Optioneering exercise (in accordance with CoLC PAN) carried out at earliest conception stage (pre-app) in order to inform the project development rather than parallel to the project brief. 2. PM: for any for planned stock changes, PM must check whether there are targets in place, noting that any planned stock changes need to perform to contribute to net zero targets.	1. PM: Set initial embodied carbon targets and implications as part of optioneering. 2. PM: Early recommendations on low carbon options ahead of RIBA Stage 2.	1. PM with design team to provide more detailed analysis of the options around the key building systems (including substructures, superstructures, finishes, MEP, landscaping) and the relationship with the building's proposed performance. 2. MEP and PM identify opportunities to reduce embodied carbon and whole life carbon with the design/project team.	1. MEP / carbon consultant complete in depth analysis of building components, identify materials, products and lifespans to generate a whole life carbon budget baseline. 2.Carbon consultant assess two carbon alternatives and agree carbon reduction target (percentage or absolute). 3.Carbon consultant produce whole life carbon budget, including total carbon emitted over lifespan of the building, carbon reduction target, and carbon reduction option list.	1. Carbon consultant finalise carbon reduction option list. 2. PM with carbon consultant set targets within the Main Contractor's Employer's Requirement and/or pre-procurement. Issue request for Information to suppliers to collect carbon data to provide a supplementary information for supplier selection.	1. Contractor achieve the agreed carbon reduction targets. 2. Contractor report as-built embodied carbon on a quarterly basis.	1. Contractor to confirm the final carbon related data to the LCA specialist. 2. Contractor to issue to the client a practical completion carbon report which should align design stage carbon targets with what was achieved at the end of construction.	1. Contractor with PM report lessons learned, good practice to the CoLC. 2. Carbon reduction strategy to include in-use and end-of-life stage.	Intentionally left blank	✓	✓		✓	
Embodied carbon	✓	✓	✓	✓	1. PM: Whole life carbon ambitions to be discussed with client. 2.PM rReview opportunity for retention of existing structure and building fabric and how quantum of materials in new building can be reduced with wider team.	1. PMdevelop a client brief to incorporate embodied carbon reduction targets based on the CoLC CAS, Design Standard, Technology Standard, and Whole Life Carbon Optioneering. 2. PM appoint LCA specialist or design team member to be responsible for WLC assessment. 3. LCA specialist or design team should set initial embodied carbon targets using CoLC CAS, Design Standard, Technology Standard, Whole Life Carbon Optioneering, rule of thumb guidance and benchmarking.	1. PM use CoLC CAS, Design Standard, Technology Standard, Whole Life Carbon Optioneering, and rule of thumb guidance during concept to maximise opportunities for low carbon design. 2. LCA specialist or design team to analyse carbon reduction options for building elements using numerical analysis (i.e., dynamic solution model (DSM) using IES, TM54 methodology, One Click LCA). 3. LCA specialist or design team to provide more detailed analysis of options around key building systems as design develops and discuss with team through workshops.	1. LCA specialist or design team to include requirements and targets for WLC in specifications and tender documentation at start of procurement. 2. PM to discuss with potential contractors and subcontractors around WLC targets, asking for options on improvement and including carbon questions on tender return forms. 3. LCA specialist or design team to continue numerical analysis and use material guides to optimise material specification. 4. LCA specialist conduct in depth analysis of elemental and component parts of entire building, identifying specific materials, products and lifespans to generate WLC budget baseline. 5. LCA specialist assess low carbon alternatives to baseline and agree the carbon reduction targets based on the Guide's requirements.	1. PM with design team finalise requirements and targets for WLC in specifications and tender docs at start of procurement. 2. PM finalise requirements with potential contractors and subcontractors around WLC targets, asking for options for improvement and including carbon questions on tender return forms. 3. LCA specialist continue numerical analysis and use material guides to optimise material specs. 4. LCA specialist update WLC budget to include design development and finalise carbon reduction options list. 5. LCA specialist send pre-procurement RFI to suppliers to collect carbon data in order to provide supplementary info for supplier selection. Review RFIs and analyse environmental credentials of procurement options.	1. Design Team to engage with contractors to reduce waste. 2. LCA specialist review alternative products and materials selections proposed by contractor against WLC requirements. 3. LCA specialist / Contractor prepare post-completion analysis by collecting numerical data throughout construction phase. 4. LCA specialist to send RFIs to suppliers to receive construction carbon data and verify environmental credentials. 5. LCA specialist undertake building site monitoring through monthly site logs and construction progress reporting.	1. LCA specialist undertake post completion analysis using as-built info to assess upfront embodied carbon. 2. Contractor should confirm final carbon related data to LCA specialist at end of site works. Develop practical completion carbon report. Align design stage carbon targets with what was achieved at end of construction.	1. Recommendations regarding embodied carbon reduction strategy over the in-use stage should be followed throughout building life cycle including end of life stage. 2. LCA specialist to include in-use and end of life stages in embodied carbon reduction strategy.	Intentionally left blank	✓	✓		✓	
Operational carbon and energy	✓	✓	✓	✓	1. PM identify a Net Zero Carbon champion within design team or external consultant. 2. PM identify project team responsibilities with lead designer / architect in order to achieve operational energy use targets; including the calculation of operational targets, documenting assumptions behind these, managing risks and validating in-use performance. 3. PM identify a project team member who can advise on demand response.	1. PM set of clear intent for Net Zero carbon targets and define what this includes, document boundaries and targets. 2. M&E to establish energy use intensity target, which aligns with this Design Standard recommendations, and embed within the brief. 3. M&E to discuss localised energy constraint issues with Distribution Network Operator. 4. M&E to identify likely eligible demand response programmes at a national and regional scale. 5. M&E to Incorporate data disclosure into BIM requirements.	1. M&E with architect to develop the concept design in accordance with critical design parameter recommendations in this guide. Specific aspects to consider at this stage include: •Building orientation •Building form factor •Likely occupancy patterns and operating scenarios •Facade glazing ratio •Technical systems integration. 2. M&E to develop a preliminary operational energy model aligned to the Energy Use Intensity targets. Use this model to guide design throughout RIBA 2. 3. M&E to implement the most significant carbon/ energy reduction measures in design including demand response and energy storage opportunities.	1. M&E to refine a full operational energy model for evaluation of predicted energy demand. Ensure this simulation goes beyond regulated energy and considers energy use from all items in the building. 2. M&E to test proposed design changes using the energy model. 3. M&E to update and document detailed targets and strategies to achieve these. Include design measures and assumptions of likely occupancy patterns and operating scenarios as well as strategies for long term adaptability. 4. M&E with Procurement to ensure proposed construction details are robust to support low energy and airtightness performance characteristics. 5. M&E to ensure that the risk of overheating has been assessed and mitigated. 6. M&E to develop demand response strategy and simulate potential impact.	1. M&E to update building energy model with latest design amendments and ensure that operational energy targets are being achieved. Document detailed targets and strategies to achieve these targets e.g. by creating a Building Performance Register. 2. Architect and M&E to confirm envelope specification and complete detail design, ensuring good continuity of insulation and airtightness. 3. M&E to iterate demand response model with exact design data to gain a more accurate prediction of carbon savings and monetary gains. Ensure that specified equipment can integrate fully to carry out demand response processes and events easily. 4. PM and M&E to include operational energy targets in the construction tender package, e.g. using a Design for Performance type of target and feedback loop. 5. PM with M&E incorporate in contractors' prelims with guarantees to recalculate energy model if items in the register are changed or value engineered, to demonstrate that 'as built' project meets agreed operational targets. 6. PM and M&E to create risk register and confirm responsibility for managing this during construction and commissioning.	1. PM where possible, ensure the appointment of a clerk of works is responsible for quality checks. 2. M&E to update energy model to account for any changes in the design or assumptions behind it and reject substitutions and omissions if achieving performance targets may be compromised by the changes. 3. PM to engage with the supply chain regarding the design targets of the project and where possible provide toolbox talks to help upskill contractors and to communicate the importance of quality construction. 4. PM with M&E input to ensure the contractor has quality monitoring processes in place to ensure proper installation of insulation, airtightness layer and mechanical equipment for the whole of the construction period. 5. Contractor carry out benchmark inspections to clarify quality expectations and continue to monitor construction quality, including in-situ thermal performance tests, thermographic and air tightness testing. 6. PM and M&E to ensure the contractor understands the commissioning requirements.	1. PM, M&E and Contractor to review final construction including rectification work, for quality, including in-situ thermal performance tests, thermographic and air tightness testing. 2. M&E to finalise as-built energy model to account for any changes in the design or assumptions behind it. 3. Contractor to ensure commissioning and testing is fully completed and witnessed and that the 'as installed' controls strategies, setpoints, commissioned flow rates, metering etc. are in line with the energy model. 4. Contractor to ensure the building user is trained and understands use of the building systems. 5. Contractor to ensure that planned demand response activities occur correctly as part of the commissioning process and that the initial setup parameters are recorded. 6. Contractor with M&E to ensure a suitably qualified individual understands the energy management and measurement systems. For further information regarding role and duties, refer to BBP better metering toolkit.	1. PM with FM to ensure for the first year of occupation both the building and the targets should be tuned to actual building usage patterns. Ensure a dual focus of improving accuracy of targets as well as improving building operation. 2. FM to ensure hourly energy consumption trends match operating hours. 3. FM to upload total energy and heating energy consumption data to a public data platform for first 5 years post-completion	Intentionally left blank	✓				

DESIGN GUIDE - PROCESS REQUIREMENTS

Topics	Applicability					Strategic definition, preparation and brief	Concept design	Developed design	Technical design	Construction	Handover and close out	In Use	Considerations	Interdependencies				
	Value				Gateway 1	Gateway 2	Gateway 3	Gateway 4	Gateway 4	Gateway 5	Gateway 6	None		CoLC				
	below £250k	£250k - £5m	£5m - £50m	Above £5m	RIBA 0	RIBA 1	RIBA 2	RIBA 3	RIBA 4	RIBA 5	RIBA 6	RIBA 7	Stakeholders involved / instructed	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement
Categories					✓	✓	✓	✓	✓	✓	✓	✓	Project Management					
					✓	✓							Client Senior Responsible Owner					
					✓	✓	✓						Building Surveying					
					✓	✓	✓	✓	✓	✓	✓	✓	Quantity Surveying					
						✓	✓	✓	✓	✓	✓		Architectural					
						✓	✓	✓	✓	✓	✓		Structural and Civil Engineering					
						✓	✓	✓	✓	✓	✓		Mechanical & Electrical Engineering					
							✓	✓	✓				Fire Engineering					
									✓	✓	✓	✓	Interior Design Services					
						✓	✓	✓					PassivHaus Design					
							✓	✓	✓				Transportation					
									✓	✓	✓	✓	Contractor					
LZC technologies		✓	✓	✓	1. PM identify project team responsibilities with lead designer / architect to achieve operational energy generation/ use targets and carbon emission reduction targets through the renewable source.	1. PM set clear intent for zero carbon targets and defi ne what this includes, document boundaries and targets. 2. M&E to set a renewable energy generation and carbon reduction target within the brief. 3. M&E to discuss localised energy constraint issues with DNO. 4. M&E to identify likely eligible demand response programmes at a national and regional scale. 5. Incorporation of data disclosure into BIM requirements.	1. M&E to complete a Low Zero Carbon feasibility study to establish the most appropriate LZC source for the building. 2. M&E to establish clear renewable energy generation and carbo reduction target, document targets and strategies to achieve this and share with all stakeholders.	1. M&E test proposed design changes using the energy model. 2. M&E update and document detailed targets and strategies to achieve these. Include design measures and assumptions of likely occupancy patterns and operating scenarios as well as strategies for long term adaptability. 3. M&E with Procurement ensure proposed construction details are robust to support low energy and airtightness performance characteristics.	1. M&E update building energy model with latest design amendments and ensure that operational energy targets are still being achieved. Document detailed targets and strategies to achieve these targets e.g. by creating a Building Performance Register. 2. PM and M&E include renewable energy generation and carbon reduction targets in the construction tender package, e.g. using a Design for Performance type of target and feedback loop. 3. PM and M&E input incorporate in contractors' prelims with guarantees to specify and installed the recommended LZC technology and to recalculate energy model if items in the register are changed or value engineered, to demonstrate that 'as built' project meets agreed operational targets.	1. PM to ensure where possible, ensure the appointment of a clerk of works is responsible for quality checks. 2. M&E to update energy model to account for any changes in the design or assumptions behind it and reject substitutions and omissions if achieving performance targets may be compromised by the changes. 3. PM to engage with the supply chain regarding the design targets of the project and where possible provide toolbox talks to help upskill contractors and to communicate the importance of quality construction. 4. PM and M&E to input ensure the contractor has quality monitoring processes in place to ensure proper installation or connection to the LZC technology for the whole of the construction period.	1. PM, M&E and Contractor to review final construction including rectification work, for quality and performance of the LZC. 2. M&E to finalise as-built energy model to account for any changes in the design or assumptions behind it. 3. Contractor to ensure the building user is trained on the LZC technology.	1. PM with FM to ensure for the first year of occupation both the building and the targets should be tuned to actual building usage patterns. Ensure a dual focus of improving accuracy of targets as well as improving building operation. 2. FM to ensure hourly energy consumption trends match operating hours. 3. FM to upload total energy and carbon data to a public data platform for first 5 years post-completion.	Intentionally left blank	✓				
Carbon reduction	✓	✓	✓	✓	1. PM identify a net zero carbon champion. 2. PM identify Carbon reduction options within the CoLC Guides.	1. PM set clear intent for zero carbon targets and define what this includes, document boundaries and targets.	1. M&E to implement the most significant carbon/energy reduction measures in design including demand response and energy storage opportunities. 2. PM to highlight the roles and opportunities for overcoming performance gap, for example by following the BSRIA Soft Landings Framework.	1. M&E and PM assess low carbon alternatives to the baseline. 2. PM agree a carbon reduction target – either percentage or absolute.	1. PM finalise carbon reduction option list. 2. M&E update building energy model with latest design amendments and ensure that operational energy targets are still being achieved. 2. M&E to calculate the BER in accordance with the National Calculation Methodology (NCM) and the Simplified Buildings Energy Model (SBEM) and report.	1. M&E to update energy model to account for any changes in the design or assumptions behind it and reject substitutions and omissions if achieving performance targets may be compromised by the changes. 2. Contractor achieve the agreed carbon reduction targets. 3. Contractor report as-built embodied carbon on a quarterly basis.	1. M&E finalise as-built energy model to account for any changes in the design or assumptions behind it 2. Contractor ensure commissioning and testing is fully completed and witnessed and that the 'as installed' controls strategies, setpoints, commissioned flow rates, metering etc. are in line with the energy model. 3. Contractor ensure the building user is trained and understands use of the building systems. 4. Contractor - where carbon reduction targets are not met, consider carbon removal options available.	1. PM with FM to ensure for the first year of occupation both the building and the targets should be tuned to actual building usage patterns. Ensure a dual focus of improving accuracy of targets as well as improving building operation. 2. FM to ensure hourly energy consumption trends match operating hours. 3. FM to upload total energy and heating energy consumption data to a public data platform for first 5 years post-completion. 4. PM report lessons learned, good practice to the CoLC. 5. Carbon reduction strategy to include in-use and end-of-life stage.	Intentionally left blank	✓	✓		✓	
Energy Efficiency	✓	✓	✓	✓	1. PM identify project team responsibilities to achieve operational energy use targets: •Calculation of operational targets •Documenting assumptions behind these •Managing risks •Validating in-use performance. 2. PM consider contractual incentives for achievement of performance targets. 3.PM identify project team member who can advise on demand response.	1. PM set energy use intensity target and embed in brief 2. M&E to discuss localised energy constraint issues with DNO 3. M&E to identify likely eligible demand response programmes at national and regional scale 4. M&E to incorporate data disclosure into BIM requirements	1. M&E to establish clear energy use targets, document targets and strategies to achieve this and share with stakeholders. 2. Develop concept design in line with critical design parameter recommendations. Aspects to consider include; •Building orientation, •Building form factor, •Facade glazing ratio, •Occupancy patterns and operating scenarios, •Technical systems integration. 3. M&E to develop preliminary operational energy model aligned with energy use intensity targets to guide throughout this stage. 4. M&E to use LETI Future of Heat Decision Tree when making decisions on heating and hot water systems. 5. M&E to implement most significant carbon/energy reduction measures in design including demand response and energy storage opportunities. 6. PM to highlight roles and opportunities for overcoming performance gap. 7. M& E to complete a passive design analysis.	1. M&E to refine a full operational energy model for evaluation of predicted energy demand, ensuring simulation goes beyond regulated energy and considers energy use from all items in the building. 2. M&E to test any proposed design changes using energy model. 3. M&E to update and document detailed targets and strategies to achieve these. Include design measures and assumptions of likely occupancy patterns and operating scenarios as well as strategies for long term adaptability. 4. M&E to ensure proposed construction details are robust to support low energy and airtightness performance characteristics. 5. M&E to ensure risk of overheating has been assessed and mitigated. 6. M&E to develop demand response strategy and simulate potential impact. 7. M&E to develop sub-metering strategy using LETI energy disclosure guidance. Heating and cooling energy consumption should be metered separately to enable fabric performance to be assessed. 8. M&E to establish secure remote source for metered data to be transmitted over communications network for aggregation and storage. 9. M&E to complete a Thermal Comfort Analysis in line with CIBSE AM11.	1. M&E to update building energy model with latest design amendments, ensure that operational energy targets are still being achieved. Document detailed targets and strategies to achieve targets. 2. Architect and M&E to confirm envelope specification and complete detail design, ensuring good continuity of insulation and airtightness. 3. M&E to check the suitability of the heating and hot water system using the LETI Future of Heat Decision Tree. Confirm HVAC systems type and performance specification. 4. M&E to iterate demand response model with exact design data to gain a more accurate prediction of carbon savings and monetary gains. Ensure that specified equipment can integrate fully to carry out demand response processes and events. 5. M&E to ensure specified metering is incorporated. 6. Include operational energy targets in the construction tender package. 7. M&E and PM to incorporate in contractors' prelims with guarantees to recalculate energy model if items in the register are changed or value engineered, to demonstrate that 'as built' project meets agreed operational targets. 8. PM to create risk register and confirm responsibility for managing this during construction and commissioning.	1. PM to ensure the appointment of a clerk of works is responsible for quality checks where possible. 2. M&E to update energy model to account for any changes in design or assumptions and reject substitutions and omissions if achieving performance targets may be compromised. 3. PM to engage with supply chain regarding the design targets of the project and where possible provide toolbox talks to help upskill contractors and to communicate importance of quality construction. 4. PM and M&E to ensure contractors understand commissioning requirements, including metering commissioning and validation of manual vs half hourly readings. 5. PM to ensure the contractor has quality monitoring processes in place to ensure proper installation of insulation, airtightness layer and mechanical equipment for the whole of the construction period. 6. Contractor to carry out benchmark inspections to clarify quality expectations and continue to monitor construction quality, including in-situ thermal performance tests, thermographic and air tightness testing. 7. PM and M&E to ensure the contractor understands commissioning requirements.	1. PM with Contractor review final construction including rectification work, for quality, including in-situ thermal performance tests, thermographic and air tightness testing. 2. M&E with Contractor finalise as-built energy model to account for any changes in the design or assumptions. 3. Contractor ensure commissioning and testing is fully completed and witnessed and that the 'as installed' controls strategies, setpoints, commissioned flow rates, metering etc. are in line with the energy model. 4. Contractor ensure the building user is trained and understands use of the building systems. 5. Contractor ensure that planned demand response activities occur correctly as part of the commissioning process and initial setup parameters are recorded. 6. Contractor ensure a suitably qualified individual understands the energy management and measurement systems. Refer to BBP better metering toolkit. 7. Contractor ensure that performance data from sensors and meters are reconciled with main meter spot meter and BMS readings and that logs are set up in BMS to facilitate long term monitoring of building performance.	1. FM - for the first year of occupation both the building and the targets should be tuned to actual building usage patterns. Ensure a dual focus of improving accuracy of targets as well as improving building operation. 2. FM ensure hourly energy consumption trends match operating hours. 3. FM ensure the metering system is operating correctly and is regularly validated against utility meters. 4. Fm identify and track key efficiency metrics. Aim to track the fewest but most useful metrics. 5. FM assign an annual budget for monitoring energy use and tuning controls in response. Aim for monthly review and quarterly 'deep dive' analysis. 6. FM line up energy efficiency assessments with post occupancy evaluation assessments to ensure occupant satisfaction with conditions in the building. 7. FM upload total energy and heating energy consumption data to a public data platform for first 5 years post-completion.	Intentionally left blank	✓				
Minimise Pollution	✓	✓	✓	✓	1. PM instruct specialist to carry out a contaminated land analysis, consider remediation options where there is a high degree of contamination. 2. PM instruct consultant to create a transport plan.	1. PM: Flood and surface water management – an appropriate consultant is appointed to carry out and demonstrate the developments compliance with BREEAM criteria. 2. PM: Site specific flood risk assessment taking into consideration current and future sources of flooding. 3. PM: All water pollution prevention systems to be designed in accordance with SuDs manual and other industry best practice. 4. PM: Refer to the contamination report and carry out remediation on the land where necessary.	1. PM use the LETI Future of Heat Decision Tree when making decisions on heating systems based on avoiding emitting noise, air and heat pollution. 2. PM with M&E - avoiding or reducing the impact of night time light pollution, through careful design and specification of light sources (BREEAM Pol 04) 3. PM with acoustician - BREEAM Pol 05 – reduction of noise pollution – avoiding or reducing the impact of external noise from the building developed. 4. PM instruct all water pollution prevention systems to be designed in accordance with SuDs manual and other industry best practice. 5. PM ensure at the design stage of assessment, where noise-sensitive areas or buildings are present , compliance can be demonstrated through the use of acousticians' calculations or by scale model investigations.	1. PM with SuDS Consultant - areas with a risk of contamination or spillage of substances have pollution prevention and separator systems.	1.PM with design team Implement the transport plan measures. 2.PM with SuDS consultant ensure compliance with the SuDS strategy.	1.M&E check compliance with the lighting strategy in line with the Guide's requirements. 2.PM review contractor's compliance with the Guide's requirements to minimise pollutions. 3.Contractor ensure SUDS manual are available for all building users.	1.Contractor provide training on all building systems.	1. FM record and test according toLocal Air Quality and POE subcategories Report lessons learned, good practice to the CoLC.	Intentionally left blank	✓				
Minimise carbon	✓	✓	✓	✓	1. PM identify a net zero carbon champion within design team or external consultant. 2. PM discuss whole life carbon ambitions with client.	1. PM set clear intent for GHG emission targets and define what this includes, document boundaries and targets. 2. M&E establish heating and hot water target, which aligns with this Design Standard recommendations, and embed within the brief.	1. M&E and Architect to consider use of low and zero carbon (LZC) technologies to minimise energy purchases and carbon emissions. Consider: • Building Integrated photovoltaic and solar hot water panels. • Ground, water and air source heat pumps and opportunities for heat recovery. • Heat and electricity storage, to improve load management and demands on mains supplies. • Local opportunities for wind and water power and for community systems.	1. M&E with Procurement ensure proposed construction details are robust to support low energy and airtightness performance characteristics. 2. Carbon consulatant produce whole life carbon budget, including total carbon emitted over lifespan of the building, carbon reduction target, and carbon reduction option list.	1. PM with M&E include heating and hot water targets and LZC technologies in the construction tender package e.g. using a Design for Performance type of target and feedback loop. 2. PM with M&E input incorporate in contractors' prelims with guarantees to recalculate energy model if items in the register are changed or value engineered, to demonstrate that 'as built' project meets agreed operational targets. Create risk register and confirm responsibility for managing this during construction and commissioning. 3. LCA specialist update WLC budget to include design development and finalise carbon reduction options list. 4. Architect and PM to ensure all transport options are included.	1. PM - Where possible, ensure the appointment of a clerk of works is responsible for quality checks. 2. PM engage with the supply chain regarding the design targets of the project and where possible provide toolbox talks to help upskill contractors and to communicate the importance of quality construction. 3. Contractor carry out benchmark inspections to clarify quality expectations and continue to monitor construction quality, including in-situ thermal performance tests, thermographic and air tightness testing. 4. PM ensure the contractor understands the commissioning requirements.	1. PM, M&E and Contractor review final construction including rectification work, for quality, including in-situ thermal performance tests, thermographic and air tightness testing. 3. Contractor ensure the building user is trained and understands use of the building systems. 4. Contractor to confirm the final carbon related data to the LCA specialist.	1. PM with FM - For the first year of occupation both the building and the targets should be tuned to actual building usage patterns. Ensure a dual focus of improving accuracy of targets as well as improving building operation. 2. FM - Ensure hourly energy consumption trends match operating hours. 3. FM upload total energy and heating energy consumption data to a public data platform for first 5 years post-completion 4. Report lessons learned, good practice to the CoLC. 5. Carbon reduction strategy to include in-use and end-of-life stage.	Intentionally left blank	✓	✓		✓	

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DESIGN GUIDE - PROCESS REQUIREMENTS

Topics	Applicability					Strategic definition, preparation and brief	Concept design	Developed design	Technical design	Construction	Handover and close out	In Use	Considerations
	Value				Gateway 1	Gateway 2	Gateway 3	Gateway 4	Gateway 4	Gateway 5	Gateway 6	None	Stakeholders involved / instructed
Categories	below £250k	£250k - £5m	£5m - £50m	Above £5m	RIBA 0	RIBA 1	RIBA 2	RIBA 3	RIBA 4	RIBA 5	RIBA 6	RIBA 7	
					✓	✓	✓	✓	✓	✓	✓	✓	Project Management
					✓	✓							Client Senior Responsible Owner
					✓	✓	✓						Building Surveying
					✓	✓	✓	✓	✓	✓	✓	✓	Quantity Surveying
						✓	✓	✓	✓	✓	✓		Architectural
						✓	✓	✓	✓	✓	✓		Structural and Civil Engineering
						✓	✓	✓	✓	✓	✓		Mechanical & Electrical Engineering
							✓	✓	✓				Fire Engineering
									✓	✓	✓	✓	Interior Design Services
						✓	✓	✓					PassivHaus Design
							✓	✓	✓				Transportation
									✓	✓	✓	✓	Contractor

Interdependencies — CoLC: Technologies | Whole Life Carbon | Climate Impact Modelling (resilience) | Circular Economy | Procurement

Circular economy	below £250k	£250k - £5m	£5m - £50m	Above £5m	RIBA 0	RIBA 1	RIBA 2	RIBA 3	RIBA 4	RIBA 5	RIBA 6	RIBA 7	Considerations	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement
Decommissioning	✓	✓	✓	✓	1. PM review of relevant Post Occupancy Evaluation Feedback from previous projects.	1. Design team to conduct a study to explore decommissioning options: a. assessing an existing building to decide if it can be refurbished / adapted to meet the project objectives to inform the general approach to project delivery. b. PM: Decommissioning pre-existing buildings, followed by provision of considerations / design guidance to facilitate the future decommissioning of the new building. The study should consider the following as a minimum: •Accessibility (see Functional adaptation strategy study). •Durability: use materials which require less frequent maintenance, repair or replacement, considering them within the context of the life span of the building. •Exposed and reversible connections: making the connections more visible provides opportunities to optimise material and product reuse. Welded connections prohibit disassembly and it is preferable to use screws and bolts to allow for disassembly and material re-use. •Layer independence: designing building systems and components in layers so that removal, adjustment or replacement of some elements is feasible, especially when different components have different life spans and maintenance needs. •Avoidance of unnecessary toxic treatments and finishes. Some finishes can contaminate the substrate in a way that they are no longer reusable or recyclable. This should be avoided unless finishes serve a specific purpose. •Standardisation can accommodate reuse and upgrading. It involves aspects such as dimensions, components, connections and modularity. 2. PM instruct demolition contractor to carry out a pre-demolition audit where necessary.	1. PM - the design to allow for functional adaptation. 2. Pre-demolition audit to consider circular economy principles. PM to set re-use and recycle targets.	**1- The design team to review the functional adaptation measures, to ensure they can be implemented. 2. PM with design team identify Circular Economy opportunities / evaluate / integrate into design where appropriate.**	1. Design team - functional adaptation implementation will be specific to the building and scope of the project, but information should be made available to the assessor covering: •Options for multiple building uses and area functions based on design details, e.g. modularity. •Routes and methods for major plant replacement, e.g. networks and connections have flexibility and capacity for expansion. •Accessibility for local plant and service distribution routes, e.g. detailed information on building conduits and connections infrastructure. •The potential for the building to be extended, horizontally or vertically. 2. Design tean identify Circular Economy opportunities / evaluate / integrate into design where appropriate	1. Contractor to implement and report on the re-used and recycled demolition waste i.e. materials, sinks, window and door frames, etc. 2. PM to ensure contractors understand requirements / use contractual obligations to establish minimum performance requirements (e.g. reuse %) / encourage better performance 3. PM to justify any diversion from the functional adaptability measures introduced at Design.	1. Contractor to create a adaptability and disassembly guide for future building users.	1. Contractor to train building user on asset characteristics allowing functional adaptability and disassembly.	Intentionally left blank		✓		✓	
Circular economy	✓	✓	✓	✓	1. PM: Stage 0 commences again once a building has reached end of life. Circular Economy principles may be used to prolong building's life or facilitate a new use. Where neither is possible, the deconstruction of the building will be undertaken after a new use for the site has been commissioned. 2. PM: The client's requirements and aspirations with regard to the building's level of sustainability, such as embracing specific CE principles, need to be communicated clearly to the design team. 3.PM: The CE design principles should inform the design team and determine the design approaches adopted.	1. Design team may be asked to produce test fits to assess other possible uses for construction elements. 2. PM: Means of disassembling building are made clear within the Construction Strategy.	1. Design team or sustainability advisor to complete CE targets and commitments' table in the CE statement template spreadsheet. 2. PM - The London Plan Policy SI 7 (A) targets should be st as a minimum level of compliance for the committed target. 3. After on-site opportunities have been exhausted, applicants should refer to the London Waste Map to consider opportunities for using local sites to manage materials and waste. PM for further info see section 4.2 in GLA CE Statement. 4. QS estimate Bill of Materials including calculations. For further info see section 4.7 in GLA CE Statement. 5. Applicants should complete and submit a pre-redevelopment audit as supporting evidence to their CE statements, where a robust in-depth assessment has not already been completed. For further info see section 4.6 in GLA CE Statement. 6. To comply with London Plan Policy SI 7(B), applicants should complete a Recycling and Waste estimate table in the CE statement template at outline and full planning application stages for module stages A to C. For further info see section 4.9 in GLA CE Statement.	1. PM with design team - the six CE principles should inform the design of the development and be used to determine the design approaches adopted. 2. Applicants should set out where they are retaining and refurbishing a building that might otherwise be demolished. Where adaptability is selected as a design approach, information should be submitted showing how the building can be adapted for different uses. For further info see section2.3, 2.5, 4.3 in GLA CE Statement. 3. For all applications, applicants should complete the 'circular economy design principles by building layer' table. Multiple CE design approaches will often be needed for each building layer or element. For further info see section 4.5 in GLA CE Statement.	1. Architect submit Bill of Materials including calculations. For further info see section 4.7 in GLA CE Statement. 2. The Bill of Materials should include assumptions on the end-of-life scenarios for each building element or material. Based on the approaches adopted and how the building and its elements have been designed to facilitate reuse or recycling, an end-of-life scenario should be described. For example, 'assumed 90 per cent reusable', 10 per cent 'business as usual BAU)'. For further info see section 4.7 in GLA CE Statement.	1. PM inspections are required to confirm that the contractor is meeting Construction Quality requirements. The information gathered must be sufficient to allow Building Systems to be repurposed effectively at the end of the building's life. 2. To comply with London Plan Policy SI 7(B), applicants should complete the actual Recycling and Waste table in the CE statement template at outline and full planning application stages for module stages A to C. For further info see section 4.9 in GLA CE Statement.	**1. Contractor to report actual Recycling and Waste table in the CE statement template at outline and full planning application stages for module stages A to C. For further info see section 4.9 in GLA CE Statement.**	1. FM - when building has reached end of life, it must be refurbished, repurposed for another use or deconstructed. 2. At post-construction stage, applicants should complete the 'key achievements' and 'lessons learnt' tables. This should: •Highlight actual performance against quantitative and qualitative targets/commitments. •Describe reasons for any differences. •Share key learnings that could inform best practice in the future. For further info see section 4.10 in GLA CE Statement.	Intentionally left blank		✓		✓	✓
Resource efficiency	✓	✓	✓	✓	1. PM: At Project Briefing (RIBA 0) – Review opportunities for reuse and retention of existing buildings, prioritising reuse. 2. PM: Where partial or complete demolition is proposed, the materials already on-site should be reviewed for their potential retention and inclusion into the proposed scheme before off-site options are considered.	1. At Project Briefing stage (RIBA 1) – Architect shall undertake feasibility on building retention and re-use and advise whether brief can be met by using existing building.	1. At Outline options (RIBA 2) – Contractor to undertake pre-demolition / pre-refurbishment audit to identify opportunities for building re-use. This will direct which building elements need to be replaced and therefore assessed from an embodied carbon perspective. A pre-demolition contractor shall be appointed at this stage to identify opportunities for building re-use. 2. Architect to conduct a study to explore the ease of disassembly and the functional adaptation and develop recommendations or design solution.	1. Contractor to implement the Site Waste Management Plan and review the construction waste targets. See City's Code of Practice for Deconstruction and Construction Sites 9th Edition 2019 (currently being updated). 2. Architect to review the design to ensure the correct recycled quantity for material has been specified and use recycled aggregates where possible. Reuse of materials should also be considered.	1. Architect to provide an update on how the adaptability recommendation have been implemented.	**1. Architect to produce a building adaptability and disassembly guide to communicate the characteristics allowing functional adaptability and disassembly to prospective tenants. 2. Consider incorporating a material passport.**	1. Contractor to report on the final quantity of waste produces per 100m2. 2. Contractor to report the final quantity of construction waste, diverted from Landfill and wither re-used or recycle.	N/A	Intentionally left blank		✓		✓	✓

DESIGN GUIDE - PROCESS REQUIREMENTS

Categories – Stakeholders involved / instructed	RIBA 0 (Gateway 1)	Strategic definition, preparation and brief – RIBA 1 (Gateway 2)	Concept design – RIBA 2 (Gateway 3)	Developed design – RIBA 3 (Gateway 4)	Technical design – RIBA 4 (Gateway 4)	Construction – RIBA 5 (Gateway 5)	Handover and close out – RIBA 6 (Gateway 6)	In Use – RIBA 7 (None)
Project Management	✓	✓	✓	✓	✓	✓	✓	✓
Client Senior Responsible Owner	✓	✓						
Building Surveying	✓	✓	✓					
Quantity Surveying	✓	✓	✓	✓	✓	✓	✓	✓
Architectural		✓	✓	✓	✓	✓	✓	
Structural and Civil Engineering		✓	✓	✓	✓	✓	✓	
Mechanical & Electrical Engineering		✓	✓	✓	✓	✓	✓	
Fire Engineering			✓	✓	✓			
Interior Design Services					✓	✓	✓	✓
PassivHaus Design		✓	✓	✓				
Transportation			✓	✓	✓			
Contractor					✓	✓	✓	✓

Topics – Materials	below £250k	£250k - £5m	£5m - £50m	Above £5m	RIBA 0	RIBA 1	RIBA 2	RIBA 3	RIBA 4	RIBA 5	RIBA 6	RIBA 7	Considerations	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement
Low impact materials (insulation, fabric)	✓	✓	✓	✓	1. PM review opportunity for retention of existing. structure and building fabric and how the quantum of materials of the new build can be reduced.	1. PM prioritise ethical and responsible sourcing of all materials. 2. Architect prioritise low embodied carbon and healthy materials. 3. Architect minimise materials with high embodied energy impacts. 4. Architect promote use of local natural materials.	1. Design team to incorporate re-used materials and design. building for disassembly to allow continued material re-use for future buildings.	1. Design team to assess design for material efficiency and to determine if all materials incorporated are necessary. 2. Architect use material guides to optimise material specification, as well as CoLC specific guides for materials (FM and Capital Build).	1. Architect use material guides to optimise material specification. 2. Architect review alternative products and materials selections proposed by the contractor against technical and performance standards and against the whole life carbon requirements.	1. Contractor and architect to ensure that all construction material delivered and used on site are inline with the sustainable procurement plan and are as specified in RIBA 1 and 2.	1. Contractor undertake post completion analysis using as-built information to assess the material used and ensure the design principles have been adhered to.	1. Pm / FM - recommendations regarding low impact material strategy over the in-use stage should be followed throughout building life cycle in case of any refurbishment or replacement.	Intentionally left blank				✓	✓
Procurement of materials	✓	✓	✓	✓	1. PM with structuresd review opportunity for retention of existing structure and building. 2. Review CoLC Procurement Code and the Responsible Procurement Policy.	1. PM put in place a sustainable procurement plan. 2. PM note requirements for ethical sourcing.	1. PM to Include sustainability aims, objectives and strategic targets to guide procurement activities.	1. PM or contractor to review details of procedures in place to check and verify the effective implementation of the sustainable procurement plan.	1. PM with architect analyse the environmental credentials for procurement options. 2. PM with architec prioritise ethical and responsible sourcing of materials. 3. PM obtain local materials and where possible, re-used / recycled materials.	1. Contractor receive construction carbon data and verify the environmental credentials. 2. Contractor to review material used to ensure that sustainable procurement plan will be adhered to.	1. Contractor undertake post completion analysis using as-built information to gauge compliance with the sustainable procurement plan.	1. PM and procurement team identify the risks and opportunities of procurement against a broad range of social, environmental and economic issues and report lessons learned to CoLC.	Intentionally left blank				✓	✓
Material durability	✓	✓	✓	✓	N/A	N/A	1. When the Design team is considering the durability of a material, they should also consider how the product can be disassembled, to allow for the future use of materials and products. 2. PM and QS note - additional coatings for durability should be avoided, as they can reduce the recyclability of the material.	1. The design team should demonstrate that they have carefully considered the drainage mechanisms of the façade and roof. 2. Design team - key exposed building elements have been designed and specified to limit long and short term degradation.	N/A	N/A	1. PM with Contractor review to ensure that the design team's recommendations have been implemented.	1. FM - regular maintenance is to be carried out in accordance with the manufacturers recommendations to ensure the full life span of the product.	Intentionally left blank				✓	
Modern methods of construction (MMC)		✓	✓	✓	1. PM determine the type of MMC that will be deployed using the MMC framework document issued by the GLA.	1. PM instruct consultant to assess the environmental impact, for example the carbon emissions equivalent of each material/ product and process, and calculate the overall carbon footprint.	1. PM with design team provide more detailed analysis of the options around the key building elements (structure, floors, fabric) and the relationship with the building's proposed performance. 2. Carbon consultant identify opportunities to reduce embodied carbon and whole life carbon with the design/project team.	1. Carbon consultant complete in depth analysis of building components, identify materials, products and lifespans to generate a whole life carbon budget baseline. 2. Carbon consultant assess low carbon alternatives and agree carbon reduction target (percentage or absolute). 3. Carbon consultant produce whole life carbon budget, including total carbon emitted over lifespan of the building, carbon reduction target, and carbon reduction option list.	1. Carbon consultant finalise carbon reduction option list. 2. PM set targets within the Main Contractor's Employer's Requirement and/or pre-procurement Request for Information to suppliers to collect carbon data to provide a supplementary information for supplier selection.	1. Contractor achieve the agreed carbon reduction targets. 2. Contractor report as-built embodied carbon on a quarterly basis.	1. Contractor to confirm the final carbon related data to the LCA specialist. 2. Contractor to issue to the client a practical completion carbon report which should align design stage carbon targets with what was achieved at the end of construction.	1. PM report lessons learned, good practice to the CoLC. 2. Carbon reduction strategy to include in-use and end-of-life stage.	Intentionally left blank		✓		✓	✓

Interdependencies: CoLC

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DESIGN GUIDE - PROCESS REQUIREMENTS

Topics	Applicability					Strategic definition, preparation and brief	Concept design	Developed design	Technical design	Construction	Handover and close out	In Use	Considerations	Interdependencies				
	Value				Gateway 1	Gateway 2	Gateway 3	Gateway 4	Gateway 4	Gateway 5	Gateway 6	None		CoLC				
					RIBA 0	RIBA 1	RIBA 2	RIBA 3	RIBA 4	RIBA 5	RIBA 6	RIBA 7	Stakeholders involved / instructed	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement
Categories	below £250k	£250k - £5m	£5m - £50m	Above £5m														
					✓	✓	✓	✓	✓	✓	✓	✓	Project Management					
					✓	✓							Client Senior Responsible Owner					
					✓	✓	✓						Building Surveying					
					✓	✓	✓	✓	✓	✓	✓	✓	Quantity Surveying					
						✓	✓	✓	✓	✓	✓		Architectural					
						✓	✓	✓	✓	✓	✓		Structural and Civil Engineering					
						✓	✓	✓	✓	✓	✓		Mechanical & Electrical Engineering					
							✓	✓	✓				Fire Engineering					
									✓	✓	✓	✓	Interior Design Services					
						✓	✓	✓					PassivHaus Design					
							✓	✓	✓				Transportation					
									✓	✓	✓	✓	Contractor					
Resilience																		
Climate change adaptation	✓	✓	✓	✓	1.PM uUse evidence from the local authority and statutory bodies to understand the known and predicted impacts of climate change on the site. 2. PM instruct consultant to carry out a microclimatic simulation or study to show the effect of urban morphology on the external microclimate of the development and surrounding area. 3. PM identify Project Outcomes and define Client Requirements in relation to conservation (e.g., minimising harm to historic fabric, preservation or conservation or bring into active use).	1. Consultant develop intervention measures for assets based on the actions taken at stage 0 to mitigate the identified impact of climate change. 2. Consultant asses available Heat Stress, Pluvial and Fluvial Flood data, both current and forecast, and understand the possible impact on the site. This will use the GIS hosted platform to show assets with their anticipated exposure to climate impacts and the recommended mitigation measures being developed as part of the climate impact modelling workstream.	1. PM with relevant consultants develop interventions based on the actions taken at Stage 0 to mitigate the identified impact of climate change. 2. PM evaluate site information to date for the historic fabric and identify sensitivity, significance, condition and threats. 3. Appoitned consultants produce measured and condition surveys and historic development drawings, and develop a historic building analysis to inform the architectural concept. 4. M&E develop the concept design in accordance with critical design parameter recommendations for overheating in the LETI guide. Specific aspects to consider for overheating at this stage include: •Building orientation •Building form factor •Facade glazing ratio •Likely occupancy patterns and operating scenarios •Facade glazing ratio •Technical systems integration	1. Design team to assess the design for resilience of the structure, fabric, building service and other installations. 2. M&E ensure that the risk of overheating has been assessed and mitigated. Conduct detailed HVAC Thermal modelling such as IES and ApacheHVAC.	1. Appointed consultants complete practicable intrusive surveys and identify the requirement for any future surveys. 2. Architect undertake technical design, including final specifications and material sourcing, for building conservation. 3. PM with design team prepare and coordinate specialist subcontractors' and conservators' information including final specifications, embedding conservation strategy. 4. Architect confirm envelope specification and complete detail design, ensuring good continuity of insulation and airtightness. 5. M&E check the suitability of the heating and hot water system using the LETI Future of Heat Decision Tree. Confirm HVAC systems type and performance specification. 5. Design team to provide an updated design to demonstrate how the recommendations or solutions proposed at Concept Design have been implemented where practical and cost effective. 6. PM to justify omissions.	1. Contractor to ensure that the climate change adaptation strategy and relevant design solutions are being implemented as and when necessary. 2. Contractor implement any requirements for protecting the historic or sensitive building fabric during construction including temporary works and commissioning of the building. 3. PM ensure the contractor has quality monitoring processes in place to ensure proper installation of insulation, airtightness layer and mechanical equipment for the whole of the construction period. 4. Contractor carry out benchmark inspections to clarify quality expectations and continue to monitor construction quality, including in-situ thermal performance tests, thermographic and air tightness testing. 5. PM to review alternative designs proposed by the contractor to ensure that they meet the climate adaptation strategy.	1. Contractor implement any requirements for protecting the historic or sensitive building fabric during any seasonal commissioning. 2. PM with contractor review final construction including rectification work, for quality, including in-situ thermal performance tests, thermographic and air tightness testing. 3. PM to undertake post completion analysis using as-built information to assess asset performance against extreme weather events and climate change.	1. FM put in place appointments to maintain historic fabric and execute conservation management plan. 2. FM carry out ongoing quadrennial inspections as required. 3. FM carry out regular maintenance of building fabric.	Intentionally left blank	✓		✓		
Biodiversity, ecology and conservation	✓	✓	✓	✓	1. Ecologist begin initial Site Appraisals including investigations and research, to identify significance, sensitivity, and conservation-related project risks (e.g., protected wildlife, materials containing lead and asbestos) which may affect the delivery of Client Requirements. 2. Ecologist define whether any specialist conservation expertise is needed in the client team.	1. Ecologist undertake specialist Site Surveys and appraisal of conservation area or opportunity for biodiversity net gain. 2. Ecologist identify specialist conservation, biodiversity and ecology Project Stakeholder interest and any future surveys necessary. Undertake consultation and respond to feedback in Project Brief. 3. Ecologist use Feasibility Studies to test the Client Requirements in relation to biodiversity, ecology and conservation and discuss options with relevant stakeholders. 4. PM and Ecologist assess the impact of the project on significance and draft a statement of significance to inform Quality Aspirations, Project Brief, Procurement Strategy and Design Programme. 5. Ecologist and PM identify conservation, ecology and biodiversity knowledge, skills and experience required in the design team and include within Responsibility Matrix. 6. Ecologist: If completing a BREEAM Assessment ensure LE02 credit completed and a site survey and evaluation completed along with site-wide outcomes looking at the risks and opportunities with the site. 7. Design or client decision confirmed for site selection surrounding previously occupied land.	1. PM with Ecologist - the Risks and opportunities of the site should be fully identified via the surveys and evaluation carried out within the preparation and brief stage. Any changes to the design based on introducing more surveys & evaluations to determine site wide outcomes will be costly at this stage. 2. Ecologist - further planning to avoid and manage negative ecological impacts on site is carried out early enough to influence the concept design stage and design brief. The negative impacts are managed according to the mitigation hierarchy and no overall loss of ecological value has occurred.	N/A	1. PM prepare and coordinate specialist subcontractors' and conservators' information including final specifications, embedding conservation strategy, biodiversity strategy and ecology management plan (where appropriate).	1. Contractor with ecologist update conservation management plan.	N/A	1. Contractor complete obligations under protected species licenses (e.g., bat license).	Intentionally left blank			✓		
Flood resilience		✓	✓	✓	N/A	1. Consultant conduct a systematic risk assessment to identify the impact of expected extreme weather conditions arising from climate change on the building over its projected life cycle. The assessment covers the installation of building services and renewable systems, as well as structural and fabric resilience aspects and includes: •Flood and surface water management – an appropriate consultant is appointed to carry out and demonstrate the developments compliance with BREEAM criteria. •Site specific flood risk assessment taking into consideration current and future sources of flooding •All water pollution prevention systems to be designed in accordance with SuDs manual and other industry best practice.	1. Design team to develop recommendations or solutions based on the climate change adaptation strategy appraisal, before or during Concept Design, that aim to mitigate the flooding and surface water run off risks. 2. Design team to ensure the following based on findings and recommendations; •Surface water run-off design solutions must be bespoke, i.e. they must take account of the specific site requirements and natural or man-made environment of and surrounding the site. The priority levels detailed in the Methodology must be followed, with justification given by the appropriate consultant where water is allowed to leave the site •All water pollution prevention systems to be designed in accordance with SuDs manual and other industry best practice. •The ground level of the building and access to both the building and the site, are designed (or zoned) so they are at least 600mm above the design flood level of the site's flood zone (see 600mm threshold) •The final design of the building and the wider site reflects the recommendations made by an appropriate consultant in accordance with the hierarchy approach outlined in section 5 of BS 8533:2017.	1. Architect to confirm design specifications and complete detailed design in line with guidelines stated in the requirements.	1. Contractor to ensure relevant maintenance agreements for the ownership, long term operation and maintenance of all specified Sustainable Drainage Systems (SuDS) are in place. 2. Design team to provide an update during Technical Design demonstrating how the recommendations or solutions proposed at Concept Design have been implemented where practical and cost effective.	1. Contractor to ensure that the climate change adaptation strategy and relevant design solution are being implemented as and when necessary.	1. Design team to review and investigate the completed building site to ensure compliance with the design. 2. Any deviation is reported and justified.	1. FM - SuDS and other infrastructures are regularly maintained. 2. Appointed consultant complete flood risk assessment to understand the level of flooding and surface water run offs.	Intentionally left blank			✓		
Local air quality	✓	✓	✓	✓	1. Consultant create a transport plan	1. M&E / consultant to identify whether the site is within a local authority air quality management area. 2. PM instruct and ensure an Air Quality Impact Assessments is provided as applicable. 3. PM review with consultant / M&E on whether to conduct an Environmental Impact Assessment Screening Matrix checklist surrounding the possible impacts of the proposed development to air pollution.	1. PM appoint Transport consultant to undertake a site-specific transport assessment (or develop a travel statement) and draft travel plan, which can demonstrably be used to influence the site layout and built form 2. Following a transport assessment (in accordance with the requirements set out in criteria, and develop a site-specific travel plan that provides a long term management strategy which encourages more sustainable travel. 3. PM and M&E use the LETI Future of Heat Decision Tree when making decisions on heating systems based on avoiding emitting air pollution.	1. M&E identify heating and hot water appliances that do not exceed that NOx, PM and carcinogenic levels identified by BREEAM. 2. The design team and M&E should ensure these products are included in the design. 3. M&E ensure all systems have a leak detection system	N/A	1. Air quality consultant conduct interim air quality inspections to identify if the measures in place to minimise pollution from travel, and HVAC systems are working correctly.	N/A	1. Air quality consultant complete post-construction testing and inspection of local air quality. 2. Air quality consultant undertake an annual assessment of air quality to ensure levels of nitrogen dioxide in 90% of the Square Mile meet health-based Limit Values and WHO Guidelines by 2025.	Intentionally left blank	✓	✓			
Passive design	✓	✓	✓	✓	1. PM: A microclimatic simulation or study shows the effect of urban morphology on the external microclimate of the development and surrounding area.	1. PM with consultant / MEP evaluate site information to date and design to minimise the adverse conditions including negative microclimatic factors. 2. Architect produce measured and condition surveys and historic development drawings, and develop a historic building analysis to inform the architectural concept. e.g. wall insulation, energy efficient systems, green roof and walls. 3. Architect and MEP design out heat by reviewing building design, waste heat and including green and blue infrastructure into the design.	1. PM with Architect develop in accordance with critical design parameter recommendations in this guide. Specific aspects to consider at this stage include: •Building orientation •Building form factor •Facade glazing ratio •Likely occupancy patterns and operating scenarios •Technical systems integration 2. M&E use the LETI Future of Heat Decision Tree when making decisions on heating and hot water systems. 3. M&E with PM implement the most significant carbon/energy reduction measures in design including demand response and energy storage opportunities.	1. M&E and Architect update and document detailed targets and strategies to achieve passive measures. Include design measures and assumptions of likely occupancy patterns and operating scenarios as well as strategies for long term adaptability. 2. M&E ensure proposed construction details are robust to support low energy and airtightness performance characteristics. 3. M&E ensure that the risk of overheating and heat island effect has been assessed and mitigated.	1. Architect confirm envelope specification and complete detail design, ensuring good continuity of insulation and airtightness.	1. PM ensure the contractor has quality monitoring processes in place to ensure proper installation of insulation, airtightness layer and mechanical equipment for the whole of the construction period. 2. Contractor carry out benchmark inspections to clarify quality expectations and continue to monitor construction quality, including in-situ thermal performance tests, thermographic and air tightness testing. 3. PM to engage with contractors to ensure that the greenery is protected during construction.	1. PM with contracotr review final construction including rectification work, for quality, including in-situ thermal performance tests, thermographic and air tightness testing.	1. FM ensure commissioning and testing is fully completed and witnessed and that the 'as installed' controls strategies, setpoints, commissioned flow rates, metering etc. are in line with the energy model. 2. Contractor and FM ensure the building user is trained and understands use of the building systems.	Intentionally left blank	✓		✓		

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DESIGN GUIDE - PROCESS REQUIREMENTS

Topics		Strategic definition, preparation and brief	Concept design	Developed design	Technical design	Construction	Handover and close out	In Use
	Gateway 1	Gateway 2	Gateway 3	Gateway 4	Gateway 4	Gateway 5	Gateway 6	None
Considerations: Stakeholders involved / instructed	RIBA 0	RIBA 1	RIBA 2	RIBA 3	RIBA 4	RIBA 5	RIBA 6	RIBA 7
Project Management	✓	✓	✓	✓	✓	✓	✓	✓
Client Senior Responsible Owner	✓	✓						
Building Surveying	✓	✓	✓					
Quantity Surveying	✓	✓	✓	✓	✓	✓	✓	✓
Architectural		✓	✓	✓	✓	✓	✓	
Structural and Civil Engineering		✓	✓	✓	✓	✓	✓	
Mechanical & Electrical Engineering		✓	✓	✓	✓	✓	✓	
Fire Engineering			✓	✓	✓			
Interior Design Services					✓	✓	✓	✓
PassivHaus Design		✓	✓	✓				
Transportation			✓	✓	✓			
Contractor					✓	✓	✓	✓

Applicability – Value: below £250k | £250k - £5m | £5m - £50m | Above £5m

Interdependencies – CoLC: Technologies | Whole Life Carbon | Climate Impact Modelling (resilience) | Circular Economy | Procurement

Wellbeing

Categories	below £250k	£250k - £5m	£5m - £50m	Above £5m	RIBA 0	RIBA 1	RIBA 2	RIBA 3	RIBA 4	RIBA 5	RIBA 6	RIBA 7	Considerations	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement
Community centric approach	✓	✓	✓	✓	1. PM identify and understand final occupants' needs to help establish appropriate health and wellbeing metrics. 2. Designer consider connection to external spaces, occupancy, daylight and thermal comfort, air quality (including healthy materials), user needs and operational energy when selecting the site or developing the Project Brief. 3. PM identify opportunities to enhance existing socia and community structures through the development. Including place making, community involvement, amenity and opportunities for meanwhile use in the developing design.	1.PM and MEP iInclude requirements for internal environmental conditions, including thermal comfort and overheating, visual and acoustic comfort, spatia needs, ventilation type, control strategies and relationships to external environments in the design pack 2. Architect consider place making, privacy, social interaction, mixed use places, community, amenity, involvement and inclusion and community consultation 3. PM include outcome targets for social value in the Project Brief. 4. PM , MEP and Consultant consider health and wellbeing alongside the energy strategy. 5. PM include an approach to active circulation.	1. PM develop an overview of the internal environmental conditions and seasonal occupant control strategies. 2. PM with architect review the design against outcomes, including daylight, controls, social spaces and inclusivity. 3. Architect iIncorporate strategies for place making, privacy, social interaction, safety, mixed use places, community involvement, inclusion and amenity and opportunities for meanwhile use into the developing design. 4. PM consider the need for and scale of private, semi-private and public external space. 5. Developer to carry out a site contamination appraisal	1. PM coordinate proposals to deliver Sustainability Outcomes for health and wellbeing including daylighting, indoor air quality (including healthy materials), responsive controls and visual, thermal and acoustic comfort. 2. M&E consider the artificial lighting and daylighting strategy. Review environmental controls, ensuring that they are simple and intuitive and supportive of the wider Sustainability Strategy and Sustainability Outcomes. 3. PM encourage active circulation and travel. 4.PM coordinate proposals to deliver Sustainability Outcomes for social and economic aims, including place making, privacy, social interaction, safety, mixed use places, community involvement, inclusion and amenity and opportunities for meanwhile use in to the developing design	1. M&E illustrate how the proposals deliver Sustainability Outcomes for health and wellbeing, including daylighting, indoor air quality (through healthy materials and other means), responsive controls and visual, thermal and acoustic comfort. 2. M&E develop the Building Manual, illustrating user interaction with the building. 3. PM integrate social and economic aims into the technical design, including outcomes for place making, privacy, social interaction, safety, mixed use places, community involvement, inclusion and amenity, and opportunities for meanwhile use 4. Contractor to ensure that the remediation strategy recommended in the contamination appraisal has been implemented.	1. Pm with contractor check that quality and installation are in line with Sustainability Outcomes for health and wellbeing, inclusivity and accessibility. 2. M&E with contractor include visual, acoustic and thermal comfort measures. Verify location, type and function of controls and M&E installations. 3. PM check the sustainable communities strategy is delivered on site, including place making, privacy, social interaction, safety, mixed use places, community involvement, inclusion and amenity. 4. Developer / contractor to review the construction impact and consider reduction and mitigation options.	1. Contracotr support the assessment of Sustainability Outcomes for wellbeing, including assisting with user training and dissemination of the Building Manual. 2. Contractor support the assessment of Sustainability Outcomes for social value. Ensure aspects of place making, space for social interaction, inclusion, etc are in place.	1. FM gather occupant feedback data to measure subjective aspects. Monitoring equipment used for quantitative metrics, such as daylight. 2. FM gather POE data to test the social value performance. The Social Value Toolkit or similar can be used to quantify efficacy of measures.	Intentionally left blank	✓		✓		
WELL type requirements (noise, air quality, accessibility, etc.)		✓	✓	✓	1. PM and Architect identify Project Outcomes and Client Requirements in relation to inclusive design. 2. PM instruct architect / consultant to undertake an access and inclusion audit of the existing site or environment to identify any Project Risks which may affect the delivery of the Client Requirements for inclusive design. 3. PM instruct consultant to identify relevant current and emerging global, European, national and local inclusive design-related trends, policy and legislation. 4. PM review feedback from previous projects. 5. PM define whether specialist inclusive design expertise is needed in the client team.	1. PM and Architect identify inclusive design needs from stakeholders, consultation groups, site audits, design standards and legislative obligations, and include in Design Brief. 2. PM source site information including site surveys relevant to inclusive design. 3.PM work with architect / consultant to use feasibility studies to verify that inclusive design needs can be accommodated within the project budget. 4. PM identify whether specialist inclusive design expert is required within the design team, include within responsibility matrix and appoint consultants e.g. WELL AP.	1. PM with architect develop the inclusive design concept and review against the project brief, input from specialist consultants, stakeholder consultation feedback and local planning authority accessibility needs. 2. Architect incorporate inclusive design concept into architectural concept and outline specification, and strategic engineering's requirements. 3. PM to include a record of key inclusive design decisions in stage report. 4. PM and design team to agree on applicable WELL v2 categories and identify the measures to achieve the necessary benchmarks.	1. Architect to undertake review of Part M of the building regulations and the Equality Act. 2. PM and architect undertake design studies and engineering analysis to test and develop inclusive design requirements in more detail with input from project stakeholders. 3. Architect integrate inclusive design considerations into a specially coordinated design aligned to stakeholder consultation feedback. 4. PM and architect identify and record project risks to inclusive design and mitigate any deviation for inclusion in stage report. 5. Architect prepare and submit design and access statement as part of planning application.	1. Design team undertake technical design, including final specifications, to manufacture and construct inclusive building. 2. PM coordinate design team and specialist subcontractors' manufacturing information, construction information, and final specifications, embedding the inclusive design requirements and other project strategies. 3. PM include inclusive design requirements in tender information or employer's requirements and review tende returns or contractors. 4. PM and architect address the Equality Act and Building Regulations Part M requirements and submit a building regulations applications.	1. PM and contractor manufacture, construct and commission inclusive design measures, informing operatives of the importance of proper workmanship and regularly inspecting the construction quality. 2. Contractor resolve inclusive design site queries 3. Contractor prepare appropriate access information for end users and occupiers for inclusion in the building manual.	1. Contractor hand over inclusive design informatior in the building manual to the client including the inclusive design principles and measures. 2. PM and contractor review project performance against learn lessons from feedback gathered on design and construction to meet the needs of all building users. 3. Contractor provide induction and training for building users and facilities management team with reference to inclusive building strategy, including disability awareness and access auditing. 4. Contractor close out any new relevant defects that arise during this period. 5. Contractor / aftercare team undertake light touch POE to gather feedback on how building is performing and addressing user needs. 6. PM organise necessary site inspections, air quality test, and noise level measured according to PM plan of WELL work in Stage 2.	1. PM / FM implement management and maintenance of building in a way that meet the needs of all building users. 2. PM / FM identify and implement any adjustments or improvements required to the building, day-to-day operations or policies to meet the needs of all building users. 3. Consultant undertake POE of inclusive performance and review the asset in operation for inclusivity needs.	Intentionally left blank	✓				

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DESIGN GUIDE - PROCESS REQUIREMENTS

Topics	Applicability					Strategic definition, preparation and brief	Concept design	Developed design	Technical design	Construction	Handover and close out	In Use	Considerations	Interdependencies				
	Value				Gateway 1	Gateway 2	Gateway 3	Gateway 4	Gateway 4	Gateway 5	Gateway 6	None		CoLC				
Categories	below £250k	£250k - £5m	£5m - £50m	Above £5m	RIBA 0	RIBA 1	RIBA 2	RIBA 3	RIBA 4	RIBA 5	RIBA 6	RIBA 7	Stakeholders involved / instructed	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement
					✓	✓	✓	✓	✓	✓	✓	✓	Project Management					
					✓	✓							Client Senior Responsible Owner					
					✓	✓	✓						Building Surveying					
					✓	✓	✓	✓	✓	✓	✓	✓	Quantity Surveying					
						✓	✓	✓	✓	✓	✓		Architectural					
						✓	✓	✓	✓	✓	✓		Structural and Civil Engineering					
						✓	✓	✓	✓	✓	✓		Mechanical & Electrical Engineering					
							✓	✓	✓				Fire Engineering					
									✓	✓	✓	✓	Interior Design Services					
						✓	✓	✓					PassivHaus Design					
							✓	✓	✓				Transportation					
									✓	✓	✓	✓	Contractor					
Post Occupancy Evaluation (POE)																		
Energy and Water Monitoring	✓	✓	✓	✓	N/A	1. PM ensure incorporation of data disclosure into BIM requirements. 2. M&E to establish measurable targets for environmental performance, amenity and comfort in the project brief.	1. M&E to use the LETI Future of Heat Decision Tree when making decisions on heating and hot water systems. 2. M&E to highlight the roles and opportunities for overcoming performance gap, for example by following the BSRIA Soft Landings Framework.	1. M&E develop sub-metering strategy using LETI energy disclosure guidance. Heating and cooling energy consumption (kWh) should be metered separately to enable fabric performance to be assessed. 2. M&E to establish a secure remote source for metered data to be transmitted over a communications network for aggregation and storage, including operational carbon, future of heat, demand response and data.	1. M&E to check the suitability of the heating and hot water system using the LETI Future of Heat Decision Tree. 2. PM and M&E to confirm HVAC systems type and performance specification to align with the Net Zero Technical Standard specifications.	1. PM ensure the contractors understand commissioning requirements, including metering commissioning and validation of manual vs. half hourly readings.	1. Contractor ensure that performance data from sensors and meters are reconciled with main meter, spot meter and BMS readings and that logs are set up in BMS to facilitate long term monitoring of building performance.	1. Owner to assign tasks to the appropriate qualified professional to complete post-construction testing and inspection to quality-assure the integrity of the building fabric, including continuity of insulation, avoidance of thermal bridging and air leakage paths (this is through airtightness testing and a thermographic survey). 2. A suitably qualified professional undertakes the survey and testing in accordance with the appropriate standard and the Design Standard guidance. 3. Contractor and FM ensure the metering system is operating correctly and is regularly validated against utility meters. 4. FM identify and track key efficiency metrics. Aim to track the fewest but most useful metrics. 5. FM assign an annual budget for monitoring energy use and tuning controls in response. Aim for monthly review and quarterly 'deep dive' analysis. 6. PM and FM line up energy efficiency assessments with post occupancy evaluation assessments to ensure occupant satisfaction with conditions in the building.	Intentionally left blank	✓				

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DESIGN GUIDE - PROJECT REQUIREMENTS

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Introduction and Accreditations

Requirements: Category	Requirements: Sub-category	Performance requirements (Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard)	Interdependencies (Technologies / Whole Life Carbon / Climate Impact Modelling (resilience / Circular Economy / Procurement)	PM Guide (Project Delivery Methodology): Task Bar (PM Guide Reference)	PM Guide (Project Delivery Methodology): PPG Activities (PM Guide Task Description)
Sustainability rating (use most current and appropriate scheme) - assess the building using at least one of the schemes listed here.	BREEAM	1. As a minimum, achieve an Outstanding rating and final certificate (≥85% including mandatory credits) for new build. 2. As a minimum, achieve an Excellent rating and final certificate (≥70% including mandatory credits) for refurbishments / fit outs / Listed Buildings.	N/A	DT Appointments Practical Completion	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements. Project closure report
	SKA	1. As a minimum, achieve Gold label in self assessment.	N/A	DT Appointments Practical Completion	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements. Project closure report
	NABERS UK	1. As a minimum achieve 5 stars (Excellent) for Design for Performance and Energy for Offices rating.	N/A	DT Appointments Practical Completion	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements. Project closure report
	Home Quality Mark (HQM)	1. As a minimum, achieve a 4 star rating and at least a score of 3 in each of the 3 Indicators of Performance (my cost, my wellbeing, my footprint), as well as all minimum requirements.	N/A	DT Appointments Practical Completion	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements. Project closure report

Sub-category	Asset type: New build	Asset type: Refurb	Asset type: Listed	Asset type: Component replacement only	Class: Residential	Class: Commercial (e.g., Offices)	Class: Public (e.g., Schools)	Value: below £250k	Value: £250k - £5m	Value: £5m - £50m	Value: Above £50m
BREEAM	✓	✓	✓		✓	✓	✓		✓	✓	✓
SKA		✓				✓			✓	✓	✓
NABERS UK		✓				✓			✓	✓	✓
Home Quality Mark (HQM)	✓				✓				✓	✓	✓

Sub-category	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
BREEAM	✓		✓	✓	✓	✓		✓	✓	✓	✓
SKA	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
NABERS UK	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Home Quality Mark (HQM)	✓		✓	✓	✓	✓		✓	✓	✓	✓

DESIGN GUIDE - PROJECT REQUIREMENTS

Requirements		Performance requirements	Asset type				Class			Value				Interdependencies					PM Guide (Project Delivery Methodology)		Key Stakeholders										
Category / Sub-category		Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	New build	Refurb	Listed	Component replacement only	Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	below £250k	£250k - £5m	£5m - £50m	Above £50m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	Task Bar PM Guide Reference	PPG Activities PM Guide Task Description	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
Whole Life Carbon																															
Whole life cycle carbon assessment	Whole life carbon	1. Report Whole Life Carbon in $kgCO_2e/sqm$ in compliance with RICS Whole Life Carbon/BSI EN 15978 Standard. 2. All buildings to conduct whole life carbon calculations and aim to achieve 40% carbon emission reductions. Review Planning Advice Note on Whole Lifecycle Carbon emission options - follow methodology. Reference where relevant Greenhouse Gas impact assessments, the Circular Economy Statement, operational energy and water assessments. Develop optimisation measures, costs, and a menu of the measures based on the cost of the optimisation in £/$kgCO_2e$ saving.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.	✓			✓							
Embodied carbon	Embodied Carbon	1. Less than 300 $kgCO_2e/sqm$ up-front Embodied Carbon towards net zero by 2027 in the City Corporation's operations. RICS Whole Life Carbon (A-C)/BSI EN 15978 Standard. 2. Small-scale housing to reduce embodied carbon by 40% or to <500 $kgCO_2/m^2$. 3. Medium- large scale housing to reduce embodied carbon by 40% or to <500 $kgCO_2/m^2$ 4. Commercial offices to reduce embodied carbon by 40% or to <600 $kgCO_2/m^2$. 5. Schools to reduce embodied carbon by 40% or to <600 $kgCO_2/m^2$. 6. By December 2023 whole-life carbon assessments for buildings above a gross internal area of 1000m^2 or which create more than 10 dwellings must be carried out. 7. By 2030 all new buildings to achieve a 65% reduction in embodied carbon emissions against baseline of 800$kgCO_2/m^2$ for domestic assets and 1000 $kgCO_2/m^2$ for non-domestic. 8. Upfront embodied carbon emissions should be verified post-construction. 9. Consider Future Homes Standard - Low carbon heating, energy efficiency homes for 75-80% lower carbon emission.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓					✓					✓
	End of Life	1. All CoLC projects are assumed to have a lifecycle of 60 years in line with RICS 2017 guidance. 2. For all domestic and non-domestic assets 50% of materials should be from re-used sources. 3. For all domestic and non-domestic assets 80% of materials should be able to be re-used at end of life. 4. Environmental Product Declarations (EPDs) should be requested from all suppliers.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.	✓		✓		✓	✓					✓
Operational carbon and energy and LZC Technologies	Energy Use Intensity (EUI)	1. To achieve a maximum Energy Use Intensity of 35 kWh/m^2.yr.	✓	✓	✓		✓				✓	✓	✓	✓					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.						✓					
		1. To achieve a maximum Energy Use Intensity of 55 kWh/m^2.yr.	✓	✓	✓			✓			✓	✓	✓	✓												✓					
		1. To achieve a maximum Energy Use Intensity of 65 kWh/m2.yr.	✓	✓	✓				✓		✓	✓	✓	✓												✓					
		*Operational energy is the energy (regulated and unregulated) consumed by a building and its occupiers. **Energy Use Intensity (EUI) in Gross Internal Area (GIA), excluding renewable energy contribution.												✓												✓					
	Space Heating Demand	1. All building types should be designed for and achieve the space heating demand target of less than 15 kWh/m^2/yr.	✓	✓	✓		✓	✓	✓		x	x	x	✓					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.						✓					
	On-site energy generation	1. Consider maximising the on-site energy generation: a. Residential Generate 100% of annual energy. b. Commercial (e.g. offices) Generate 2-floors requirement of annual energy. c. Public (e.g. schools) Generate 70% of annual energy.	✓	✓	✓		✓	✓	✓		x	x	x	✓					Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.						✓					
	Airtightness	1. Passivhaus airtightness (n50) ≤ 0.6 $m^3/h.\ m^2$@50Pa).	✓	✓			✓	✓	✓		x	x	x	✓					Witness, testing and commissioning	Ensure the Building Service Engineer and other specialist are in attendance to witness testing & commissioning.						✓			✓		✓
	LZC technologies	1. Establish the LZC technologies appropriate and available to the building and its energy demand. 2. Specify the most suitable LZC technology based on the above for the building. Where there is a peak heat demand of more than 100kW, the building must be connected to existing decentralised energy networks. 3. Track and disclose the reduction in CO_2 emissions as result of the LZC technology. 4. All new builds are 100% powered by renewable energy. Any energy not met by on-site renewables must be met by an investment into additional renewable capacity.	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓			✓			✓		✓		✓
		Net Zero 1. CoLC and Square Mile to aim for Net Zero on scope 1, 2 and 3 through compliance with Operational Energy and Carbon and LZC Technology Categories. The building emission rate (BER) expressed as carbon dioxide emissions (CO_2-eq) per square metre per year (kg CO_2-eq/m²/year). The BER is to be calculated in accordance with the National Calculation Methodology (NCM) and the Simplified Buildings Energy Model (SBEM) and reported. 2. CoLC to reduce/remove at least 1050ktCO_2e to reach Net 0- 100% of Scope 1 & 2 and 66% of Scope 3 in line with SBTi. 3. Square Mile to reduce/remove at least 1,528ktCO_2e to achieve net zero in line with SBTi. 4. Between 2025-2050 there will need to be an upgrade to Zero Carbon at a rate of 3,750 homes per day.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓		DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓			✓		✓			✓		✓
		Technologies 1. Within the Square Mile work with other organisations to develop a Climate Action Fund to invest in effective zero carbon technologies and accelerate decarbonisation in line with the CoLC Net Zero Technical Guide.	✓	✓	✓			✓		✓	✓	✓	✓	✓	✓		✓		DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓			✓		✓			✓		✓

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DESIGN GUIDE - PROJECT REQUIREMENTS

Requirements		Performance requirements	Asset type				Class			Value				Interdependencies					PM Guide (Project Delivery Methodology)		Key Stakeholders										
Category / Sub-category		Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	New build	Refurb	Listed	Component replacement only	Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	below £250k	£250k - £5m	£5m - £50m	Above £50m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	Task Bar PM Guide Reference	PPG Activities PM Guide Task Description	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
	Carbon reduction	Building design 1. All buildings to conduct whole life carbon calculations and aim to achieve 40% carbon emission reductions. 2. All New buildings to be designed in accordance with the CoLC Net Zero Design and Technical Guide to achieve Net Zero. 3. All new buildings to achieve zero net regulated CO_2-eq emissions at operation by complying with the requirements of the Net Zero t=Technical and Design Guides by 2050. 4. The CoLC current operation's emission to be reported and zero net regulated CO_2-eq emissions is achieved by 2027, through remedial actions introduced in compliance with the CoLC's Technical and Design Guides requirements. 5. The Square Mile's CO_2-eq emissions are reported and net zero CO_2-eq emissions is achieved by 2040 through remedial actions introduced in compliance with the CoLC's Technical and Design Guides requirements. 6. For further information regarding carbon reduction percentages and amounts, please review the embodied carbon sub-category.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓				DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓			✓		✓			✓		✓
		Carbon Removals 1. Increase presence of green roofs to 65,800m² by 2024 in the Square mile to assist in carbon absorption and storage. 2. Introduce new land management practices across CoLC open spaces aiming to maximise their ability to remove carbon. 3. If on-site carbon emission reduction is unavailable, offsetting of residual CO_2 emissions through 'allowable solutions' for the lifetime of the building to achieve national targets for zero-carbon homes and non-domestic buildings must be investigated. 4. Where carbon targets cannot be met on-site the City Corporation will require carbon abatement elsewhere in line with the CoLC's off-setting requirements.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓				DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓			✓		✓			✓		✓
	Energy Efficiency	Energy Performance targets 1. All new-build homes will be expected to achieve EPC C by 2035. 2. All rented non-domestic buildings will be expected to be EPC B by 2030.	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓			✓		✓			✓		✓
		Passive design 1. Ensure appropriate thermal comfort levels are achieved in all occupied spaces in line with relevant industry standards such as CIBSE Guide A, CIBSE TM52 and CIBSE TM59. 2. Implement passive design measures to reduce the total heating, cooling, mechanical ventilation, lighting loads and energy consumption.	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓			✓		✓			✓		
		Materials 1. Emissions arising from demolition, construction and transport of construction materials and waste must be monitored and reported to help reduce the impact of construction works on air quality. This must be carried out inline with Air Quality Category, Transport requirements. 2. Local reclaimed brick should be sourced wherever possible. An unfired brick system with much lower embodied carbon may be suitable for internal non-load bearing walls and can also help with humidity regulation.	✓	✓			✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.				✓							✓
		Pollution reductions 1. All feasible and viable on-site or near-site options for carbon emission reduction must be applied before consideration of offsetting. 2. Low and zero carbon technologies must be evaluated, and non-combustion-based technologies should be prioritised. 3. All new buildings to achieve a 65% reduction in embodied carbon emissions in line with the Embodied Carbon and Energy Category. 4. All buildings to conduct whole life carbon calculations and aim to achieve 40% carbon emission reductions.	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓				DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.				✓							✓

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Requirements		Performance requirements	Asset type				Class			Value				Interdependencies					PM Guide (Project Delivery Methodology)		Key Stakeholders										
Category / Sub-category		Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	New build	Refurb	Listed	Component replacement only	Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	below £250k	£250k - £5m	£5m - £50m	Above £50m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	Task Bar: PM Guide Reference	PPG Activities: PM Guide Task Description	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
Minimise carbon		Light Pollution 1. BREEAM Pol 04 Reduction of night time light pollution through effective design that removes the need for external lighting or via reducing the impact by aligning with BREEAM Pol 04 requirements; •External lighting pollution has been eliminated through effective design that removes the need for external lighting. This does not adversely affect the safety and security of the site and its users. •OR alternatively, where the building does have external lighting: o The external lighting strategy has been designed in compliance with Table 2 (and its accompanying notes) of the Institution of Lighting Professionals (ILP) 2. Guidance notes for the reduction of obtrusive light, 2011. •All external lighting (except for safety and security lighting) can be automatically switched off between 23:00 and 07:00. •If safety or security lighting is provided and will be used between 23:00 and 07:00, this part of the lighting system complies with the lower levels of lighting recommended during these hours in Table 2 of the ILP guidance notes. •Illuminated advertisements are designed in compliance with ILP PLG05 The Brightness of Illuminated Advertisements.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓					Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.	✓	✓	✓	✓		✓					✓
		Light Pollution 1. (Institute of Lighting Professionals ILP Guidance 2021) The ILP guidance and its accompanying notes outlines four sets of recommendations based on the design, location and use of a building: •Limits to the average upward light ratio of the luminaires, to restrict sky glow. •Limiting illuminance at the windows of nearby properties for which light trespass might be an issue. •Limiting the intensity of each light source in potentially obtrusive directions beyond the site boundaries. •Limiting the average luminance of the building if it is floodlit.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓					Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.	✓	✓	✓	✓				✓			✓
		Light Pollution 1. Limit the City's contribution to light spillage and 'sky glow' by the following measures: •Ensure that any upward light is directed at vertical surfaces rather than into the sky to minimise light pollution. •Consider retaining natural darkness as is appropriate in environmental sensitive areas. •Retail: retail frontages are often over lit and spill too much light into the environment, consider reducing light intensity of frontages during darkness.	✓	✓	✓					✓	✓	✓	✓	✓					Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.	✓	✓	✓	✓		✓					✓
		Light Pollution 1. (Bat Conservation Research Lab, University of the West of England, Bristol) Take sustainable approach to lighting whilst being functional (safety) including identifying the possible impact to local biodiversity such as bats; •Natural darkness should be retained in areas such as the river, parks, gardens and churchyards where birds, bats and other fauna and flora benefit from the observation of the circadian cycle where people are unlikely to visit during darkness. •Identify local bat species via bat surveys and identify lighting solutions to minimise the impact on local bats. Some species respond to lighting in different ways dependent on the light type, colour and habitat, some bats being attracted to artificial lights and some have an aversion. •Consider the use of LED lighting which does not generally emit insect attracting UV.	✓	✓	✓					✓	✓	✓	✓	✓					Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.	✓	✓	✓	✓		✓					✓
		Noise Pollution 1. Identify noise sensitive areas within 800m of development and develop a noise impact assessment compliant with BS 4142: 2014.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓					Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.	✓	✓	✓	✓		✓					✓
		Construction 1.A contaminated land professional undertakes a site investigation, risk assessment and appraisal, which deems that land within the development footprint to be affected by contamination. This report identifies: •The degree of contamination •The contaminant sources or types •The options for remediating sources of contamination which present an unacceptable risk. 2.The client or principal contractor confirms that a remediation strategy will be implemented, in line with the report. As per BREEAM LE01 Site Selection. 3.Ensure the Principal Contractor(s) holds a EMS/EMAS ISO14001 certificate or for BS 8555, evidence of their status, e.g. a copy of their phase 4 audit as per BREEAM Man 03. 4. Create and implement an erosion and sedimentation control plan for all construction activities alongside measures implemented to reduce pollution from construction activities.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			N/A			Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.	✓	✓	✓	✓		✓					✓
		Refrigerants BREEAM Pol 01 impact of refrigerants; 1. Ideally, where possible no refrigerants should be used within the plant or systems however if they are installed they should follow the BREEAM Pol 01 requirements. 2. All systems with electric compressors comply with the requirements of BS EN 378:20161 (parts 2 and 3). Refrigeration systems containing ammonia comply with the Institute of Refrigeration Ammonia Refrigeration Systems code of practice. 3. The direct effect life cycle CO_2 equivalent emissions (DELC) of ≤100 CO_2-eq/kW. For systems which provide cooling and heating, the worst performing output based on the lower of kW cooling output and kW heating output is used to complete the calculation. 4. All refrigerants used have a global warming potential (GWP) ≤10. 5. Systems using refrigerants have a DELC of ≤1000kgCO_2-eq/kW cooling and heating capacity.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓	✓	✓	✓	✓	✓		✓			✓

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Requirements		Performance requirements	Asset type				Class			Value				Interdependencies					PM Guide (Project Delivery Methodology)		Key Stakeholders										
Category / Sub-category		Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	New build	Refurb	Listed	Component replacement only	Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	below £250k	£250k - £5m	£5m - £50m	Above £50m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	Task Bar: PM Guide Reference	PPG Activities: PM Guide Task Description	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
	Minimise pollution	Monitoring 1. Undertake an annual assessment of air quality to ensure levels of nitrogen dioxide in 90% of the Square Mile meet health-based Limit Values and WHO Guidelines by 2025: •The recommendation is an annual nitrogen dioxide AQG level of 10 $\mu g/m^3$. •The recommendation is a short-term (24-hour) nitrogen dioxide AQG level of 25 $\mu g/m^3$.	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.		✓		✓				✓		✓	✓
	Minimise pollution	Monitoring 1. Developers are required to, where appropriate provide Air Quality Impact Assessments - please refer to Air pollution sub-category - indoor air quality for guidance. 2. Water Monitoring: For water consuming building areas consuming 10% or more of the buildings total water demand, fit easily accessible sub meters or water monitoring equipment, connected to an appropriate utility monitoring and management system e.g. BEMS. 3. Water leak detection systems to be installed to detect any major leaks within the building alongside flow control devices to regulate the water supply of each WC or sanitary facility as per BREEAM Wat 02 and 03 credit requirements.	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.		✓		✓				✓		✓	
	Minimise pollution	Monitoring BREEAM Pol 01 Impact of Refrigerants; 1. Refrigerant Leak detection - All systems are hermetically sealed or only use environmentally benign refrigerants. Where the systems are not hermetically sealed: Systems have: •A permanent automated refrigerant leak detection system, that is robust and tested, and capable of continuously monitoring for leaks. •An inbuilt automated diagnostic procedure for detecting leakage is enabled. •In the event of a leak, the system must be capable of automatically responding and managing the remaining refrigerant charge to limit loss of refrigerant.	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.											
	Minimise pollution	Water Pollution BREEAM Pol 03 Flood and surface water management; 1. SuDs are considered by all developers in new major developments and should, where possible, provide multifunctional benefits. 2. There is no discharge from the developed site for rainfall up to 5mm (confirmed by the appropriate consultant). 3. Areas with a low risk source of watercourse pollution, an appropriate level of pollution prevention treatment is provided, using appropriate SuDS techniques. 4. Areas with a high risk of contamination or spillage of substances, such as petrol and oil, have separators (or an equivalent system) are installed in surface water drainage systems. 5. Chemical or liquid gas storage areas have a means of containment fitted to the site drainage system (i.e. shut-off valves). This is to prevent the escape of chemicals to natural watercourses in the event of a spillage or bunding failure. 6. All water pollution prevention systems have been designed and installed in accordance with the recommendations of documents such as the SuDS manual and other relevant industry best practice. They must be bespoke solutions taking account of the specific site requirements and natural or man-made environment of and surrounding the site. 7. A comprehensive and up to date drainage plan of the site will be made available for the building or site occupiers. 8. Relevant maintenance agreements for the ownership, long term operation and maintenance of all specified SuDS must be in place. 9. All external storage and delivery areas are designed and detailed in accordance with the current best practice planning guidance.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓	✓	✓	✓							✓
	Minimise pollution	Water Pollution BREEAM Pol 03 Flood and surface water management 1. To increase the resilience and resistance of the development to flooding, and therefore reducing the risk of water pollution. 2. The ground level of the building and access to both the building and the site, are designed (or zoned) so they are at least 600 mm above the design flood level of the site's flood zone (see 600mm threshold). 3. The final design of the building and the wider site reflects the recommendations made by an appropriate consultant in accordance with the hierarchy approach outlined in section 5 of BS 8533:2017.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓	✓	✓	✓							✓
	Minimise pollution	Water Pollution 1. Local authorities are required to approve a drainage system and its subsequent maintenance prior to construction.	✓				✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓	✓	✓	✓							✓
	Minimise pollution	Water Pollution 1. FOG (fats oils and greases) regulation state it is illegal to dispose of anything in a sewer that can block or restrict flow. •Make occupants aware of legislation to reduce the risk of pollution through sharing information.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓	✓	✓	✓							✓
	Minimise pollution	Water Pollution 1. Incorporate trees, shrubs and gardens ensure they are planted, protected, enhanced to collect and attenuate water runoff.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓	✓	✓	✓							✓
	Minimise pollution	Air Pollution 1. The hourly limit of 200$\mu g/m^3$ Nitrogen dioxide must not be breached. 2. Annual Average PM10 value of 20$\mu g/m^3$. 3. Development that would result in deterioration of the City's Nitrogen dioxide or PM10 pollution levels will be resisted. 4. Annual Average PM.2.5 value of 10$\mu g/m^3$. 5. Reduce emissions of NOx from large buildings by at least 3% per year. 6. All gas boilers will be required to have a NOx rating of <24mgNOx/KWh at 0% O2. 7. Chimneys should terminate a minimum of 2m above roof height where possible. Stack discharge velocity should be at least 10m/sec. minimum. 8. Appliances 1MW or greater will be required to achieve a stack discharge velocity of 15m/sec.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓	✓	✓	✓						✓	✓

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Requirements		Performance requirements	Asset type				Class			Value				Interdependencies					PM Guide (Project Delivery Methodology)		Key Stakeholders										
Category / Sub-category		Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	New build	Refurb	Listed	Component replacement only	Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	below £250k	£250k - £5m	£5m - £50m	Above £50m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	Task Bar PM Guide Reference	PPG Activities PM Guide Task Description	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
		Air pollution Monitoring & Plans 1. The City Corporation will monitor air quality to assess compliance with Air Quality Limit. 2. Nitrogen dioxide monitoring – continuous analysers will be used to monitoring Nitrogen dioxide levels, producing average hourly readings. These will be calibrated twice a year. 3. Data will also be collected from diffusion tubes across 100 locations in the square mile to compare levels to the annual mean limit value and detecting hot spots. 4. Pollutant alerts with messages for City Air Smart Phone app based on air quality data when pollutant levels are high. 5. Annual assessments of air quality to ensure levels are within the guidelines. 6. Develop a plan for reducing the air quality impact on days of high and very high air pollution. 7. Develop a logistics approach that avoids deliveries during peak congestion and pedestrian footfall times. 8. All new developments to be air quality neutral as a minimum and developments subject to an Environmental Impact Assessment to be Air Quality Positive in line with the requirements of the emerging London Plan.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓	✓	✓	✓						✓	✓
		Air Pollution City of London Transport 1. Ensure that subject to operational requirements, 100% of vehicles owned or leased by the City Corporation are electric or hybrid by 2025. 2. Require electric or hybrid vehicles as a default for the Corporate taxi contract, together with annual emission reduction targets. 3. Require zero emission and electric or hybrid vehicles as a default for courier contracts, together with annual emission reduction targets. 4. Have an entirely zero emission fleet by 2037 at the latest.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓	✓	✓	✓						✓	✓

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Requirements: Category / Sub-category		Performance requirements: Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	Asset type: New build	Asset type: Refurb	Asset type: Listed	Asset type: Component replacement only	Class: Residential	Class: Commercial (e.g., Offices)	Class: Public (e.g., Schools)	Value: below £250k	Value: £250k - £5m	Value: £5m - £50m	Value: Above £50m	Interdependencies: Technologies	Interdependencies: Whole Life Carbon	Interdependencies: Climate Impact Modelling (resilience	Interdependencies: Circular Economy	Interdependencies: Procurement	PM Guide (Project Delivery Methodology): Task Bar – PM Guide Reference	PM Guide (Project Delivery Methodology): PPG Activities – PM Guide Task Description	Key Stakeholders: Project Management	Key Stakeholders: Building Surveying	Key Stakeholders: Quantity Surveying	Key Stakeholders: Architectural	Key Stakeholders: Structural and Civil Engineering	Key Stakeholders: Mechanical & Electrical Engineering	Key Stakeholders: Fire Engineering	Key Stakeholders: Interior Design Services	Key Stakeholders: PassivHaus Design	Key Stakeholders: Transportation	Key Stakeholders: Contractor
Circular economy																															
Circular economy	Circular economy	A Circular Economy Statement should be submitted (detail proportionate to the scale of the development), to demonstrate: •How all materials arising from demolition and remediation works will be re-used and/or recycled. •How the proposal's design and construction will reduce material demands and enable building materials, components and products to be disassembled and re-used at the end of their useful life. •Opportunities for managing as much waste as possible on site. •Adequate and easily accessible storage space and collection systems to support recycling and re-use. •How much waste the proposal is expected to generate, and how and where the waste will be managed in accordance with the waste hierarchy. •How performance will be monitored and reported.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓		Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.	✓			✓							✓
Circular economy	Design Principles	1. Maximise re-use: re-use the existing asset, recover materials and products on site or from another site, share materials or products for onward re-use. 2. Design for optimisation: longevity, flexibility, adaptability .assembly, disassembly, and recoverability. 3. Use standardisation: Designing and constructing buildings that apply standardised elements or modular designs for materials and products that enable a reduction in construction waste and easier re-use in next life. 4. Product as a service: Establish and promote a payment structure through which customers have unlimited access to resources but only pay for what is used, or for the result linked to their use. This represents a transition from selling products to selling services. 5. Minimise impact and design waste out: use low impact new materials, use recycled content or secondary materials, design out waste, and reduce construction impact.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.	✓			✓							✓
Circular economy	Building in Layers	1. RICS New Rules of Measurement (NRM) form the basis of CE statement reporting, outline application stage in the Bill of Materials. Building layers and their life span: •Site NRM 8. •Skin and shell (e.g., facade): 20-60 years NRM 2.3, 2.5, 2.6. •Structure, superstructure and frame: 30-120 years NRM 2.1, 2.2 2.4, 7 o Substructure (e.g., excavation, foundation, basement) NRM 1. •Services (buidlings): 7-30 years NRM 5. •Space plan / interior: 3 - 40 years 6 NRM 2.7, 2.8, 3 oConstruction materials: NRM 0. •Stuff and content: 3-5 years (FF&E).	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓		Feasibility / Initial Surveys	Approve the Primary Consultants Feasibility Report.	✓			✓							✓
Decommissioning	Adaptable Design	1. Conduct a study to explore the ease of disassembly and the functional adaptation potential of different design scenarios, followed by recommendation and solutions covering: •Options for multiple building uses and area functions based on design details, e.g. modularity. • Routes and methods for major plant replacement, e.g. networks and connections have flexibility and capacity for expansion. •Accessibility for local plant and service distribution routes, e.g. detailed information on building conduits and connections infrastructure. •The potential for the building to be extended, horizontally or vertically. 2. Create a guide for future building users to communicate the functional adaptability and disassembly characteristics of the asset.	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓		Concept Design	DT to prepare a Scheme Design report on completion	✓			✓	✓			✓			✓
Decommissioning	Demolition	1. Complete a pre-demolition audit of any existing buildings, structures or hard surfaces being considered for demolition to determine how all materials arising from demolition and remediation works will be re-used and/or recycled. The audit must account for emissions associated with decommissioning and could be completed as part of the Circular Economy Statement. 2. Embed Circular Economy Principles when refurbing historic building to utilise best practice low carbon interventions.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓		Concept Design	DT to prepare a Scheme Design report on completion	✓			✓	✓			✓			✓
	Materials	1. The waste hierarchy should be followed to firstly prevent waste being generated, preparing for re-use, recycling, recovery and finally disposal. 2. Follow the Circular Economy principles for New Builds: waste reduction is planned from the project inception to completion, re-using secondary products and materials. 3. Follow the Circular economy hierarchy for existing buildings: Retain, Refit, Refurbish, Reclaim/re-use, Re-manufacture, Recycle.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	Procurement Strategy	Procurement Strategy Report	✓			✓							✓

DESIGN GUIDE - PROJECT REQUIREMENTS

Requirements: Category	Requirements: Sub-category	Performance requirements: Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	Asset type: New build	Asset type: Refurb	Asset type: Listed	Asset type: Component replacement only	Class: Residential	Class: Commercial (e.g., Offices)	Class: Public (e.g., Schools)	Value: below £250k	Value: £250k - £5m	Value: £5m - £50m	Value: Above £50m	Interdependencies: Technologies	Interdependencies: Whole Life Carbon	Interdependencies: Climate Impact Modelling (resilience	Interdependencies: Circular Economy	Interdependencies: Procurement	PM Guide (Project Delivery Methodology): Task Bar (PM Guide Reference)	PM Guide (Project Delivery Methodology): PPG Activities (PM Guide Task Description)	Key Stakeholders: Project Management	Key Stakeholders: Building Surveying	Key Stakeholders: Quantity Surveying	Key Stakeholders: Architectural	Key Stakeholders: Structural and Civil Engineering	Key Stakeholders: Mechanical & Electrical Engineering	Key Stakeholders: Fire Engineering	Key Stakeholders: Interior Design Services	Key Stakeholders: PassivHaus Design	Key Stakeholders: Transportation	Key Stakeholders: Contractor
Resource efficicency	Design	1. Review opportunities for re-use and retention of existing buildings in line with the Decommissioning Category requirements. 2. Architect shall undertake feasibility on building retention and re-use and advise whether brief can be met by using existing building. 3. Undertake pre-demolition / pre-refurbishment audit inline with Decommissioning Category requirements. This will help identify which building elements need to be replaced and therefore assessed from an embodied carbon perspective. 4. All buildings should be designed to allow for future adaptation and change of function in line with the principles of a Circular Economy, Design Principles to extend their life.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	Concept Design	DT to prepare a Scheme Design report on completion	✓			✓							✓
	Construction	1. Encourage waste minimisation and waste prevention through the re-use of materials and using fewer resources in the production and distribution of products. 2. Meet the target for construction and demolition waste of 95% re-use/recycling/recovery under BREEAM. 3. Implement a Site Waste Management Plan (SWMP)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	Construction Programme	Review a detailed 4-week level 3 programme with an analysis of performance against the previous 4-week programme.	✓			✓							✓
Materials																															
Low impact materials	Re-use/Recycle	1. Identify re-used or recycled materials and aim for at least 20% recycled or re-used content. 2. Re-use materials from demolished buildings and design future buildings for disassembly, to allow for materials to be re-used. 3. Circular economy statements need to demonstrate how materials resulting from demolition and remediation works will be re-used/recycled.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓		Concept Design	DT to prepare a Scheme Design report on completion	✓			✓	✓			✓			✓
	Sourcing materials	1. Use low-carbon building materials such as low-carbon cement. 2. Sustainably sourced materials to be used in construction. 3. Carry out material efficiency review to determine whether all materials proposed are necessary. 4. Specify and use locally sourced materials. 5. Ensure longevity of materials.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	Procurement Strategy	Procurement Strategy Report	✓			✓	✓			✓			✓
Procurement of materals	Construction	1. Undertake a pre-demolition / pre-refurbishment audit to identify opportunities for building (or building components) re-use. 2. Use a sustainable procurement plan that covers the following as a minimum: •Procure construction products locally where possible. •Include sustainability aims, objectives and strategic targets to guide procurement activities. •Identify the risks and opportunities of procurement against a broad range of social, environmental and economic issues. For further information, please check CoLC Procurement Code	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	Construction Programme	Review a detailed 4-week level 3 programme with an analysis of performance against the previous 4-week programme.	✓	✓									✓
Material durability	Design	1. Design for adaptability or flexibility. 2. Design for disassembly. 3. Design to avoid a premature end of life for all components through considering maintenance and durability. 4. Design to prevent water damage.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓		Procurement Strategy	Procurement Strategy Report	✓	✓		✓	✓	✓		✓			
	Re-use	1. Undertake a pre-demolition / pre-refurbishment audit to identify opportunities for building (or building components) re-use. 2. If re-use is not possible, materials may be carefully and selectively separated for processing and recycling into new elements, materials, and objects.		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓		Concept Design	DT to prepare a Scheme Design report on completion	✓	✓		✓	✓	✓		✓			
Modern methods of construction (MMC)	Modern methods of construction	1. Include the type of MMC that will be deployed within the delivery programme inline with the GLA guidelines. 2. Disclose whole life carbon performance at in use stage.	✓				✓	✓	✓		✓	✓	✓		✓		✓	✓	Procurement Strategy	Procurement Strategy Report	✓			✓	✓						✓

DESIGN GUIDE - PROJECT REQUIREMENTS

Requirements		Performance requirements	Asset type				Class			Value				Interdependencies					PM Guide (Project Delivery Methodology)		Key Stakeholders										
Category	Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	New build	Refurb	Listed	Component replacement only	Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	below £250k	£250k - £5m	£5m - £50m	Above £50m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	Task Bar: PM Guide Reference	PPG Activities: PM Guide Task Description	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
Resilience																															
Climate Change Adaptation	Overheating	Measures to consider: 1. Solar shading to prevent solar gain through glazing. 2. High thermal mass of building fabric to moderate temperature fluctuations. operate cooling stations 3. Passive ventilation and heat recovery - elemental approach to buildings that cannot be sufficiently retrofitted to get as close to Passivhaus standards as possible. 4. Cool streets programme, pedestrian tunnels 5. Heat resilient public realm and highway surfaces. 6. Minimise contribution to the urban heat island effect. 7. Self-standing structures such as canopies and shade sails. 8. Incorporate pools and fountains in the public realm to increase cooling effect, utilise seawtaer / riverwater cooling as appropriate 9. Improving air tightness of buildings that are mechanically ventilated / cooled, minimises how hard the mechanical units need to work to maintain temperatures. 10. Consider painting external facades and roofs with paints that reflect solar radiation. 11. Phase Change Materials - store and release energy in the form of latent heat to increase reliance on mechanical cooling systems. 12 Prioritise cooling to specific areas only - work with building occupiers to agree plans to only occupy and operate specific cool areas during high heat days, and adjust all services to operate in specific areas only. Also oversize cooling systems. 13. Live information of internal conditions 14. Reflective window films and photochromic glazing, reduction of window sizes on south/east/west facades. 15. Integrate Adiabatic Cooing - direct spraying water into ventilation systems 16. Greening of publicn spaces, tree planting, green roofs / walls 17. Reduce office occupancy, and increase ceiling heights. Please note the Intervention Measures within the Climate Impact Modelling workstream within the GIS Tool.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			DT Appointments	Prepare a list of primary and secondary Consultants.	✓	✓		✓	✓	✓					✓
	Flooding	1. Flood risk assessment and mitigation. 2. Sacrificial land and/or natural flood risk management areas. 3. Flood defence assets maintenance and management regimes - protect key assets, critical infrastructure and sensitive equipment in flood zones. 4. Sustainable rain and surface water management policies and implementation e.g. rainwater attenuation and SuDS. 5. SuDs e.g. infiltration trenches, soakways, swales, natural detention basins, geocellular storage systems, biosolar roofs, blue green roofs, pervious pavements, rain gardens. 6. Rainwater harvesting - added benefit of reducing water consumption.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			DT Appointments	Prepare a list of primary and secondary Consultants.	✓	✓		✓	✓						
	Other adaptation measures	1. Improving Blue/Green Infrastructure. 2. Biodiversity protection and enhancement for wildlife to survive changes in climate. 3. Air quality impact assessment to ensure buildings and services will not contribute to worsening vulnerability to photochemical smog. 4. Building retrofits. 5. Increase the quality and provision of green space and coverage in the Square Mile and wider City Corporation spaces. 6. Introduce climate-resistant and adaptive landscaping. 7. Enhancing monitoring, surveying and tracking of ecosystem health. 8. Strengthen water quality monitoring networks. 9. Mitigate impacts of extreme weather events in line with BREEAM Wst 05 requirements and in line with assessment criteria in BREEAM, with a focus on structural and fabric resilience when applicable. 10. Use of cool materials. 11. Solutions to protect utilities underground, reduces humidity levels within substation buildings. 12. Consider precipitation prevention measures including: - Bio retention swales / rain gardens in open spaces and along wider streets, bio retention planters - Temporary Detention Basins in hard surfaced areas - Smart Underground rainwater harvesting water attenuation tanks - Permeable surfacing and storage, oversized kerb drainage Please note the Intervention Measures within the Climate Impact Modelling workstream within the GIS Tool.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓			Concept Design	DT to prepare a Scheme Design report on completion	✓	✓		✓	✓			✓			
	Community resilience	Consider the following measures: 1. Action to tackle food poverty. 2. Support mutual aid and community aid groups. 3. Climate-ready, fortified public health programmes. 4. Strengthen community and business networks to build adaptive capacity. 5. Emergency support and contingency planning for food networks and businesses. 6. Reduce vulnerability by empowering and engaging communities, supportive livelihoods and tackling health inequalities. 7. Cross-boundary and inter-agency working, particularly those to address flood risk, water scarcity and other climate risks with a close link to public health.	✓	✓	✓		✓		✓	✓	✓	✓	✓	N/A					Concept Design	DT to prepare a Scheme Design report on completion	✓										
	Planning & management	Consider the following measures: 1. Develop financial package and programme to manage resilience actions. 2. Embed principles of inclusion and equity throughout all climate action strategies. 3. Mainstream climate resilience into City Corporation governance and decision-making. 4. Identify resilience risks to the Corporation's buildings. 5. Public communications and awareness raising campaigns. 6. Strengthen City Corporation knowledge, skills and capacity. 7. Emergency planning. 8. Continue to fund flood modelling. 9. Develop urban heat vulnerability index and mitigation strategy. 10. Review above and below ground space utilisation in the Square Mile. 11. Ports and markets operational resilience planning. 12. Establish research partnerships to inform future action planning and management of natural capital. 13. Open a City Corporation Ecological Research and Education programme. 14. Pest and disease horizon scanning, surveillance and research programme. 15. Model food supply networks through the Square Mile to inform future planning. 16. Explore and facilitate opportunities to promote regional food production.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓			DT Appointments Risk Management	Prepare a list of primary and secondary Consultants Identify Risks Initial Risk workshop	✓										

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Requirements		Performance requirements	New build	Refurb	Listed	Component replacement only	Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	below £250k	£250k - £5m	£5m - £50m	Above £50m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	PM Guide Reference	PM Guide Task Description	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
Category / Sub-category		Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	Asset type				Class			Value				Interdependencies					PM Guide (Project Delivery Methodology): Task Bar	PPG Activities	Key Stakeholders										
		17. Review and expand data collection, monitoring and reporting. 18. Strengthen resilience requirements for planning. 19. Diversify energy sources and partner with regional organisations and utility providers to increase back-up power for critical services. 20. Develop City Corporation and Square Mile water footprint management strategy. 21. Work with partners to accelerate actions to address water leak management. 22. Food 'waste' collection and redistribution system. 23. CAS plan aims to achieve a climate ready City Corporation avoiding disruption to services from climate risks and preparing the Square Mile to adapt to future climate projections. 24. Make climate resilient design a requirement for development proposals. 25. Define climate resilience priorities for the markets and how theses can be acted upon. 26. Develop guidance to help decision makers and stakeholders understand climate risk. 27. Develop a resilience strategy that covers market operations, assets, and tenant businesses.																													
	Thermal Comfort and safety	1. BREEAM Hea 04 Thermal comfort: Thermal modelling to be carried out in accordance with BRE Hea 04 requirements. 2. The Building should be designed to limit the risk of overheating in accordance with adaptive comfort methodology such as CIBSE TM52 standards.	✓	✓	✓		✓	✓	✓							✓			DT Appointments	Prepare a list of primary and secondary Consultants.	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
		1. Promote occupants activity, comfort and well being by providing quality thermal comfort which reduces heat loss and energy usage. 2. Design alternatives for regularly occupied buildings (dependant on building type): •Localised active cooling or heating systems. •Passive systems such as nightime air, wind flow. •Individual thermal controls for at least 50% of individual occupant spaces and option to adjust air temperature, radiant temperature, air speed and humidity.	✓	✓	✓		✓	✓	✓							✓			DT Appointments	Prepare a list of primary and secondary Consultants.	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
		1. Incorporate mechanical cooling/other cooling in occupied spaces – strategies for this include: •Passive Ventilation. •Operable Windows. •Exterior/Interior Window Shading. •Shade Structures. •Increased Insulation. •High Performance Windows and Facades. •Solar + Storage. •Ceiling Fans.	✓	✓	✓		✓	✓	✓					✓		✓			DT Appointments	Prepare a list of primary and secondary Consultants.	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
	Designing for heat resilience	1. Select materials and systems using climate change projections to design a heat resilient facility and reduce the risk of overheating such as: •Passive daylighting solutions. •Vertically stacked double skin facades. •Exterior window shades. •Light-coloured exteriors. •Shaded arcades. •Thermally massive materials. 2. Optimise building layout by: •Segregating temperature-sensitive electronics and computer control system from other systems. •placing heat-generating equipment like transformers and switchgear outdoors, where permitted. •Splitting the facility cooling loads among different HVAC systems in the facility for redundancy and improved multi-zone control. 3. Identify heat-related points of failure and include design interventions such as: •Selecting systems with higher heat tolerance. •Adding Energy Recovery Ventilation systems. •Providing additional or redundant ventilation systems, either mechanical or natural, to cool electrical equipment or ventilate subsurface tunnels.	✓	✓	✓		✓	✓	✓							✓			DT Appointments	Prepare a list of primary and secondary Consultants.	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Biodiversity, ecology and conservation	Water quality	(House of Commons Environmental Audit Commitee, water quality in rivers fourth report) 1. Work to improve the quality of local water sources by monitoring pollutant levels, embedding SUDS in projects and reducing the use of pollutants during the construction, use and decommissioning of a site to improve local water quality. This will help to insure key freshwater species like Eels and Barbels are protected.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓	✓	✓	✓							✓
		(London sustainable drainage action plan & London Assembly at home with nature - Encouraging biodiversity in new housing developments) 1. Protect diversity and encourage biodiversity by, where possible, including onsite green infrastructure such as water retention ponds and ensure all future buildings have sustainable measures as part of normal practice.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓															
		(London sustainable drainage action plan & London Assembly at home with nature - Encouraging biodiversity in new housing developments) 1. Establish, where approproate site based treatment and recycling programmes	✓	✓	✓		✓	✓		✓	✓	✓	✓			✓															
		Requirements as per Water pollution and monitoring requirments within Pollution Minimisation	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓															
	Planning	(City of London Climte Action Strategy) 1. Introduce land management practices as per the Environment Bill, to show planners a 10% net gain in biodiversity will result before any project is green-lit - dependant on: •The site. •Soil management. •Reducing the removal and re-deposition of soil on site. •All non-planned paved areas to have sufficient soil depth and quality for growing vegetables. •On or off site tree planting and maximise the ability to remove carbon. •Optimise biodiversity and resilience value.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓	✓	✓	✓							✓
		As per BREEAM Land Use & Ecology (LE) credits: 1. The client or contractor confirms compliance is monitored against all relevant UK and EU or international legislation relating to the ecology of the site. 2. The site is evaluated using the BREEAM Ecological Risk Evaluation Checklist, a Suitably Qualified Ecologist (SQE) carries out survey and evaluation to influence site preparation, works, layouts. 3. Risks and feasibility of enhancement of the sites ecological value is included within the decisions made during site preparation, design and construction works. 4. A section on Ecology and Biodiversity has been included as part of the tenant or building owner information. 5. A landscape and ecology management plan or equivalent has been developed in accordance with BS 42020: 2020 Section 11.1.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A							✓	✓	✓	✓							✓

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Requirements		Performance requirements	Asset type				Class			Value				Interdependencies					PM Guide (Project Delivery Methodology)		Key Stakeholders										
Category / Sub-category		Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	New build	Refurb	Listed	Component replacement only	Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	below £250k	£250k - £5m	£5m - £50m	Above £50m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	Task Bar (PM Guide Reference)	PPG Activities (PM Guide Task Description)	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
	Mitigating risks	1. Negative impacts from site preparation and construction works are managed according to the mitigation hierarchy and SQEs recommendations as outlined in BREEAM LE03 credit. 2. (LEED) Protect or restore habitat – Preserve and protect from all development and construction activity 40% of greenfield area on the site (if exists). 3. Restore a portion of the site identified as previously disturbed. 4. At least 75% of the proposed development is on previously occupied land, if the land is deemed contaminated, a contaminated land professional undertakes site investigation and confirms that a remediation strategy will be implemented.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓	✓	✓	✓							✓
	Ecological change and enhancement	1. Change and enhance ecology by adopting locally relevant ecological measures from recognised local ecological expertise, in collaboration with representative stakeholders. 2. Positive change in ecological value (significant net gain) as a result of the project in accordance with BREEAM and HQM Ecology Calculation methodology. 3. If unable to enhance ecology on site, include measures for the projects zone of influence. 4. Adopt a Biodiversity strategy which incorporates tree planting to address both biodiversity and climate change concerns.This will include discouraging Landscaped areas requiring high irrigation, unless fed by rainwater or grey water collected on site to account for periods of drought due to climate risks. and selecting drought tolerant Species for window boxes . 5. Implement an Urban Greening strategy; green roofs and green walls as appropriate. 6. Long term management and maintenance of ecology throughout the project has been implemented through input from the project team in collaboration with other stakeholders. Detailed management and maintenance plans are included within tenant or building owner information that encourages understanding and supportive behaviours.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓	✓	✓	✓							✓
Flood resilience	Planning and implementation	1. Mitigate impacts of extreme weather events in line with BREEAM Wst 05 requirements and in line with assessment criteria in BREEAM, with a focus on structural and fabric resilience when applicable. 2. Avoid construction on high flood risk areas inline with LEED LT credit. 3. Ensure compliance with the following CoLC Local Plan Policies: • Section 3.18.1 Core Strategic Policy CS18: flood risk • Policy DM 18.1 Development in the City Flood Risk Area • Policy DM 18.2 Sustainable Drainage Systems 4. Sewer infrastructure design must allow for projected future sea level rise (SLR) increases in precipitation and frequency of high storm intensity.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓	✓	✓	✓	✓	✓					✓
Flood resilience	Flood and surface water management	(BREEAM Pol 03 Flood and surface water management) Ensure the following: •SuDs are considered by all developers in new major developments and should, where possible, provide multifunctional benefits. •There is no discharge from the developed site for rainfall up to 5 mm (confirmed by the appropriate consultant). •Areas with a low risk source of watercourse pollution, an appropriate level of pollution prevention treatment is provided, using appropriate SuDS techniques. •Areas with a high risk of contamination or spillage of substances, such as petrol and oil, have separators (or an equivalent system) are installed in surface water drainage systems. •Chemical or liquid gas storage areas have a means of containment fitted to the site drainage system (i.e. shut-off valves). This is to prevent the escape of chemicals to natural watercourses in the event of a spillage or bunding failure. •All water pollution prevention systems have been designed and installed in accordance with the recommendations of documents such as the SuDS manual2 and other relevant industry best practice. They must be bespoke solutions taking account of the specific site requirements and natural or man-made environment of and surrounding the site. •A comprehensive and up to date drainage plan of the site will be made available for the building or site occupiers. •Relevant maintenance agreements for the ownership, long term operation and maintenance of all specified SuDS must be in place. •All external storage and delivery areas are designed and detailed in accordance with the current best practice planning guidance.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓	✓	✓	✓	✓	✓					✓
Flood resilience	Flood and surface water management	(BREEAM Pol 03 Flood and surface water management) To increase the resilience and resistance of the development to flooding: 1. The ground level of the building and access to both the building and the site, are designed (or zoned) so they are at least 600 mm above the design flood level of the site's flood zone (see 600mm threshold). 2. The final design of the building and the wider site reflects the recommendations made by an appropriate consultant in accordance with the hierarchy approach outlined in section 5 of BS 8533: 2017	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓	✓	✓	✓	✓	✓					✓
Flood resilience		Tree planting 1. Trees can be used as standalone features within soil-filled tree pits, tree planters or structural soils. Tree pits and planters can be designed to collect and attenuate runoff by providing additional storage within the underlying structure (CoL Flood risk assessment, 2017). 2. It is crucial that tree species are chosen for their adaptability to the prevailing site conditions rather than a strict adherence to only native species (City of Westminster, 2010). 3. Bringing plants back where construction and high rates of urban growth have removed valuable eco-systems is key to creating sustainable comfortable cities. Urban greening will prevent climate events such as flooding and heat waves.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓			✓	✓	✓					✓
Flood resilience		1. Existing surfaces provide a surface suitable for pedestrian and/or vehicular traffic, while allowing rainwater to infiltrate through the surface and into underlying layers. 2. Specify surfaces with an aggregate sub-base to provide good water quality treatment before water is infiltrated to the ground, re-used, or discharged to a watercourse or other drainage system.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓			✓	✓	✓					✓

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Requirements		Performance requirements	Asset type				Class			Value				Interdependencies					PM Guide (Project Delivery Methodology)		Key Stakeholders										
Category / Sub-category		Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	New build	Refurb	Listed	Component replacement only	Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	below £250k	£250k - £5m	£5m - £50m	Above £50m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	Task Bar PM Guide Reference	PPG Activities PM Guide Task Description	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
	Design	1. Include a rainwater collection basin or a detention basin in the design and as part of the SuDS management system to help with attenuate runoffs and also to address all non-potable water consumptions (such as WC flushing) during construction and operation of the asset. 2. Consider including the following water runoff storage and/or conveyance structures in the design as appropreiate: • Infiltration trenches to create temporary subsurface storage of stormwater runoff. • Swales to store and/or convey runoff and remove pollutants. • Soakaways to store or drain the water in large areas such as highways. • Natural Detention basins to remove pollution and reduce runoff downstream. • Blue Green Roofs as a source-control feature • Green Roofs to intercept and retain precipitation, reducing the volume of runoff and attenuating peak flows.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓			✓	✓	✓					✓
		1. New developments must be constructed with separate down pipes for foul and surface water which will aid with conversion in the future should new surface water pipes be constructed within the City of London. 2. Site drainage should be designed inline with Thames Water recommendations should only be combined at the final manhole prior to leaving the site and entering the combined sewer.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓			✓	✓	✓					✓
		1. Use methods and materials that reduce the impact from a flood, ensuring that structural integrity is maintained, and the drying out and cleaning required, following inundation and before reoccupation, is minimised. 2. Where flood resistance measures are not appropriate, enhance the features of the property so that they resist the ill-effects of flood water and dry out quickly and without permanent damage.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓			✓	✓	✓					✓
	Transport	1. BREEAM Tra 01 Transport assessment and Travel Plan - no later than Concept Design stage, undertake a site-specific transport assessment (or develop a travel statement) and draft travel plan, which can demonstrably be used to influence the site layout and built form. 2. This should include (where relevant) •Travel patterns and attitudes of existing building users towards sustainable transport methods (cycling, public transport) •Predicted travel patterns and transport impact of future building or site users •Current local environment for pedestrians and cyclists •Number of existing accessible amenities within 500m of the site •Disabled access •Existing public transport index •Current facilities for cyclists 3. Based on the transport assessment develop a travel plan that provides a long term management strategy which encourages more sustainable travel such as negotiating with local bus, train or tram companies to increase local provision, provision of EV charging stations for a minimum of 3kW for at least 10% of the total car parking capacity for the development, provision of parking priority spaces for car sharers – at least 5% of the total car parking capacity.	✓	✓	✓			✓	✓	✓	✓	✓	✓		✓				DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.		✓		✓				✓		✓	✓
		1. BREEAM Tra 02 – Provide Cyclist facilities based on the number of building occupants from the sliding scale of compliance, such as storage spaces, showers, lockers and changing facilities.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓	✓								✓	✓
		1. During construction, where possible, use electric construction vehicles such as excavators, forklifts and loaders from local suppliers. 2. Identify opportunities to purchase electric construction vehicles within the City of London to support with a Transition to a Zero Emission Fleet.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.										✓	✓
		1. Monitor and measure the transport of construction materials to minimise air quality impacts (BREEAM Man 03 Responsible Construction practices): •Ensure processes are in place to facilitate collecting and recording feedback from the community and to address any concerns related to the development footprint. •Assign responsibility to an individual for monitoring, recording and reporting transportation data resulting from all on-site construction processes (and dedicated off-site manufacturing) throughout the build programme. •Report the total carbon dioxide emissions (total kgCO_2/project value) from the construction process via BREEAM Projects. 2. Set targets for transportation movements and impacts resulting from delivery of the majority of construction materials to site and construction waste from site. As a minimum cover: 3. Transportation of materials from the point of supply to the building site, including any transport, intermediate storage and point of supply monitor as a minimum: •Materials used in major building elements. •Ground works and landscaping materials. •Transportation of construction waste from the construction gate to waste disposal processing or recovery centre gate. This monitoring must cover the construction waste groups outlined in the project's resource management plan. 4. Report separately for materials and waste, the total transport-related carbon dioxide emissions (kgCO_2-eq), plus total distance travelled (km).	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.								✓		✓	✓

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Category / Sub-category		Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	New build	Refurb	Listed	Component replacement only	Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	below £250k	£250k - £5m	£5m - £50m	Above £50m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	Task Bar (PM Guide Reference)	PPG Activities (PM Guide Task Description)	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
Local air quality	Nitrogen Oxides (NOx)	1. All heating and hot water is supplied by non-combustion systems. For example, only powered by electricity. If this cannot be met, ensure the below can be: •Ensure appliances installed align with the maximum NOx emissions levels for 2 credits under BREEAM Pol 02 including: oGas Boilers, Low and high pollution location – 24mg/kWh. oOil Boiler, low pollution location – 67mg/kWh, high pollution location – 50mg/kWh. oBiomass and solid fossil fuel boiler, low pollution location 70mg/m3, high pollution location – 50mg/m3. oGas heat pump using external combustion, low pollution location – 30mg/kWh, high pollution location – 30mg/kWh. oOil heat pump using external or internal combustion/ gas and oil local space heaters/ biomass, solid fuel and wood pellets for closed fronted local space heaters, low pollution location – 70mg/kWh, high pollution location – 50mg/kWh.	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.											
	Fine Particulate Matter	1. BREEAM Pol 02 local air quality – VOC and PM. 2. Ensure appliances (mg/m^3) installed align with the maximum VOC and PM10 emissions levels for 2 credits including; •Biomass boilers – Low pollution location, PM 11, VOC 5. High pollution location, PM 4, VOC 5 •Solid fossil fuel boiler - Low pollution location, PM 17 ,VOC 5. High pollution location, PM 4, VOC 5 •Wood pellet closed face local space heater - Low pollution location, PM 22 , VOC 22. High pollution location, PM 10, VOC 10 •Biomass and solid fuel closed face local space heater - Low pollution location, PM 25, VOC 25. High pollution location, PM 10, VOC 10	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓	✓		✓				✓		✓	✓
		1. Ensure products align with the exemplary level Formaldehyde and TVOC emissions requirements for BREEAM ; •Interior paints and coatings; Formaldehyde ≤ 0.01 mg/m^3, TVOS ≤ 0.3 mg/m^3, TSVOC ≤ 0.1 mg/m^3. Category 1A and 1B carcinogens; ≤ 0.001 mg/m^3. •Wood based products including wood flooring; Formaldehyde ≤ 0.02 mg/m^3, TVOC ≤ 0.3 mg/m^3, TVOS ≤ 0.1 mg/m^3, Category 1A and 1B carcinogens; ≤ 0.001 mg/m^3. •Flooring materials (including floor level compounds and resin floor); Formaldehyde ≤ 0.01 mg/m^3, TVOS ≤ 0.3 mg/m^3, TSVOC ≤ 0.1 mg/m^3. Category 1A and 1B carcinogens; ≤ 0.001 mg/m^3. •Ceiling,wall, acoustic and thermal insulation materials; Formaldehyde ≤ 0.01 mg/m^3, TVOS ≤ 0.3 mg/m^3, TSVOC ≤ 0.1 mg/m^3. Category 1A and 1B carcinogens; ≤ 0.001 mg/m^3. •Interior adhesive and sealants (including flooring adhesive); Formaldehyde ≤ 0.01 mg/m^3, TVOS ≤ 0.3 mg/m^3, TSVOC ≤ 0.1 mg/m^3. Category 1A and 1B carcinogens; ≤ 0.001 mg/m^3.	✓	✓	✓			✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓	✓		✓				✓		✓	✓
		1. Annual Average PM10 value of 20 $\mu g/m^3$. 2. Development that would result in deterioration of the City's Nitrogen dioxide or PM10 pollution levels will be resisted.	✓	✓	✓			✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.											
		1. Annual Average PM2.5 value of 10$\mu g/m^3$.	✓	✓	✓			✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.		✓		✓				✓		✓	✓
	Air Quality Monitoring & plans	1. Undertake an annual assessment of air quality to ensure levels of Nitrogen dioxide in 90% of the Square Mile meet health-based Limit Values and WHO Guideline by 2025.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.		✓		✓				✓		✓	✓
		1. Developers are required to provide Air Quality Impact Assessments as applicable.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.		✓		✓				✓		✓	✓
		1. Option to follow EIA guidance; development plans may be required to conduct Environmental Impact Assessment Screening Matrix checklist surrounding the possible impacts of the proposed development to air pollution. They may also need to consider: •What are the observed trends shown by recent air quality monitoring data and what would happen to these trends in light of proposed development and / or allocations. •The impact of point sources of air pollution (pollution that originates from one place). •The potential cumulative impact of a number of smaller developments on air quality as well as the effect of more substantial developments, including their implications for vehicle emissions. •Ways in which new developments could be made appropriate in locations where air quality is or is likely to be a concern, and not give rise to unacceptable risks from pollution. This could, for example, entail identifying measures for offsetting the impact on air quality arising from new development including supporting measures in an air quality action plan or low emissions strategy where applicable. •Opportunities to improve air quality or mitigate impacts, such as through traffic and travel management and green infrastructure provision and enhancement.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.		✓		✓				✓		✓	✓

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DESIGN GUIDE - PROJECT REQUIREMENTS

Requirements: Category	Requirements: Sub-category	Performance requirements: Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	Asset type: New build	Asset type: Refurb	Asset type: Listed	Asset type: Component replacement only	Class: Residential	Class: Commercial (e.g., Offices)	Class: Public (e.g., Schools)	Value: below £250k	Value: £250k - £5m	Value: £5m - £50m	Value: Above £50m	Interdependencies: Technologies	Interdependencies: Whole Life Carbon	Interdependencies: Climate Impact Modelling (resilience	Interdependencies: Circular Economy	Interdependencies: Procurement	PM Guide (Project Delivery Methodology): Task Bar (PM Guide Reference)	PM Guide (Project Delivery Methodology): PPG Activities (PM Guide Task Description)	Key Stakeholders: Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
		1. (DEFRA Air Quality Monioring Methods) Identify, where possible the opportunity to include air quality monitoring tools to be installed at strategic locations in and around the project site such as those which have MCERTS certification.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.		✓		✓				✓		✓	✓
	Indoor air quality	1. BREEAM Hea 02 IAQ plan and Post construction indoor air quality measurement: Pre – occupancy •Produce a site specific indoor air quality plan to facilitate a process that leads to design, specification and installation decision around minimising indoor air pollution during occupation of the building. The Indoor air quality plan must consider the following: o Removal of contaminant sources. o Dilution and control of contaminant sources. o Where present, consideration is given to the air quality requirements of specialist areas such as laboratories. o Procedures for pre-occupancy flush out. o Third party testing and analysis. o Maintaining good indoor air quality in-use. 2. Post Construction indoor air quality measurement. •The formaldehyde concentration in indoor air is measured post construction (but pre-occupancy) and does not exceed 100$\mu g/m^3$ averaged over 30 minutes (World Health Organization guidelines for indoor air quality: Selected pollutants, 2010). •The formaldehyde sampling and analysis is performed in accordance with ISO 16000-2 and ISO 16000-3. •The total volatile organic compound (TVOC) concentration in indoor air is measured post construction (but pre-occupancy) and does not exceed 500$\mu g/m^3$over 8 hours. •The TVOC sampling and analysis is performed in accordance with ISO 16000-5 and ISO 16000-6 or ISO 16017-1. •Where levels are found to exceed these limits, the project team confirms the measures that have, or will be, undertaken in accordance with the IAQ plan, to reduce the TVOC and formaldehyde levels to within the above limits. •The measured concentration levels of formaldehyde ($\mu g/m^3$) and TVOC ($\mu g/m^3$) are reported (via the BREEAM Scoring and Reporting Tool if a BREEAM Assessment is being sought).	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	N/A					DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.		✓		✓				✓		✓	✓
Passive design	Analysis	1. As a minimum, the passive design analysis should cover: - Site location. •Site weather. •Microclimate. •Building layout. •Building orientation. •Building form. •Building fabric. •Thermal mass or other fabric thermal storage. •Building occupancy type. •Daylighting strategy. •Ventilation strategy. •Adaptation to climate change.														✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓			✓		✓					
		1. Project team carries out an analysis of existing building fabric, form, site location and outline scheme design to influence decisions made during the Concept Design stage and identifies opportunities for the implementation of passive design solutions and retrofit measures that reduce energy demand. 2. Use passive design measures to reduce total heating, cooling, mechanical ventilation and lighting loads and energy consumtpion in line with results of passive design analysis. 3. Utilise passive HVAC strategies. 4. Provide direct exhaust airflow measurement device and automatic indication devices on all natural ventillation openings intended to meet the minimum opening requirements. 5. Highlight to developers the need for passive heat gain, resulting in smaller, simpler heating and hot water systems e.g.: prioritise reduced fabric heat loss so that incidental room heat gains can become primary heat source. 6. Ensure that design decisions reflect the energy hierarchy - seek to limit building energy demand through passive measures and efficient fabric design prior to considering systems' optimisation to satisfy demand. 7. Integrate passive design features to mitigate cooling demand into proposals as outlined in the Energy Statement, these are to be applied and elaborated in the design development and reserved matters stages, (in accordance with the Adaptive Pathways Implementation Plan). 8. In accordance with NYC Climate resilience design guidelines all efforts should be made to reduce the Urban Heat Island effect with a minimum of 50% of the projects site area to be shaded, vegaetated and/or high solar reflectance surfaces. As well as passive ventilation design and passive daylight solutions being consciously considered.	✓	✓			✓	✓	✓					✓		✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓					✓					
		Planning and assessments 1. Complete and document a site survey or assessment that includes heat island effect potential •Leads to identification of paving, shading, or roofing materials that can be included.(LEED v4.1 Building Design and Construction Site Assessment). 2. Identify key buildings at risk of contributing to the urban heat island. 3. Evaluate sources of heat pollution that contribute to the Urban Heat island including developing strategies relating to: •Waste Heat recovery technology. •Electric charging infrastructure for medium and heavy duty vehicles. •HVAC controls for intermittent ventilation (New York Design Guide).	✓	✓	✓		✓	✓	✓							✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓	✓									✓
	Heat island effect	Roof measures: LEED v4/1 Building Design and Construction Site Assessment 1. Use roofing materials that have an aged SRI equal to or greater than 64 (low sloped roof) and 32 (steep sloped roof). 2. Install a vegetated roof. 3. Parking; place a minimum of 75% of parking spaces under cover. The roof must have an fed SRI of at least 32, be a vegetated roof or be covered in energy generation systems.	✓	✓	✓		✓	✓	✓							✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓			✓	✓	✓		✓			✓

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DESIGN GUIDE - PROJECT REQUIREMENTS

Requirements		Performance requirements	Asset type: New build	Asset type: Refurb	Asset type: Listed	Asset type: Component replacement only	Class: Residential	Class: Commercial (e.g., Offices)	Class: Public (e.g., Schools)	Value: below £250k	Value: £250k - £5m	Value: £5m - £50m	Value: Above £50m	Interdependencies: Technologies	Interdependencies: Whole Life Carbon	Interdependencies: Climate Impact Modelling (resilience	Interdependencies: Circular Economy	Interdependencies: Procurement	PM Guide (Project Delivery Methodology): Task Bar – PM Guide Reference	PM Guide (Project Delivery Methodology): PPG Activities – PM Guide Task Description	Key Stakeholders: Project Management	Key Stakeholders: Building Surveying	Key Stakeholders: Quantity Surveying	Key Stakeholders: Architectural	Key Stakeholders: Structural and Civil Engineering	Key Stakeholders: Mechanical & Electrical Engineering	Key Stakeholders: Fire Engineering	Key Stakeholders: Interior Design Services	Key Stakeholders: PassivHaus Design	Key Stakeholders: Transportation	Key Stakeholders: Contractor
Category / Sub-category		Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard																													
		Non - roof measures 1. Use existing plant material or install plants that provide shade over paving areas within 10 years of planting. Can include vegetated planters and must be in place at the time of occupancy. 2. Provide shade by structures covered by energy generation systems such as PV and wind turbines - if on a roof is it should have an aged Solar reflectance value o at least 0.28 in accordance with ANSI/CRRC S100. If not on a roof or no information then the initial SR but be at least 0.33. 3. Provide shade with vegetated structures. 4. Use paving materials with an initial SR of at lest 0.33. 5. Use an open-grid pavement system (at least 50 % unbound). 6. A minimum of 50% of the projects site area shall be shade, vegetated and/or high solar reflectance surfaces. 7. Lighter reflective surfaces such as light-coloured coatings, membranes and pavement materials. 8. Provision of trees to provide natura solar shading. 9. Self standing structures such as canopies and shade sails to aid solar shading. 10. Incorporate water bodies such as pools and fountains in the public realm to increase the cooling effect.	✓	✓	✓		✓	✓	✓							✓			DT Appointments	Prepare a list of primary and secondary Consultants. To complete and review the Schedule of services and scope of works reflects the Project requirements.	✓			✓	✓	✓		✓			✓

DESIGN GUIDE - PROJECT REQUIREMENTS

Requirements		Performance requirements	Asset type				Class			Value				Interdependencies					PM Guide (Project Delivery Methodology)		Key Stakeholders										
Category / Sub-category		Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	New build	Refurb	Listed	Component replacement only	Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	below £250k	£250k - £5m	£5m - £50m	Above £50m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	Task Bar: PM Guide Reference	PPG Activities: PM Guide Task Description	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
Well being																															
Community engagement	Waste	1. All efforts should be made to assist businesses and residents to reduce the amount of waste they produce and increase the proportion of waste they recycle. 2. CoLC committed to improve recycling opportunites in flats as 99% of the square mile is flats, by improving recycling this can contribute to 32% recycling rate by 2025.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N/A					Project Brief	Verify the objectives and priorities of the project. Ensure expectations are reasonable and attainable.Clarify client roles and the project structure. Gather contextual information.	✓			✓						✓	✓
	Energy	1. Efforts should be made (through training, monitoring energy consuption and commissioning building services) to ensure that post occuancy EPC A or BREEAM Excellent ratings are not affected by the tenants– also ensure than tenants get involved and play an active part in improving said ratings. 2. Encouraging consumers to tariff switches such as the uptake of smart meters to help the widespread rollout of net zero technologies. 3. Tackle fuel poverty by providing targeted energy efficiency measures and discounts on bills as highlighted within the Energy and Carbon Efficiency section.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓					Witness/testing & Commissioning	Ensure the Building Service Engineer and other specialist are in attendance to witness testing & commissioning. Ensure that appropriate key staff training has taken place.	✓					✓					✓
	Travel/ Transport	1. Promote sustainable travel patterns & transport modes 2. Improve conditions for pedestrians and cyclists through better management of the facilities 3. All development proposals must be accompanied by an assessment of transport implications during construction & operation, focusing on: •Road dangers •Pedestrian environment and movement •Cycling infrastructure provision •Public transport •The street network oThis helps understand and mitigate the likely impact of the development on transport networks. 4. Loss of a pedestrian route will only be permitted where an alternative public pedestrian route of at least an equivalent standard is provided. Routes of historic importance should be safeguarded. 5. Provide public access across private land where it enhances the connectivity, legibility and capacity of the City's street network. 6. Create new pedestrian rights of way where this would improve movement and contribute to the character of an area. 7. All off-street car parking spaces and servicing areas must be equipped with the facility to conveniently recharge electric vehicles. 8. Designated parking must be provided for Blue Badge holders within developments. For domestic buildings, motorcycle parking must be provided at a ratio of 10 motor cycle parking spaces per 1 car parking space whenever any car parking spaces are provided.	✓	✓	✓		✓	✓	✓		✓	✓	✓	N/A					Project Brief	Verify the objectives and priorities of the project. Ensure expectations are reasonable and attainable.Clarify client roles and the project structure. Gather contextual information.	✓									✓	✓
	Construction Impact	1. Developers must consider minimising noise pollution arising from site acitivites. Where minimising is not possible, noise mititgation methods should be implemented e.g restricted operating hours, noise attention methods. 2. Internal and external lighting should be designed to avoid spillage of light beyond what is needed to protect light-sensitive areas such as housing, hospitals, important areas of nature conservation. 3. Where ground work is required, developers must carry out a detailed site investigation to establish site contamination and undertake a risk assessment. Remediating sources of contamination which present an unacceptable risk must be carried out.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N/A					Project Brief	Verify the objectives and priorities of the project. Ensure expectations are reasonable and attainable.Clarify client roles and the project structure. Gather contextual information.	✓					✓					✓
	Climate resilience	1. Local communities must be encourged and involved in order to effectively reduce the vulnerability of their area against the impact of climate change. 2. There should be active engagement with tenant and occupiers on resilience issues. 3. Consideration should be given to mitigation of health impacts where overheating may be an issue. 4. Development should aim to improve occupant's internal environment and comfort.	✓	✓	✓		✓	✓	✓		✓	✓	✓			✓			Project Brief	Verify the objectives and priorities of the project. Ensure expectations are reasonable and attainable.Clarify client roles and the project structure. Gather contextual information.	✓										
		1. Smoke-free environment: •Prohibited outdoor smoking at ground level within 7.5 meters of all building air intake. •Signage is present to communicate the ban. •Prohibited outdoor smoking on decks, patios, balconies, roof tops and other occupied outdoor area above ground level.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N/A					Concept Design	DT to prepare a Scheme Design report on completion	✓			✓		✓		✓			✓

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Requirements: Category / Sub-category		Performance requirements: Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard
WELL Building type requirements	Internal Environments	1. Ventilation Design - complete one of the following: •Mechanically ventilated spaces •Newly installed ventilation systems are designed to meet one or more of 90% of the project area. oASHRAE 62.1-2010 or any more recent versions (Ventilation Rate Procedure or IAQ Procedure). oASHRAE 62.2-2016. oEN 16798-1. o AS 1668.2-2012 or any more recent version. o CIBSE Guide A: Environmental Design, version 2007 or any more recent version. 2. Existing ventilation systems have been tested and balanced to meet supply and exhaust rates set in one or more ventilation guidelines listed above within the last five years. 3. Naturally ventilated spaces: •Newly installed ventilation systems are designed to meet one or more of 90% of the project area. oNatural Ventilation Procedure in ASHRAE 62.1-2010 or any more recent versions. oEN 16798-1. oCIBSE AM10: Natural Ventilation in non domestic buildings. oAS 1668.4-2012 or any more recent version. oAny reference above, which describes natural ventilation procedures. 4. Vents and windows used to meet the ventilation requirements in one of the standards mentioned above are permanently open or have controls to prevent their closure during periods of occupancy (openable windows not used in ventilation calculations may be user operated). 5. Outdoor air meets the following thresholds as an average for the previous year: •PM2.5 less than 35 µg/m³. •PM10 less than 70 µg/m³. 6. Ventilation Monitoring: one of the following carbon dioxide thresholds in met in occupied spaces: •900 ppm or less. •not more than 500 ppm above outdoor levels.
		Construction Pollution Management: 1. For construction occurring after enrolment or the start of subscription, the following requirements are met: •Ducts are maintained per one of the below: oDucts are sealed and protected from possible contamination during construction. oDucts are cleaned prior to installing registers, grills and diffusers. 2. If permanently installed ventilation system is operating during construction, filters must meet the following: •Media filters with a PM10 removal rating of at least 70% (e.g., MERV 8) are used to filter return air. •All filters are replaced prior to occupancy. 3. The project implements the following moisture and dust management procedures: •Carpets, acoustical ceiling panels, fabric wall coverings, insulation, upholstery and furnishings and other absorptive materials are stored separately in a designated area protected from moisture damage. •All active areas of work are isolated from other spaces by sealed doorways or windows or using temporary barriers. •Walk-off mats are used at entryways to reduce the transfer of dirt and pollutants. •Saws and similar tools use dust guards or collectors to capture generated dust.
	Noise	1. The following requirements are met: •An annotated document is submitted and made available to occupants showing labelled zones throughout the project floor plan or similar schematic document as follows: oLoud zones: includes areas intended for loud equipment or activities (e.g. mechanical rooms, kitchens, fitness rooms, social spaces, recreational rooms, music rooms). oQuiet zones: includes areas intended for concentration, wellness, rest, study and/or privacy (e.g. restorative spaces, lactation rooms, nap rooms). oMixed zones: includes areas intended for learning, collaboration and/or presentation (e.g., auditoriums, classrooms, breakout spaces). oCirculation zones: includes occupiable areas not intended for regular occupancy (e.g. hallways, egress, atria, stairs, lobbies). 2. If Loud zones directly border Quiet zones, projects provide a plan for reprogramming or mitigating sound transmission between Loud zones and Quiet zones.
	Mind	Provide connection to nature: 1. The project integrates the following throughout the space, including common circulation routes, shared seatings, and rooms: •Natural Materials, patterns, shapes, colours, images or sounds. •One of the following: oPlants e.g. potted plants, planted walls OR oWater e.g. fountain.
		Provide connection to place: 1. The project integrates design elements that address the following: •Celebration of culture e.g. culture of occupants, workplace, surrounding communities. •Celebration of place e.g. local architecture, materials, flora, artists. •Integration of art. •Human delight.

Row	Asset type: New build	Refurb	Listed	Component replacement only	Class: Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	Value: below £250k	£250k - £5m	£5m - £50m	Above £50m	Interdependencies: Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	PM Guide (Project Delivery Methodology): Task Bar – PM Guide Reference	PPG Activities – PM Guide Task Description	Key Stakeholders: Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
Internal Environments – Ventilation Design		✓	✓	✓		✓	✓		✓	✓	✓	✓					Concept Design	DT to prepare a Scheme Design report on completion	✓					✓					✓
Internal Environments – Construction Pollution Management	✓	✓	✓	✓		✓	✓		✓	✓	✓			N/A			Concept Design	DT to prepare a Scheme Design report on completion	✓					✓					✓
Noise	✓	✓	✓	✓		✓	✓		✓	✓	✓			N/A			DT Appointments	Prepare a list of primary and secondary Consultants.	✓					✓					✓
Mind – Provide connection to nature	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			N/A			Concept Design	DT to prepare a Scheme Design report on completion	✓			✓				✓			✓
Mind – Provide connection to place	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			N/A			Concept Design	DT to prepare a Scheme Design report on completion	✓			✓				✓			✓

DESIGN GUIDE - PROJECT REQUIREMENTS

Requirements		Performance requirements	Asset type				Class			Value				Interdependencies					PM Guide (Project Delivery Methodology)		Key Stakeholders										
Category / Sub-category		Performance standards and specifications from industry standards, regulations and guidance to set the CoL Standard	New build	Refurb	Listed	Component replacement only	Residential	Commercial (e.g., Offices)	Public (e.g., Schools)	below £250k	£250k - £5m	£5m - £50m	Above £50m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience	Circular Economy	Procurement	Task Bar	PPG Activities	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
	Accessibility	Integrate universal design: 1. The project considers best practices in universal design to accommodate a diverse range of occupant abilities and needs throughout the project, by implementing at minimum one design, operations or policy strategy in each of the following categories: •Physical access: entry, exit and key interaction points that enable inclusive entrance and strategies that enable flexible usability of the space to accommodate change as needed. •Developmental and intellectual health: strategies that use colour, texture, images and other multi-sensory visually perceptible information (e.g. to accommodate sensory requirements of neurodiverse individuals). •Wayfinding: strategies that help individuals intuitively navigate through the project (e.g. signage, tactile maps, symbols, auditory cues, information systems). •Operations: operational policies and programs that support inclusion and accommodate a diverse range of needs (e.g. diversity and inclusion training, flexible work hours for individuals with disabilities). •Technology: technology (e.g. audio and visual equipment, web access) that helps individuals fully utilise a space (e.g. to assist blind or deaf individuals, or those who do not speak the native language), made available to all occupants at no cost. •Safety: strategies that support easy access to all spaces and amenities and minimize risk of injury, confusion or discomfort (e.g. lighting or clear sightlines to increase feelings of security).	✓	✓	✓			✓	✓		✓	✓	✓	N/A					Concept Design	DT to prepare a Scheme Design report on completion	✓			✓		✓		✓			✓
Post Occupancy Evaluation (POE)																															
Embodied carbon	Embodied carbon	1. Average carbon content of heat supplied (gCO_2/kwh per year) should be reported in-use. 2. Reduce operational energy consumption to 35kWh/m² per year for small scale housing (energy use intensity in GLA).	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.	✓					✓					✓
Operational energy and carbon	Post Occupancy performance	1. Carry out a post occupancy assessment to ensure that the design performance meets the in-use performance of the building.	✓	✓	✓		✓	✓	✓	x	x	x	x	✓	✓		✓		Project Close-Out review	Compile lessons learned log	✓										
Energy and water monitoring	Energy Monitoring	1. Appropriate energy monitoring and management systems are installed for the various end-use categories of energy consuming systems. 2. Separate landlord and tenant energy use meters and clearly label meters with serial number and end use. 3. Use a central repository for data that has a minimum of 18 months data storage.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.		✓				✓			✓		✓
	Water Monitoring	1. Water-consuming plant or building areas, are either fitted with easily accessible pulsed or digital sub-meters or have water monitoring equipment integral to the plant or area.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					DT Appointments	QF170 Mechanical and Electrical Engineer's Services ScopeArrange a Kick-Off meeting with Primary Consultants.		✓				✓			✓		✓
	Data Disclosure	1. Disclose energy use data (residential) including: •Collect annual building energy consumption and generation. •Aggregate average operational reporting e.g. by post code for anonymity or upstream meters. •Collect water consumption meter readings. •Upload five years of data to GLA and/or CarbonBuzz online platform. •Consider uploading to Low Energy Building Database.	✓	✓	✓		✓				✓	✓	✓	✓					Witness, testing and commissioning	Ensure the Building Service Engineer and other specialist are in attendance to witness testing & commissioning.	✓	✓				✓			✓		✓
		1. Disclose energy use data (commercial / Public) including: •Carry out an annual Display Energy Certificate (DEC) and include as part of annual reporting. •Report energy consumption by fuel type and respective benchmarks from the DEC technical table. •For multi-let commercial offices produce annual landlord energy (base building) rating and tenant ratings as well as or instead of a whole building DEC. •Upload five years of data to a publicly accessible database such as GLA and/or CarbonBuzz.	✓	✓	✓			✓	✓		✓	✓	✓	✓					Witness, testing and commissioning	Ensure the Building Service Engineer and other specialist are in attendance to witness testing & commissioning.	✓	✓				✓			✓		✓
Local air quality	Local air quality	1. Monitor the following at least once a year: •PM2.5. •PM10. 2. One of the following: •Total VOC. Benzene, Formaldehyde, Toluene. •Carbon Monoxide. •Ozone.	✓	✓	✓			✓	✓					✓					DT Appointments	Prepare a list of primary and secondary Consultants.	✓					✓					✓

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DESIGN GUIDE - INFORMATION REQUIREMENTS

Topic	Information requirements - Assurance	Information requirements - KPI's	New build	Refurb	Listed	Component replacement only	Commercial	Residential	Public	below £250k	£250k - £5m	£5m - £50m	Above £5m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
			Asset type / Class / Value											Interdependencies					Stakeholders										
Category / Sub-category	A list of data which suppliers need to gather to demonstrate compliance with the nz standards and guidance (templates will be produced at a later date)	A list of data which suppliers need to gather to demonstrate compliance with CoL KPIs (templates will be produced at a later date)																	Key stakeholders to be considered throughout project lifecycle who will input into design and construction										
Introduction and Accreditations																													
Sustainability rating	BREEAM Pre-assessment document Confirmation of BRE Registration and Assessment number Interim (Design) Stage Assessment Report and compliant evidence Final (Post Construction Review) Assessment Report and compliant evidence	Planning requirements: led to 75% of new commercial developments with over 20,000m² floor space achieving at least a BREEAM 'Excellent' rating since 2014. Embed sustainability principles into the design of all refurbishments and new build projects. Increase engagement and communications about sustainability with residents, businesses, visitors and other stakeholders.	✓	✓	✓		✓	✓	✓		✓	✓	✓			N/A			✓		✓	✓	✓	✓		✓	✓	✓	✓
	Complete SKA informal self- assessment of the environmental performance of fit-out Commission a quality-assured assessment and certificate from a RICS-accredited SKA assessor Obtain clear guidance on good practice in fit-out and how to implement it Benchmark the performance of fit-out against other similar buildings and Industry	Embed sustainability principles into the design of all refurbishments and new build projects. Increase engagement and communications about sustainability with residents, businesses, visitors and other stakeholders.		✓			✓				✓	✓	✓			N/A			✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	Accredited NABERS Energy for Offices rating Validation Record Template completed Simulation Report	Embed sustainability principles into the design of all refurbishments and new build projects. Increase engagement and communications about sustainability with residents, businesses, visitors and other stakeholders.		✓	✓		✓				✓	✓	✓			N/A			✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	Home Quality Mark (HQM) Pre-assessment document Confirmation of HQM Registration and Assessment number Interim (Design) Stage Assessment Report and compliant evidence Final (Post Construction Review) Assessment Report and compliant evidence	Embed sustainability principles into the design of all refurbishments and new build projects. Increase engagement and communications about sustainability with residents, businesses, visitors and other stakeholders.	✓					✓			✓	✓	✓			N/A			✓		✓	✓	✓	✓		✓	✓	✓	✓

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			New build	Refurb	Listed	Component replacement only	Commercial	Residential	Public	below £250k	£250k - £5m	£5m - £50m	Above £5m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
Topic	**Information requirements - Assurance**	**Information requirements - KPI's**	**Asset type / Class / Value**											**Interdependencies**					**Stakeholders**										
Category / Sub-category	A list of data which suppliers need to gather to demonstrate compliance with the nz standards and guidance (templates will be produced at a later date)	A list of data which suppliers need to gather to demonstrate compliance with CoL KPIs (templates will be produced at a later date)																	Key stakeholders to be considered throughout project lifecycle who will input into design and construction										
Introduction and Accreditations																													
Whole life carbon																													
Embodied carbon	Life cycle assessment - materials EPD Certificates Energy Assessment - report average carbon content of heat supplied (gCO_2/kwh per year)	No CAS KPIs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓		✓		✓	✓					✓
Whole life cycle carbon assessment	Confirmation of Whole life Carbon Calculations. Optimisation measures with costings	Support the integration of whole life carbon and cost analysis. Scope 3 Capital Projects Emissions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓			✓							
Operational carbon and energy + LZC Technology	Energy Strategy report to detail EUI and space heating demand	Maximise the use of renewable energy sources across our operational buildings. Energy consumption kWh/m² floor area	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓										✓					
	As designed BRUKL - output from energy modelling providing design energy results Energy Modelling using appropriate software Permeability / air test results showing air tightness figure	Part L modelling - *Further details can be seen in the Technical Standard* Energy consumption kwh/m2 floor area	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓										✓					
	As built BRUKL - output from energy modelling providing as built / post construction results Permeability / air test results showing air tightness figure	Energy consumption kWh/m² floor area	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓										✓					
	Post Construction Evaluation report showing post occupancy evaluation (POE) requirements (and results where completed)	No CAS KPIs	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓					✓										
	LZC Technology feasibility study	Develop a Square Mile renewable energy strategy	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓					✓			✓		✓			✓		✓
Minimising Carbon	**Carbon Reduction** Net zero strategy with energy modelling Confirmation of climate action fund Whole life carbon calculations Carbon removals strategy	Accelerate the move to net zero carbon and energy efficient tenanted buildings, working closely with tenants to achieve shared goals	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓		✓			✓		✓
	Minimise Pollution Low Zero Carbon Technology options	Maximise the use of renewable energy sources across our operational buildings	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓		✓			✓		✓
	Energy Efficiency Thermal comfort Modelling	Accelerate the move to net zero carbon and energy efficient tenanted buildings, working closely with tenants to achieve shared goals Reduce pollution and increase the resilience of the Square Mile. Reduce air pollution through implementing our ambitious air quality and transport strategies.	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓		✓			✓		✓

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Topic	Information requirements - Assurance	Information requirements - KPI's	New build	Refurb	Listed	Component replacement only	Commercial	Residential	Public	below £250k	£250k - £5m	£5m - £50m	Above £5m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
			Asset type / Class / Value											Interdependencies					Stakeholders										
Category / Sub-category	A list of data which suppliers need to gather to demonstrate compliance with the nz standards and guidance (templates will be produced at a later date)	A list of data which suppliers need to gather to demonstrate compliance with CoL KPIs (templates will be produced at a later date)																	Key stakeholders to be considered throughout project lifecycle who will input into design and construction										
Introduction and Accreditations																													
Circular Economy																													
Decommissioning	Circular Economy Statement. Functional adaptability Strategy	Support the integration of circular economy principles into day-to-day activities of the Corporation. Embed circular economy principles into our capital projects and reduce carbon intensity by using life cycle carbon and cost assessment techniques and design specifications. Use our planning role to influence others to embed carbon analysis and circular economy principles in capital projects through use of the Supplementary Planning Document - Planning for Sustainability. Embrace circular economy principles across our strategies and work.	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓		✓			✓	✓			✓			✓
Circular economy	Circular Economy Statement.	Support the integration of circular economy principles into day-to-day activities of the Corporation. Embed circular economy principles into our capital projects and reduce carbon intensity by using life cycle carbon and cost assessment techniques and design specifications. Use our planning role to influence others to embed carbon analysis and circular economy principles in capital projects through use of the Supplementary Planning Document - Planning for Sustainability. Embrace circular economy principles across our strategies and work.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓			✓							✓
Resource efficiency	Circular Economy Statement. Site Waste Management Plan.	Support the integration of circular economy principles into day-to-day activities of the Corporation. Embed circular economy principles into our capital projects and reduce carbon intensity by using life cycle carbon and cost assessment techniques and design specifications. Use our planning role to influence others to embed carbon analysis and circular economy principles in capital projects through use of the Supplementary Planning Document - Planning for Sustainability. Support the integration of low impact materials	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓			✓							✓

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Topic	Information requirements - Assurance	Information requirements - KPI's
Category / Sub-category	A list of data which suppliers need to gather to demonstrate compliance with the nz standards and guidance (templates will be produced at a later date)	A list of data which suppliers need to gather to demonstrate compliance with CoL KPIs (templates will be produced at a later date)
Introduction and Accreditations		
Materials		
Low impact materials	Materials Management Plan Site waste management plan Responsible sourcing certificates	Support the integration of low impact materials
Procurement of materials	Bill of Materials Circular Economy Statements Follow CoLC Procurement Code	Support the integration of low impact materials. Strengthen our requirements and supplier engagement to drive performance and innovation in delivering sustainable products and solutions. Support organisations in the Square Mile to build circular, low carbon and resilient supply chains. Promote responsible procurement and investment practices.
Material durability	Development of material durability optioneering throughout RIBA stages	Support the integration of low impact / highly durable materials.
Modern methods of construction	Development of modern methods of construction optioneering throughout RIBA stages	Support the integration of low impact materials

Topic	Asset type / Class / Value											Interdependencies					Stakeholders										
	New build	Refurb	Listed	Component replacement only	Commercial	Residential	Public	below £250k	£250k - £5m	£5m - £50m	Above £5m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
Category / Sub-category																	Key stakeholders to be considered throughout project lifecycle who will input into design and construction										
Low impact materials	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓				✓	✓	✓			✓	✓			✓			✓
Procurement of materials	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓									✓
Material durability	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓		✓	✓	✓		✓			
Modern methods of construction	✓				✓	✓	✓		✓	✓	✓		✓		✓	✓	✓			✓	✓						✓

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Topic	Information requirements - Assurance	Information requirements - KPI's	Asset type / Class / Value: New build	Refurb	Listed	Component replacement only	Commercial	Residential	Public	below £250k	£250k - £5m	£5m - £50m	Above £5m	Interdependencies: Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement	Stakeholders: Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
Category / Sub-category	A list of data which suppliers need to gather to demonstrate compliance with the nz standards and guidance (templates will be produced at a later date)	A list of data which suppliers need to gather to demonstrate compliance with CoL KPIs (templates will be produced at a later date)																	Key stakeholders to be considered throughout project lifecycle who will input into design and construction										
Introduction and Accreditations																													
Resilience																													
Climate change adaptation	Asset identification Sustainability Statements Risk Assessment and risk workshop Confirmation of intervention measures designed in and installed / implemented (drawings, specifications, photographs, etc.) Flood Risk Assessment	Embed resilience measures into our upgrade plans for our owned and operated buildings. Embed a climate resilience lens into all our decision-making. Make the Square Mile public realm more climate change ready through adding in more green spaces, urban greening, flood resistant road surfaces, adaptable planting regimes and heat resistant materials. Strengthen our planning guidance on climate resilience measures for new developments.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	✓	✓	✓					✓
Biodiversity, ecology and conservation	BREEAM Evidence requirements: One or more of the appropriate evidence types listed in the BREEAM Evidential requirements such as Design drawings and professional specialist reports Completed BREEAM and HQM Ecology Risk Evaluation Checklist A copy of the Ecological Survey and Evaluation document such as a Phase 1 habitat assessment. Site visits confirming measures have been carried out in-practice in line with SQEs recommendations As-built evidence to show the changes in the BREEAM Change in Ecological value calculator have been carried out as planned in line with SQEs recommendations e.g. as built drawings, photos, SQE sign off.	Introduce new land management practices across our open spaces aiming to maximise their ability to remove carbon, and optimise their biodiversity and resilience value. Advocate the importance of green spaces and urban greening as natural carbon sinks, and their contribution to biodiversity and overall wellbeing. Make the Square Mile public realm more climate change ready through adding in more green spaces, urban greening, flood resistant road surfaces, adaptable planting regimes and heat resistant materials. Enhance greening and biodiversity across our public realm and open spaces.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			✓	✓	✓	✓							✓

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Category / Sub-category	A list of data which suppliers need to gather to demonstrate compliance with the nz standards and guidance (templates will be produced at a later date)	A list of data which suppliers need to gather to demonstrate compliance with CoL KPIs (templates will be produced at a later date)
Introduction and Accreditations		
Flood resilience	Flood Risk Report Climate Change Adaptation Strategy	Embed resilience measures into our upgrade plans for our owned and operated buildings. Embed a climate resilience lens into all our decision-making. Make the Square Mile public realm more climate change ready through adding in more green spaces, urban greening, flood resistant road surfaces, adaptable planting regimes and heat resistant materials. Reduce the risk of flooding through developing sustainable rain and surface water management policies, resulting in a connected system of water recycling, sustainable urban draining and rainwater management measures.
Local air quality	Transport Assessment and Travel Plan Marked up drawing showing cyclist facilities locations and details. Confirmation including a formal commitment with targets set and tables / systems of monitoring and reporting energy and CO_2 from site activities and transportation of materials and waste. Confirmation of heating and hot water source / plant including specifications, drawings and manufacturers datasheets. Must show type, NOx emissions, VOCs and PM10 levels. Manufacturers datasheets / confirmations of VOC and formaldehyde and carcinogen levels of all finishes materials. Air Quality Assessment Environmental Impact Assessment Screening Matrix checklist Confirmation of the installation of air quality monitoring tools Site specific indoor air quality plan Results from post construction on site VOC and formaldehyde testing.	Facilitate collaborative action on air pollution in London. Reduce air pollution through implementing our ambitious air quality and transport strategies.
Passive design	Passive design solutions integrated into the design development by the Architect Passivhaus solutions integrated into the design development by the Architect Energy modelling and reporting	Embed passive design and resilience measures into our upgrade plans for our owned and operated buildings. Make the Square Mile public realm more climate change ready through integrating passive solutions, adding in more green spaces, urban greening, flood resistant road surfaces, adaptable planting regimes and heat resistant materials.

Topic	Asset type / Class / Value											Interdependencies					Stakeholders										
	New build	Refurb	Listed	Component replacement only	Commercial	Residential	Public	below £250k	£250k - £5m	£5m - £50m	Above £5m	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
Category / Sub-category																	Key stakeholders to be considered throughout project lifecycle who will input into design and construction										
Introduction and Accreditations																											
Flood resilience	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			✓			✓	✓	✓					✓
Local air quality	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓				✓			✓		✓		✓		✓	✓
Passive design	✓				✓	✓	✓					✓		✓			✓	✓		✓		✓			✓		✓

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Category / Sub-category	A list of data which suppliers need to gather to demonstrate compliance with the nz standards and guidance (templates will be produced at a later date)	A list of data which suppliers need to gather to demonstrate compliance with CoL KPIs (templates will be produced at a later date)																	Key stakeholders to be considered throughout project lifecycle who will input into design and construction										
Introduction and Accreditations																													
Wellbeing																													
Community centric approach	Waste reduction techniques and initiatives Energy monitoring systems and commissioning reports BREEAM In Use Assessment (optional) Assessment of transport implications Contractor pollution control methods and policies, including minimising light pollution Site investigation with risk assessment and remediation strategy Climate resilient techniques	Upskill our workforce on net zero. Upskill our workforce on climate resilience. Upskill our workforce on Circular Economy approaches. Share best practice on standards, tools, platforms and expertise to facilitate green and sustainable investment and growth. Encourage global movement towards disclosure and production of credible transition plans as the norm. Foster an ambition to achieve net zero emissions by 2050 or sooner for UK-based financial and professional services firms. Join other investors working through development and implementation of net zero transition action plans. Support financial institutions committing to net zero in the 2040s at the latest, covering all emissions, including scope 3 and where data allows reliable measurement. Support charities and SMEs to consider, prepare for and lead the response to climate change. Share learning and best practice about the challenges and opportunities of our net zero journey. Address existing inequalities and ensure no one is left behind. Prepare people for skills needed in a net zero economy. Facilitate collaborative action on air pollution in London. Work with our creative and educational sector partners to deliver sustainable initiatives.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓			✓		✓				✓	✓
WELL type requirements (noise, air quality, accessibility, etc.)	Air quality monitoring regime and testing results by Air Quality Consultant. Marked up drawings / photographs showing smoke free areas and signage, along with smoke free policies agreed and adhered to. M&E drawings, specifications, datasheets confirming ventilation strategy and monitoring, testing results, and confirmation of relevant / applicable standards met. Contractor confirmation of (as applicable): - sealed and protected ducts, and cleaning regime / confirmation completed - replacement of filters, and media filters with a PM10 removal rating - moisture and dust management procedures Marked up drawing / schematic showing labelled noise zones. Marked up drawings / specifications / photos showing internal spaces with natural materials and planting or water fountain. Confirmation / evidence of meeting the 'connection to place' requirements. Confirmation of universal design / accessibility including in design, policy and operations using drawings, specifications, photos, etc.	Advocate the importance of green spaces and urban greening as natural carbon sinks, and their contribution to biodiversity and overall wellbeing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓			✓		✓		✓			✓

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Topic	Information requirements - Assurance	Information requirements - KPI's
Category / Sub-category	A list of data which suppliers need to gather to demonstrate compliance with the nz standards and guidance (templates will be produced at a later date)	A list of data which suppliers need to gather to demonstrate compliance with CoL KPIs (templates will be produced at a later date)
Introduction and Accreditations		
Post Occupancy Evaluation (POE)		
Energy and Water Monitoring	Schematics, drawings, specifications confirming metering strategy, along with the monitoring and management systems. Confirmation of energy use data disclosure, reporting strategy. Confirmation of data upload to Carbon Buzz or GLA. Copy of DEC	No CAS KPIs

Topic	Asset type / Class / Value										
	New build	Refurb	Listed	Component replacement only	Commercial	Residential	Public	below £250k	£250k - £5m	£5m - £50m	Above £5m
Energy and Water Monitoring	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Topic	Interdependencies				
	Technologies	Whole Life Carbon	Climate Impact Modelling (resilience)	Circular Economy	Procurement
Energy and Water Monitoring	✓				

Topic	Stakeholders										
	Project Management	Building Surveying	Quantity Surveying	Architectural	Structural and Civil Engineering	Mechanical & Electrical Engineering	Fire Engineering	Interior Design Services	PassivHaus Design	Transportation	Contractor
Category / Sub-category	Key stakeholders to be considered throughout project lifecycle who will input into design and construction										
Energy and Water Monitoring	✓					✓					✓

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MONITORING AND REPORTING

This section summarises the monitoring and reporting requirements for Project Managers applying the Net Zero Design Standard and the principal project data interfaces with other associated CoLC documents and processes.

The ➲**Design Standard 'Tracker'** is intended to assist the CoLC PM in monitoring and reporting on a project's performance against the Project, Process and Information requirements of the Standard.

The Best Available Technology (BAT) Guidance sets out the activities to be applied by Project Managers to identify and evidence the selection of ➲**Best Available Technology (BAT)** for CoLC projects across the RIBA stages. The Best Available Technology (BAT) Tool is designed to be used by the Project Manager to demonstrate compliance with the requirements given in the Standard's Performance and Technical tables.

The CoLC Whole Life Carbon Methodology and WLC Assessment Template can be applied to record WLC on projects to support net zero targets, improve resilience and inform future building resilience action plans. The emissions data captured in the assessment can be used to evidence contribution to the relative CAS KPIs.

Resilience interventions that have been identified and applied for the priority assets (undertaking refurbishments) must be managed in collaboration with the Asset Managers and recorded in the Buildings Resilience Plan, taking this approach will ensure that contribution to the Resilient Buildings KPIs is consistent.

As noted above (➲**How to Use this Standard**), the Net Zero Standard provides users with an overview of and access to other CoLC tools to embed sustainability across CoLC assets.

Monitoring

The ➲**Net Zero Design Tracker** provides a consistent approach for the PM to monitor project requirements and maintain a record of the project's status against these. To support the successful completion of the Tracker, the PM should create and maintain a Net Zero Design Standard folder in the Project File to collate all the requisite information to show compliance with the Standard. It is recommended that the PM communicates to the Project Delivery Team and other relevant stakeholders e.g., Commercial Services what information is required to be retained and when, responsibilities for collating information and to provide access to the project file.

Lessons Learnt

Throughout the project, the PM should discuss with the Project Delivery Team opportunities to improve, and lessons learnt. This should be captured in the Design Standard Tracker Comments column for each RIBA stage, so that all lessons learnt can be easily extracted at any stage within the project and shared within the organisation to inform and enhance project delivery and accelerate delivery of the Climate Action Strategy targets

Filing Structure

This Project file should be used to store / collate copies of the supporting evidence (as summarised in the Tracker's Evidence column) throughout project delivery. The file should be structured with folders aligned with the RIBA project delivery stages and / or CoLC Gateways.

The Project file should also be used to maintain records of:

- Best Available Technology Assessments and the Project Manager's explanation if / where this is not considered applicable to a given project.
- The Monitoring Performance Approach.
- The associated data requirements to confirm that the technology meets the performance requirements of the BAT Assessment; and
- Monitoring and collection of operational data to confirm that the BAT performance standards have been met.

The project's Net Zero Design Standard folder should be held in SharePoint so that it is available for review by the CoLC Senior Officer at the end of each RIBA Stage and or CoLC Gateway or as required.

Whole Life Carbon Assessment, Climate Impact Modelling and Resilience monitoring data requirements significantly overlap with those for the Net Zero Standard and hence, the PM is expected to find it beneficial to maintain records all the supporting information within the Project File.

Relevant Gateway Approvals
Gateway 1 - Project Briefing
Gateway 2 - Project Proposal
Gateway 3 - Options Appraisal
Gateway 4 - Detailed Options Appraisal a. Inclusion in capital programme b. Approval of the Court of Common Council c. Detailed Design
Gateway 5 - Authority to start work
Gateway 6 - Outcome report

Reporting

The use of the Net Zero Design Standard is mandatory for all projects, and it is recommended that where possible the requirements should be implemented on projects. However, it is not currently mandatory to comply with all categories or requirements of the Standard.

It is recognised that full compliance may not always be practical or possible. It is accepted that larger projects (with capital value over a defined financial value) will be able to achieve greater compliance with this standard than smaller projects, but it is expected that the standard is applied in such a way that provision is made for authorised deviations from the requirements of the Standard. PMs are expected to keep justification for such deviations as part of the project file to be detailed as necessary in gateway reporting or for audit review.

CoLC will establish procedures for review and confirmation of compliance with the requirements of the Standard.

It is recommended that the Net Zero Design Tracker and supporting files are reviewed by the City of London Senior Officer on a structured basis to confirm compliance with the requirements of the Standard throughout project delivery. It is suggested that review and sign-off should be obtained as soon as is practical following the end of each RIBA stage / Gateway.

This element is Work in Progress / awaiting input from the CoLC.

Continuous Improvement

Application of the Design Standard will generate data on the energy and carbon performance of CoLC buildings and projects. It is anticipated that over time, review and analysis of this data set will support the identification of 'better performing' approaches and projects and that this information will then inform refinement of the Standard to help drive further improvement and ultimately reduction in the CoLC's climate change risk profile.

The PM has a key role to play in generating and collating project-specific information for the Design Standard, Climate Impact Modelling and understanding of CoLC asset Resilience.

➲Access & Download Net Zero Tracker here

WHO TO CONTACT WITH QUERIES

The guide is owned by the CoLC Property Projects Group and questions should be directed to the Property Projects Team.

For subject matter experts queries please contact the following:

- **Head of Energy and Sustainability** - Energy and Sustainability
- **Climate Action Programme Director** - Climate Action Programme
- **Property Projects Director** – Property projects
- **Director Building Surveying Operational Property** – Operational property
- **Environmental Resilience Officer** – Resilience
- **Senior Energy Engineer** – Energy
- **Principal Planning Officer** – Planning
- **Responsible Procurement Manager** – Commercial Services

// Building Blocks for Net Zero

Appendix 1 - Net Zero Technology Guide

Introduction

The Technology Guide (Performance Standards and Technical Standards) is provided to support the wider Net Zero Design Standard and provide further details on the application of technologies to support with the transition to net zero carbon. This Appendix provides information on performance and technical implementation of specific building technologies, and the best available technology in the design, major refurbishment, and replacement activities across the CoLC estate.

The Technology Guide is divided into ten main Technology Categories which are then further split into Sub-Categories. Each category and sub-category is divided into an introduction, and into two further sections providing information on Performance Standards and a Technical Standards for implementation of specific building technologies across the estate.

Guidance is also provided at the end of the Section on choosing the Best Available Technology to lead to the most appropriate net zero solution and providing evidence of this selection process.

The Sections below introduce the Categories and Sub-Categories, providing an overview of the technology and the Sub-Categories. As technology choices will vary between building and project types, information is provided in the category introductions as a starting point to support optioneering between technology sub-categories.

Although the Technology Guide is divided into technology categories, it is important, where feasible and appropriate, to take a whole system approach which considers the interplay between technologies in the overall design of the project. Within the technology introductions, information is provided on the interdependencies between the technology categories to provide initial guidance in this area. For new construction or where a range of services and fabric are being refurbished a detailed whole building assessment should be undertaken, which may involve building modelling and assessments by the design team.

Detailed references are provided to support the performance standards and technical guidance, these references allow for further detailed research information to be easily accessed. By reviewing these references, the regular update and maintenance of this information can also be supported.

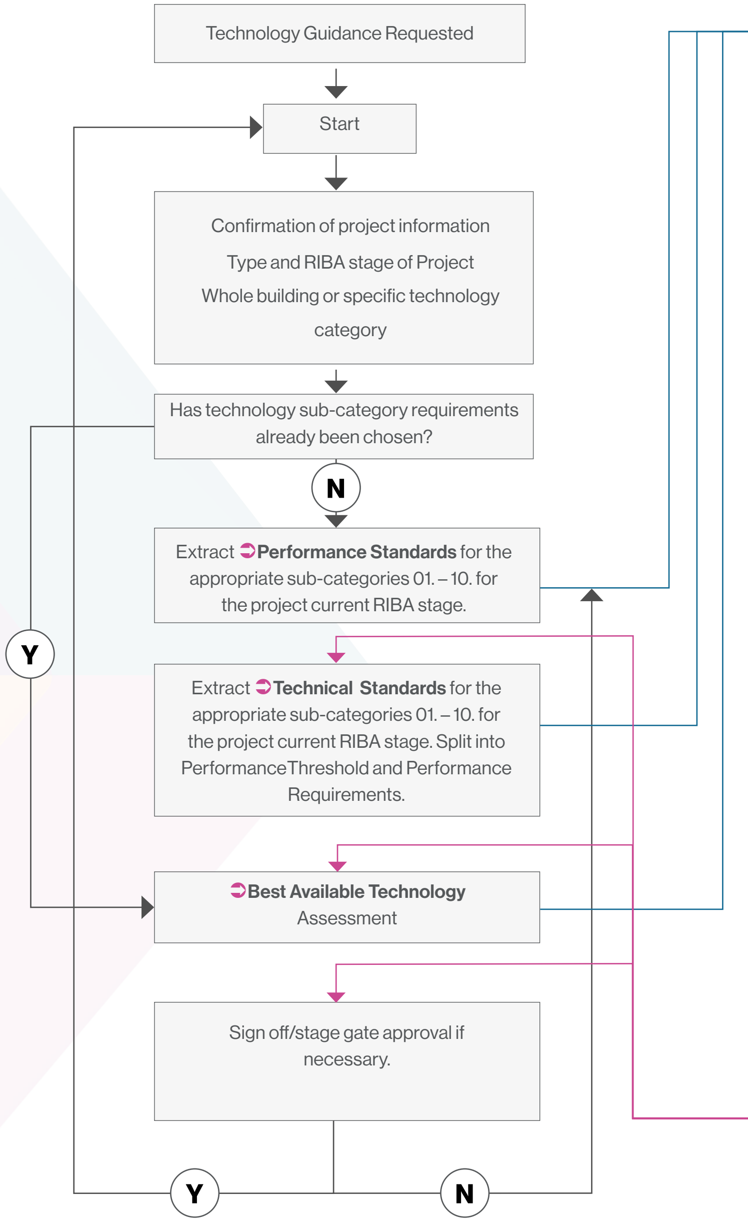
Interactive User Guide & Structure

The Interactive User Guide allows users to navigate through this Technology Standard to find relevant Performance and Technical tables of requirements which contain detailed information that will support net zero technology decision making. The information is split into the ten categories and subcategories and can be searched using the hyperlinks in the table on the next page.

The **Technology Guide** is provided to support the wider Net Zero Design Standard and provide further details on the application of net zero carbon technologies.

The process map offers hyperlinks to take users to the relevant sections in the Technology Guide providing users with context and guidance.

Please note that all Sub-categories in the interactive table on the right are linked to their respective **definitions.**



START

	Performance	Technical	BAT
01. Fabric			
Wall Insulation	■	●	◆
Roof insulation	■	●	◆
Windows and Doors	■	●	◆
Floor insulation	■	●	◆
Draught-proofing	■	●	◆
02. Heating			
Heat pumps	■	●	◆
Boilers (Gas / Electric)	■	●	◆
Electric Convectors	■	●	◆
Radiant heaters	■	●	◆
District heating	■	●	◆
03. Future Heating			
Hydrogen	■	●	◆
Blended Natural Gas	■	●	◆
Low Carbon CHP	■	●	◆
04. Hot Water			
Centralised System	■	●	◆
Point of Use	■	●	◆
Solar hot water	■	●	◆
05. Cooling			
Air cooled chillers	■	●	◆
Water Cooled chillers	■	●	◆
Cooling Towers	■	●	◆

	Performance	Technical	BAT
05. Cooling continued			
DX spit unit systems	■	●	◆
Variable Refrigerant Flow (VRF)	■	●	◆
Hybrid VRF	■	●	◆
06. Ventilation			
Air Handling/Mechanical ventilation	■	●	◆
Extract only ventilation	■	●	◆
Heat Recovery	■	●	◆
Ground sourced air heat exchanger	■	●	◆
Dehumidification	■	●	◆
07. Electric Power			
Power Factor Correction	■	●	◆
EV charging	■	●	◆
Lighting	■	●	◆
08. Controls			
BMS	■	●	◆
Metering	■	●	◆
09. Renewables			
Solar PV	■	●	◆
Solar thermal	■	●	◆
Battery storage	■	●	◆
10. Components			
Pumps	■	●	◆
Fans	■	●	◆
Refrigerants	■	●	◆
Water quality	■	●	◆

RETURN

Performance Standards:

The Performance Standard provides recommended threshold performance to support identification and specification of efficient and low carbon technologies and components. These Performance Standards are split into two main categories:

- **Performance Thresholds:** These standards provide the minimum performance standards that would be expected for a project. These are mainly based on Part L of the Building Regulations Guidance.
- **Performance Requirement:** Further guidance on higher performance standards than minimum thresholds that it is recommended to deliver to ensure the project moves towards or achieves net zero design.

These minimum performance standards and requirements have been developed from a literature review of existing regulations, policy, industry standards, and best practice guidance.

The Performance Standards included consideration of the different project types, namely:

- New construction,
- Refurbishments, and.
- Listed buildings

As well different building types including:

- Residential,
- Commercial, and
- Public buildings

This aligns with the categories and descriptions in the overall Net Zero Design Standard.

Technical Standards:

The Technical Standards provide guidance on the application of the technology or component within the project. As with the Performance Standards, the application of these Technical Standards is considered through the lens of different project and asset types. Information is also provided where the Technical Standards overlap with relevant existing CoLC standards and guidance.

The guidance for the Technical Standards is divided into the following sections:

- Key design and operation considerations
- Compatibility/ Future Proofing, and Environmental Impact.

One of the ten 'Technology Categories' is Fabric. For this category the guidance is divided into:

- Installation Requirements,
- Structural Requirements
- Compatibility/ Future Proofing, and
- Material/ Environmental Requirements

Guidance in the Future Proofing section is aligned with the outputs of the CoLC current Climate Impact Modelling works. This work is assessing the potential impact and mitigation measures of climate change on building assets with respect to temperature and pluvial / fluvial flooding risk.

TECHNOLOGY CATEGORIES

The section below introduces the ten technology categories and individual technology sub-categories covered by these categories. This section is also providing guidance on the interdependencies between the technology categories. For example, when considering roof upgrades, consideration of roof mounted renewable technologies should also be assessed.

Further information on the categories and sub-categories will be found within the Performance Standards and Technology Standards guidance with references within the Appendix.

BUILDING FABRIC

Overview

The term 'building fabric' refers to structural material and components of a building and is generally considered the layer of materials separating the interior of the building from the exterior.

The design of building fabric has a major impact on the operation of a building, including how much heat is transferred from the interior of the building to the exterior or gained from the exterior. A measure of this heat transfer can be determined by the material's U-value. The higher the U-value, the more potential for heat transfer to occur.

Heat can also be lost through a measure called air permeability, which quantifies how 'leaky' a building is. A building with higher air permeability is allowing the uncontrolled movement of air though holes or poor detailing within the building fabric. Uncontrolled movement of air can increase heating or cooling demand.

Building fabric also can impact the building in the following ways:

- Daylight Provision whilst minimising energy demand without any undesirable side effects,
- Internal solar gains through design, size, and orientation of the windows,
- Noise and air quality,
- Improved thermal mass for heat storage
- Building aesthetics.

Consideration of these aspects when designing or refurbishing building fabric can contribute to a more energy efficient building in operation.

Interdependencies

In the context of building services and fabric, there is an inter-dependency between heating demand and other systems. For example, if improvements are made to a lighting system within a building, such as the replacement of in-efficient T-12 or T8 fluorescent lamps with efficient LED's, it may result in an increase in the building's heating load. Lighting systems generate heat when they are in use, and if they are upgraded to more energy-efficient options, they may produce less waste heat

Internal Cavity Wall Insulation

Cavity wall insulation involves the installation of insulating materials to the cavity (gap) between the inner and outer side of a cavity wall. Many cavity walls are insulated by injecting material into the cavity and requires specialist installers to adequately drill holes into the wall, fill the cavity, and properly reseal the hole, most likely with cement.

If the building being insulated has cavity walls, it is proposed that cavity wall insulation should be considered prior to solid wall insulation.

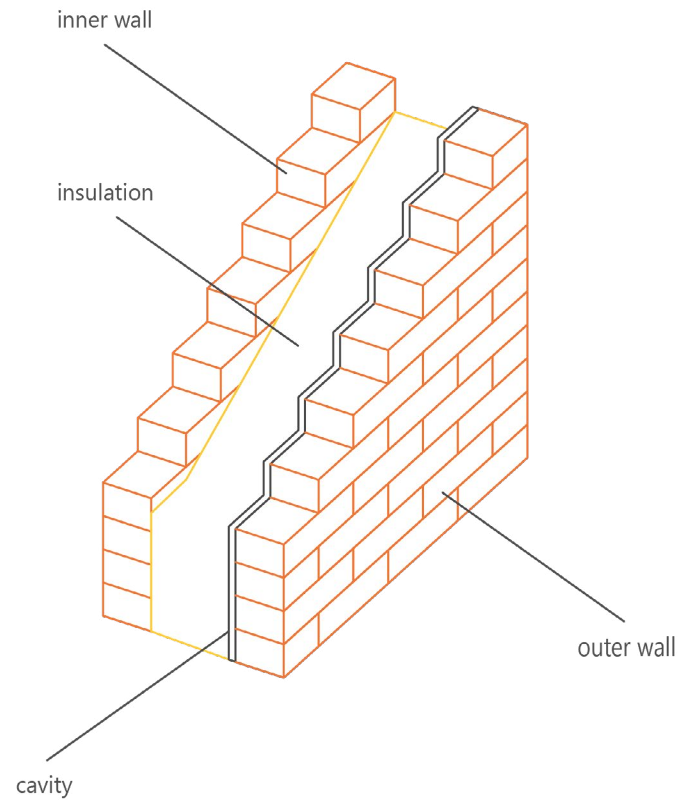


Figure 10 Cavity Wall

External Solid Wall Insulation

External solid wall insulation involves fixing a layer of insulating material to the external (cold) side of a wall. This insulating material is then covered with special types of render or cladding. The finish can be altered to match the desired aesthetic of the building. External wall insulation has the benefit of not interrupting the usage of the building and should not affect the activities of the building's occupants. Additionally, external wall insulation will not reduce the floor area of the building as all works are completed on the external face of the building. In addition to reducing heat loss, a solid wall insulation installation also makes a building more airtight, therefore additional natural or mechanical ventilation may be required to maintain air quality.

Internal Solid Wall Insulation

Internal solid wall insulation involves attaching a layer of insulating material to the internal (warm) side of a wall. A solid wall differs from a cavity wall as it is constructed of a single series of brick or stone. Internal wall insulation is a suitable option for insulating a solid wall, if the property has planning restrictions or other aesthetic value, as this will not alter the outer facade of the building. In addition to reducing heat loss, a solid wall insulation installation also makes a building more airtight, therefore additional natural or mechanical ventilation may be required to maintain air quality.

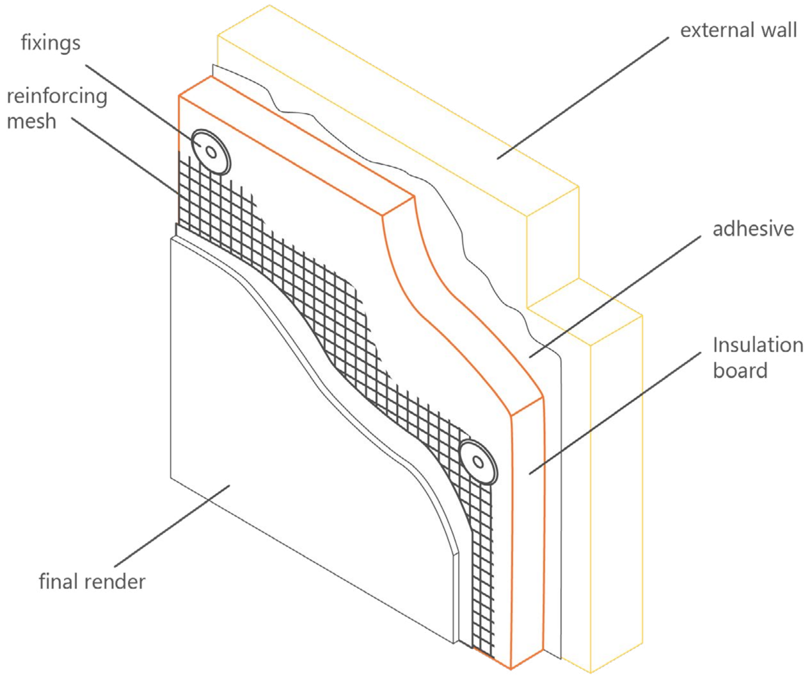


Figure 11 External Solid Wall Insulation

Roof Insulation

There are two main roof configurations:

Pitched Roofs:

- Warm roof: This is where insulation is installed immediately under the roof, within the plane of the roof pitch, meaning that the loft space beneath is also kept warm.
- Cold roof: This is where insulation is installed immediately above the ceiling of the top storey, meaning the loft space is not heated. This generally involves insulating between and over joists immediately above the ceiling of the top floor. Cold roof solutions are generally less expensive to install because there is a lot of available space, and so more economic, deeper insulation materials can be used.

Flat Roofs:

- Warm deck (or warm roof): The 'deck' of the roof is below the insulation.
- Cold deck (or cold roof): The insulation is installed below the roof deck. For ventilation purposes, and to avoid condensation forming, ventilation usually provided around the perimeter of the roof.
- Inverted roof: The insulation is installed above the uppermost weatherproof membrane, of the roof structure, effectively protecting it from heat and cold which can cause damage in the long term.

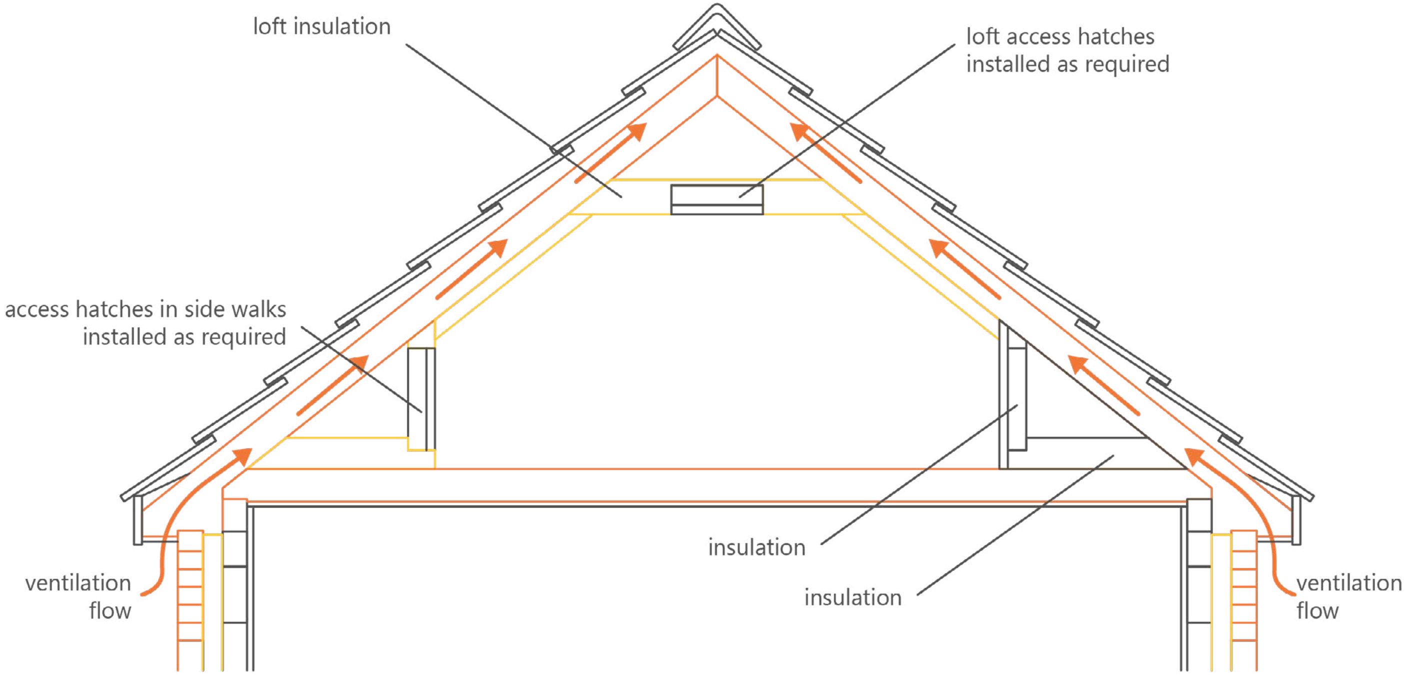


Figure 12 Room in Roof Insulation

Window – Including Shading (and doors)

Making windows and glazed doors more energy efficient will reduce the heat loss, reducing heating costs and lower the building's carbon footprint. Energy efficient glazing seeks to minimise heat loss through windows avoiding draughts and cold spots. Well-designed glazed systems can help reduce condensation build-up within the building.

Floor Insulation

Newer buildings tend to have solid floors, built upon a concrete foundation. This makes insulating solid floor challenging as this is generally served by installing a rigid insulation foam. This can cause issues with adjusting the height of doors, radiators and plug sockets etc. Most modern buildings are already fitted with insulation, so this expensive disruption is generally mitigated in most solid floor buildings.

Draught-proofing and Air Tightness

Air tightness typically refers to how 'leaky' a building is. Air tightness testing involves determining the amount of air leakage (m3 of air/m2 of internal surface area of the building). Buildings with high air permeability will have higher heating requirements due to cold air leaking through the building fabric of the building.

Air typically leaks through:

- Unsealed or poorly sealed doors and windows,
- Unsealed vents, skylights, and exhaust fans, gaps in or around ceiling insulation and around ceiling penetrations (for example, downlights, pipes, and cables),
- Gaps around wall penetrations (for example, pipes, conduits, power outlets, switches, air-conditioners, and heaters),
- Gaps between building envelope junctions (for example, floor–wall or wall–ceiling),
- Poorly fitted or shrunken floorboards.

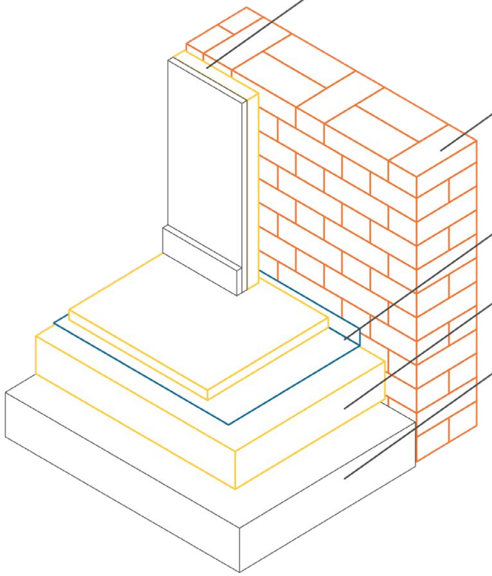


Figure 13 Solid Floor Insulation

TECHNOLOGY GUIDE - PERFORMANCE STANDARDS

Requirements	Performance Requirements	Measurement Standards / Test Conditions	Asset Type: New build	Asset Type: Refurb	Asset Type: Listed	Building Type: Residential	Building Type: Commercial	Building Type: Public (e.g. Schools)
Category / Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoLC Standard							
Building fabric								
Wall Insulation Performance Threshold	Note: These U-values provided are maximums and should not be exceeded. The notional value is based on a theoretical design required to be compliant within Part L regulations. The Limiting Values are not to be exceeded under current regulations. **Building Regulations: Approved Document L1 2021 Requirements (Residential)** •Limiting U-Value (new residential) = 0.26 W/m2K •Limiting U-Value (existing residential / new element) = 0.18 W/m2K •If existing element is higher than 0.7 W/m2K then must be improved to at least 0.30 W/m2K for external insulation. **Building Regulations: Approved Document L2 2021 Requirements (Non-Residential)** •Limiting U-Value (new & existing buildings) = 0.26 W/m2K •If existing element is higher than 0.7 W/m2K then must be improved to at least 0.30 W/m2K for external insulation	Building Regulations Conservation of fuel and power: Approved Document Part L1 [GN.1] Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2]	✓	✓	✓	✓	✓	✓
External solid wall insulation Performance Requirements	**Performance Requirements (LETI Design Guide):** •Residential = 0.13-0.15 W/m2K •Non-Residential = 0.12-0.15 W/m2K	The U-value must be calculated in accordance with the conventions in the current version of BR443 conventions for calculating U-values [WI.1] LETI Design Guide [W.11]	✓	•	•	✓	✓	✓
Internal solid wall insulation Performance Requirements	**Performance Requirements (LETI Design Guide):** •Residential = 0.13-0.15 W/m2K •Non-Residential = 0.12-0.15 W/m2K	The U-value must be calculated in accordance with the conventions in the current version of BR443 conventions for calculating U-values [WI.1] LETI Design Guide [W.11]	✓	✓	•	✓	✓	✓
Internal cavity wall insulation Performance Requirements	**Performance Requirements (LETI Design Guide):** •Residential = 0.13-0.15 W/m2K •Non-Residential = 0.12-0.15 W/m2K	The U-value must be calculated in accordance with the conventions in the current version of BR443 conventions for calculating U-values [WI.1] LETI Design Guide [W.11]	✓	•	•	✓	✓	✓
Roof Insulation Performance Threshold	Note: These U-values provided are maximums and should not be exceeded. The notional value is based on a theoretical design required to be compliant within Part L regulations. The Limiting Values are not to be exceeded under current regulations. **Building Regulations: Approved Document L1 2021 Requirements (Residential):** •Limiting U-Value (new residential) = 0.16 W/m2K •Limiting U-Value (existing residential / new element) = 0.15 W/m2K •If existing element is higher than 0.35 W/m2K then must be improved to at least 0.16 W/m2K. **Building Regulations: Approved Document L2 2021 Requirements (Non-Residential):** •Limiting U-Value (new & existing buildings) = 0.18 W/m2K (flat) and 0.16 W/m2K (pitched) •If existing element is higher than 0.35 W/m2K then must be improved to at least 0.16 W/m2K (pitched) or 0.18 W/m2K for flat roofs.	Building Regulations Conservation of fuel and power: Approved Document Part L1 [GN.1] Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2]	✓	•	•	✓	✓	✓
Roof insulation Performance Requirements	**Performance Requirements (LETI Design Guide):** •Residential = 0.10-0.12 W/m2K •Non-Residential = 0.10-0.12 W/m2K	The U-value must be calculated in accordance with the conventions in the current version of BR443 conventions for calculating U-values [WI.1] LETI Design Guide [W.11]	✓	•	•	✓	✓	✓
Window Performance Threshold	Note: These U-values provided are maximums and should not be exceeded. The notional value is based on a theoretical design required to be compliant within Part L regulations. The Limiting Values are not to be exceeded under current regulations. **Building Regulations: Approved Document L1 2021 Requirements (Residential):** •Limiting U-Value Window (new residential) = 1.6 W/m2K •Limiting U-Value Glazed door (new residential) = 1.6 W/m2K •Limiting U-Value Rooflight (new residential) = 2.2 W/m2K •Limiting U-Value for windows and door (existing residential / new element) = 1.4 W/m2K •Limiting U-Value for rooflights (existing residential / new element) = 2.2 W/m2K •Notional U-Value = 1.2 W/m2K (Frame Factor =0.7) **Building Regulations: Approved Document L2 2021 Requirements (Non-Residential):** •Limiting U-Value Window = 1.6 W/m2K •Limiting U-Value Door = 1.6 W/m2K •Limiting U-Value Rooflight = 2.2 W/m2K	Building Regulations Conservation of fuel and power: Approved Document Part L1 [GN.1] Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2]	✓	•	•	✓	✓	✓

TECHNOLOGY GUIDE - PERFORMANCE STANDARDS

Requirements	Performance Requirements	Measurement Standards / Test Conditions	Asset Type: New build	Asset Type: Refurb	Asset Type: Listed	Building Type: Residential	Building Type: Commercial	Building Type: Public (e.g. Schools)
Category / Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoLC Standard							
Window – including shading (and doors) Performance Requirements	**Performance Requirements (LETI Design Guide):** All new buildings = 1.0 W/m2K (triple glazed) with a g-value between 0.5-0.6 Window edges are susceptible to thermal bridging, ensuring installation is in line with the Zero Carbon Hub Thermal Bridging Guide, these elements can be limited to ψ=0.03	The U-value must be calculated in accordance with the conventions in the current version of BR443 conventions for calculating U-values [WI.1] LETI Design Guide [W.11]	✓	•	•	✓	✓	✓
Floor Insulation **Performance Threshold**	Note: These U-values provided are maximums and should not be exceeded. The notional value is based on a theoretical design required to be compliant within Part L regulations. The Limiting Values are not to be exceeded under current regulations. **Building Regulations: Approved Document L1 2021 Requirements (Residential):** •Limiting U-Value (new residential) = 0.18 W/m2K •Limiting U-Value (existing residential / new element) = 0.18 W/m2K •If existing element is higher than 0.7 W/m2K then must be improved to at least 0.25 W/m2K. **Building Regulations: Approved Document L2 2021 Requirements (Non-Residential):** •Limiting U-Value (new & existing buildings) = 0.18 W/m2K •If existing element is higher than 0.7 W/m2K then must be improved to at least 0.25 W/m2K.	Building Regulations Conservation of fuel and power: Approved Document Part L1 [GN.1] Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2]	✓	•	•	✓	✓	✓
Floor insulation Performance Requirements	**Performance Requirements (LETI Design Guide):** •Residential = 0.08-0.10 W/m2K •Non-Residential = 0.09-0.12 W/m2K	The U-value must be calculated in accordance with the conventions in the current version of BR443 conventions for calculating U-values. [WI.1] The U-value of the floor of an extension may be calculated using the exposed perimeter and floor area of either the whole enlarged building o the extension alone. If meeting such a standard would create significant problems in relation to adjoining floor levels, a lesser standard may be appropriate.	✓	•	•	✓	✓	✓
Draft Proofing and Air Tightness Performance Threshold	Note: These air permeability values provided are maximums and should not be exceeded. The notional value is based on a theoretical design required to be compliant within Part L regulations. The Limiting Values are not to be exceeded under current regulations. **Building Regulations: Approved Document L1 2021 Requirements (Residential):** • Notional new residential = 5 m3/(h.m2) at 50 Pa • Limiting value for new residential = 8 m3/(h.m2) at 50 Pa **Building Regulations: Approved Document L2 2021 Requirements (Non-Residential):** • Limiting value for new and existing buildings = 8 m3/(h.m2) at 50 Pa	Building Regulations Conservation of fuel and power: Approved Document Part L1 [GN.1] Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2]	✓	•	•	✓	✓	✓
Draught-proofing and air tightness Performance Requirements	**Performance Requirements (LETI Design Guide):** • All new developments: <1 m3/(h.m2) at 50 Pa	The Approved Documents now refer to CIBSE TM23 [DP.2] for measuring air tightness.	✓	•	•	✓	✓	✓

TECHNOLOGY GUIDE - TECHNOLOGY STANDARDS

GO BACK

					New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)	City of London Documents and Guidance	Location and Description	Project Management	Mechanical Engineer	Electrical Engineer	Architect	Public Health Engineer	Fire Engineer	Contractor	Building FM / End User
Requirements	Technical standards - For references, please refer to the 'Appendix' tab				Asset Type			Building Type			City of London Document Interlinks (TBC)		Key Stakeholders							
Category / Sub-category	Further guidance on design considerations and how the technology category or sub-category should be installed to deliver the performance standard targets										Task Bar	PPG Activities								
Building fabric	Installation Requirements	Structural Requirements	Compatibility / Future Proofing	Material / Environmental Requirements																
External solid wall insulation	• Insulation should be fitted without any air gaps and tight to the structure. Where fire-stopping socks are required, these should fully fill the areas where they are fitted [WI.9]. • Hygrothermal modelling should be used to assess moisture risk as advised in BS 5250. The simple Glaser method is only suitable for moisture closed and weathertight constructions, whereas dynamic hygrothermal simulation (using software such as WUFI or Delphin) should be used for moisture open constructions where wind driven rain or other moisture sources are present [WI.10] • Adhesives and mechanical fixings must: i.Provide adequate pull-out resistance to wind loads, dead loads, and bending loads. ii.Meet requirements for fire performance. iii.Accommodate thermal movements of the building Existing & Listed Consideration: Externally fixed systems require relocating, such as electrical systems and rainwater goods.	• Consult Fire Specialist to determine that any proposed insulation meets the required fire regulations for each specific building use. • As a minimum requirement, movement joints in render must be provided to match the locations of movement joints in the structure. They should also be located at changes of substrate. The principal guidance standards relating to joint design and sealant selection are BS 6093 [WI.6] and BS 6213 [WI.7] respectively. • If the insulation is considered non-combustible, e.g. mineral wool, fire barriers may not be required. Fire barriers or stops may, however, need to be considered in vulnerable areas, e.g. at window openings, doorways, and around penetrations in the system. Check with appropriate Building Regulation guidance. Fire barriers are required by Building Regulations to close the zone occupied by the insulation. • Solid Wall (Internal and External) Insulation may not be feasible for complex building shapes that make coherent coverage difficult [WI.8] • The decision whether to use mechanical fixings largely depends on the form and condition of the walls and the degree of loading required to be countered. Most adhesive-fixed systems recommend additional mechanical fixings.	• As insulation is added, the airtightness increases, meaning less ventilation is moving through the building. This can be mitigated naturally through openable windows and extract fans or with the use of a ventilation systems such as MVHR, consult a suitably qualified MEP engineer to determine ventilation requirements. [WI.3]. • Fabric losses should be calculated according to the latest BS EN 12831 Standard. External design temperatures should reflect typical low temperatures experienced in the winter heating season and as a guide should be exceeded for 99.6% of the year [WI.11]. Consideration: Complete an overheating analysis if retrofitting improved fabric and air tightness. This should be inline with Part O of the Building Regulations [WI.12]. CIBSE TM49 offers specific overheating guidance for properties in London [WI.13] Residential Consideration: Overheating risk should be mitigated following the principles laid out in PAS 2035 [WI.14]. External shading, whether that be permanent or automated, is the most effective way to reduce solar gains in a room and should be considered first and foremost [WI.15].	• The U-value must be calculated in accordance with the conventions in the current version of BR443 conventions for calculating U-values. [WI.1]. • The Fire Safety Bill published in March 2020 places beyond doubt that external wall systems fall within the scope of the Regulatory Reform (Fire Safety) Order 2005 [WI.2]. Consult fire specialist to determine if proposed insulation meets the required fire regulations. • Insulation that has zero ozone depletion and a global warming potential less than 5 in manufacture and installation must be used (CoLC Housing Guide). Existing & Listed Consideration: When retrofitting insulation in older builds, assess the breathability of the insulation material as this prevents moisture ingress and can prevent the growth of mildew, mould and improve overall air quality.	•	•	•	•	•	•	1) City of London Corporation: Housing Design Guide Dec 2020	1a) Section 6.10: •Comply with British Standards at the time of construction. •Comply with the requirements of the Local Authority Building Control (LABC), including the LABC warranty. •Comply with the project-wide requirements of energy efficiency.		✓		✓		✓	✓	✓
Internal solid wall insulation	• Insulation should be fitted without any air gaps and tight to the structure. Where fire-stopping socks are required, these should fully fill the areas where they are fitted [WI.9]. • Hygrothermal modelling should be used to assess moisture risk as advised in BS5250. The simple Glaser method is only suitable for moisture closed and weathertight constructions, whereas dynamic hygrothermal simulation (using software such as WUFI or Delphin) should be used for moisture open constructions where wind driven rain or other moisture sources are present [WI.10] • There is a surface condensation risk if IWI is installed on only part of an external wall. This is because the external wall will become cold where the IWI is installed as it has been isolated from the room heating [WI.4]. Consideration: Internal solid wall insulation reduces the available floor area of the room where it is installed.	• Consult Fire Specialist to determine that any proposed insulation meets the required fire regulations for each specific building use. • As a minimum requirement, movement joints in render must be provided to match the locations of movement joints in the structure. They should also be located at changes of substrate. The principal guidance standards relating to joint design and sealant selection are BS 6093 [WI.6] and BS 6213 [WI.7] respectively. • If the insulation is considered non-combustible, e.g. mineral wool, fire barriers may not be required. Fire barriers or stops may, however, need to be considered in vulnerable areas, e.g. at window openings, doorways, and around penetrations in the system. Check with appropriate Building Regulation guidance. Fire barriers are required by Building Regulations to close the zone occupied by the insulation. • Solid Wall (Internal and External) Insulation may not be feasible for complex building shapes that make coherent coverage difficult [WI.8]	• As insulation is added, the airtightness increases, meaning less ventilation is moving through the building. This can be mitigated through openable windows and extract fans. Consult MEP engineer to determine if new ventilation systems such as MVHR is required [WI.3]. • Positive Input Ventilation (PIV) should not be installed with internal wall insulation. This is due to increased risk of interstitial condensation between the wall and the IWI [WI.4] • Fabric losses should be calculated according to the latest BS EN 12831 Standard. External design temperatures should reflect typical low temperatures experienced in the winter heating season and as a guide should be exceeded for 99.6% of the year [WI11]. Consideration: Ensure that all the services (plug sockets, pipes, switches, radiators etc.) installed on the wall are properly considered and reinstated. Where these services penetrate the insulation layer, the vapour-control layer or the air barrier, the penetrations should be either kept to a minimum, if possible, or properly sealed. A schedule of penetrations should be provided prior to works. Consideration: Complete an overheating analysis if retrofitting improved fabric and air tightness. This should be inline with Part O of the Building Regulations [WI.11]. CIBSE TM49 offers specific overheating guidance for properties in London [WI.12]	• The U-value must be calculated in accordance with the conventions in the current version of BR443 conventions for calculating U-values. [WI.1]. • The Fire Safety Bill published in March 2020 places beyond doubt that external wall systems (including IWI) fall within the scope of the Regulatory Reform (Fire Safety) Order 2005 [WI.2]. Consult fire specialist to determine if proposed insulation meets the required fire regulations. • In the case of some foam cavity wall insulating materials an assessment of the risk of the emission of formaldehyde gas will need to be carried out. • Insulation that has zero ozone depletion and a global warming potential less than 5 in manufacture and installation must be used [WI.12]. Existing & Listed Consideration: When retrofitting insulation in older builds, assess the breathability of the insulation material as this prevents moisture ingress and can prevent the growth of mildew, mould and improve overall air quality.	✓	✓	✓	✓	✓	✓	1) City of London Corporation: Housing Design Guide Dec 2020	1a) Section 6.10: •Comply with British Standards at the time of construction. •Comply with the requirements of the Local Authority Building Control (LABC), including the LABC warranty. •Comply with the project-wide requirements of energy efficiency.		✓		✓		✓	✓	✓
Internal cavity wall insulation	• Insulation should be fitted without any air gaps and tight to the structure, cavity closers, lintels and cavity trays. Mortar snots should be removed to ensure a tight fit with the structure and cavities cleared of all debris. Where fire-stopping socks are required, these should fully fill the areas where they are fitted, including at the heads of cavities [WI.9]. • Hygrothermal modelling should be used to assess moisture risk as advised in BS5250. The simple Glaser method is only suitable for moisture closed and weathertight constructions, whereas dynamic hygrothermal simulation (using software such as WUFI or Delphin) should be used for moisture open constructions where wind driven rain or other moisture sources are present [WI.10] • There is a surface condensation risk if IWI is installed on only part of an external wall. This is because the external wall will become cold where the IWI is installed as it has been isolated from the room heating [WI.4]. Consideration: If a cavity is present, prioritise insulating the cavity prior to any solid wall insulation.	• Consult Fire Specialist to determine that any proposed insulation meets the required fire regulations for each specific building use. • As a minimum requirement, movement joints in render must be provided to match the locations of movement joints in the structure. They should also be located at changes of substrate. The principal guidance standards relating to joint design and sealant selection are BS 6093 [WI.6] and BS 6213 [WI.7] respectively. • If the insulation is considered non-combustible, e.g. mineral wool, fire barriers may not be required. Fire barriers or stops may, however, need to be considered in vulnerable areas, e.g. at window openings, doorways, and around penetrations in the system. Check with appropriate Building Regulation guidance. Fire barriers are required by Building Regulations to close the zone occupied by the insulation. • Solid Wall (Internal and External) Insulation may not be feasible for complex building shapes that make coherent coverage difficult [WI.8]	• As insulation is added, the airtightness increases, meaning less ventilation is moving through the building. This can be mitigated through openable windows and extract fans. Consult MEP engineer to determine if new ventilation systems such as MVHR is required [WI.3]. • Positive Input Ventilation (PIV) should not be installed with internal wall insulation. This is due to increased risk of interstitial condensation between the wall and the IWI [WI.4] • Fabric losses should be calculated according to the latest BS EN 12831 Standard. External design temperatures should reflect typical low temperatures experienced in the winter heating season and as a guide should be exceeded for 99.6% of the year [WI11]. Consideration: Complete an overheating analysis if retrofitting improved fabric and air tightness. This should be inline with Part O of the Building Regulations [WI.11]. CIBSE TM49 offers specific overheating guidance for properties in London [WI.12] . Residential Consideration: Overheating risk should be mitigated following the principles laid out in PAS 2035 [WI.14]. External shading, whether that be permanent or automated, is the most effective way to reduce solar gains in a room and should be considered first and foremost [WI.15].	• The U-value must be calculated in accordance with the conventions in the current version of BR443 conventions for calculating U-values. [WI.1]. • The Fire Safety Bill published in March 2020 places beyond doubt that external wall systems (including IWI) fall within the scope of the Regulatory Reform (Fire Safety) Order 2005 [WI.2]. Consult fire specialist to determine if proposed insulation meets the required fire regulations. • In the case of some foam cavity wall insulating materials an assessment of the risk of the emission of formaldehyde gas will need to be carried out. • Insulation that has zero ozone depletion and a global warming potential less than 5 in manufacture and installation must be used [WI.12]. Existing & Listed Consideration: When retrofitting insulation in older builds, assess the breathability of the insulation material as this prevents moisture ingress and can prevent the growth of mildew, mould and improve overall air quality.	•	•	•	•	•	•	1) City of London Corporation: Housing Design Guide Dec 2020	1a) Section 6.10: •Comply with British Standards at the time of construction. •Comply with the requirements of the Local Authority Building Control (LABC), including the LABC warranty. •Comply with the project-wide requirements of energy efficiency.		✓		✓		✓	✓	✓
Roof insulation	• Insulation should be installed tight to the structure, without air gaps, and should extend to the wall insulation. For roofs insulated at ceiling level, the long-term protection of the insulation layer should be considered: boarded areas should be provided above the insulation to give access for maintenance [RI.1] • Roofs that have multiple rooms will inherently have thermal bridges due to internal walls. However, these can be mitigated, usually by returning a layer of insulation along the wall or floor that is causing the thermal bridge. [RI.2] • Hygrothermal modelling should be used to assess moisture risk as advised in BS5250. The simple Glaser method is only suitable for moisture closed and weathertight constructions, whereas dynamic hygrothermal simulation (using software such as WUFI or Delphin) should be used for moisture open. • Air leakage into roof voids can carry a high amount of moisture and significantly increases the risk of condensation on timbers and the underside of roofing membranes. An air barrier should form part of all RIRI construction on the warm side [RI.2] • Ensure that a free flow of external air is maintained to reduce moisture issues when insulating at ceiling level, this could be through mechanical means, but natural ventilation is recommended to reduce energy consumption. Retrofit Consideration: No retrofit should be undertaken without assessing the internal ventilation system and its adequacy for dealing with internal moisture loads and air quality. A functioning, and preferably continuous ventilation system should be in operation upon completion of the works	• Architects should provide drawings showing airtightness layers, vapour control layers (if needed), insulation materials and structures. This should be provided for all relevant junctions, edges and corners associated with the roof insulation [RI.2]. • The roof insulation design must consider the current moisture strategy of the building as well as the [RI.2]: i.exposure, ii.external weather finish, iii.the roof construction, iv.internal moisture loads (occupancy and activities). • Schedule 1 Part B of the Buildings Regulations 2010 contains requirements for fire safety, which includes requirement B3, relating to internal fire spread (structure). This provides that the building shall be designed and constructed so that, in the event of fire, its stability will be maintained for a reasonable period, as referenced in Schedule 1 Part B of the Building Regulations 2010 [RI.3].	• If wiring is encapsulated in, or directly behind insulation, there can be a risk of overheating. An electrician should be consulted on the need to replace or derate the cable. • A schedule of penetrations, their dimensions, orientation, and the applicable sealing method should be provided as part of the design [RI.2]. • As insulation is added, the airtightness increases, meaning less ventilation is moving through the building. This can be mitigated through openable windows and extract fans. Consult MEP engineer to determine if new ventilation systems such as MVHR is required [RI.4]. Retrofit Considerations: Rooms in roofs are particularly susceptible to overheating from internal and solar gains, especially if there are south facing windows or roof lights. Residential Consideration: Overheating risk should be mitigated following the principles laid out in PAS 2035 [RI.5]. External shading, whether that be permanent or automated, is the most effective way to reduce solar gains in a room and should be considered first and foremost [RI.2]. Consideration: Complete an overheating analysis if retrofitting improved fabric and air tightness. This should be inline with Part O of the Building Regulations [RI.9]. CIBSE TM49 offers specific overheating guidance for properties in London [RI.10]	• The U-value must be calculated in accordance with the conventions in the current version of BR443 conventions for calculating U-values [RI.6]. • The Fire Safety Bill published in March 2020 places beyond doubt that roof systems fall within the scope of the Regulatory Reform (Fire Safety) Order 2005 [RI.7]. Consult fire specialist to determine if proposed insulation meets the required fire regulations. • There are several options of roof insulation materials and techniques [RI.8]: i.Blanket loft insulation (also called matting insulation) – the most common and easiest to install type of loft insulation. Made from mineral or glass fibre and comes in foil-backed rolls which can be placed between joists ii.Loose-fill insulation – made from fire retardant lightweight fibres and can be used in difficult to access spaces with irregular joists or to supplement existing insulation iii.Blown-in insulation – though not suitable for DIY installation, blown-in insulation, whereby cellulose mineral fibres are blown into loft space using specialist equipment, is quick to install and useful for spaces where access is limited, such as gaps between roof joists iv.SIPS - The high strength and low weight of SIPs allow large sections of building to be lifted in one piece, for speed of construction. Panels may also be erected one at a time by hand where access is restricted. SIP roofs do not require support trusses, leaving clear, warm, habitable roof spaces. Existing & Listed Consideration: When retrofitting insulation in older builds, assess the breathability of the insulation material as this prevents moisture ingress and can prevent the growth of mildew, mould and improve overall air quality.	✓	•	•	✓	✓	✓	1) City of London Corporation: Housing Design Guide Dec 2020	1a) Section 6.10: •Comply with British Standards at the time of construction. •Comply with the requirements of the Local Authority Building Control (LABC), including the LABC warranty. •Comply with the project-wide requirements of energy efficiency.		✓		✓		✓	✓	✓
Window – including shading (and doors)	• Windows and doors should be installed so that the thermal integrity of the insulated plane is maintained [W.1]: i. tolerance around a window or door should be in accordance to BS 8213-4 [W.2] ii. window or door units should be located with an overlap between the inner face of the unit and the inner face of the external leaf – for windows an overlap between 30mm and 50mm, and for doors 50mm. iii. Fully insulated and continuous cavity closers should be used, installed tight to the insulation and cavity apertures. For door units, install perimeter insulation within the threshold zone or use a reinforced cavity closure. • For natural ventilation calculations, designer should provide copy of the results from a software modelling tool recommended in CIBSE AM 10 [W.3]. • To account for thermal expansion, the following gaps should be provided [W.4]: i.3mm ap between the glass edge and the frame ii.5mm gap at the bottom bead for drained systems • For rooms with identified excessive solar gains, consider installing solar films or brise soleil to provide shading and reduce the excessive gains to prevent overheating, ensure the daylight factors are maintained with the guidance set out in BRE Information Paper 22/12 [W.7], CIBSE Lighting Guide LG10 [W.8] and BS EN 17037 [W.9].	• BS 6375-1 explains how to calculate the appropriate design wind load for a particular location and then how to use that to specify a weather resistance class for the proposed windows or doors [W.5]. • BS 6375-1, Table 1 gives classification values for air permeability, watertightness and wind resistance for each of five UK exposure categories [W.5]. This standard relates to vertical windows and doors. • Designers should assess methods of minimising thermal bridges [W.1]: i. Lintels: consider using independent lintels with an insulated cavity closure between the inner and outer lintel. For common leaf lintels, the base plate should not be continuous, and the lintel core should be insulated. ii. Insulated cavity closers should be used for all construction types. • Additionally, insulated plasterboard should be used in reveals to abut jambs and should be considered within reveal soffits. • For doors specified as 'fire-doors', the gaps around the tops and sides of the door should not exceed 4mm and hinges should be a minimum of 3mm. • Fire doors are assigned an FD rating associated with length of time they can withstand fire for. For instance an FD30 fire door will offer 30 minutes of protection, while an FD60 fire door will offer 60 minute fire protection. The FD rating is assigned following stress testing in conditions specified in BS 476-2:1987 [W.12]. • Consult a fire specialist to determine the required FD rating for each door in the buildings design. The most common integrity ratings are: - FD30 – 30 minutes - FD60 – 60 minutes - FD90 – 90 minutes - FD120 – 120 minutes	• For listed buildings and buildings in conservation areas a case can be made for exemption where complying with required standards would unacceptably alter the character and appearance of the window [W.6]. • BREEAM credits are available where the daylight factors are inline with the guidance set out in BRE Information Paper 22/12 [W.7], CIBSE Lighting Guide LG10 [W.8] and BS EN 17037 [W.9]. • Part O of The Building Regulations provide guidance on maximum areas of glazing as a percentage of floor area, the values are provided below, with high risk locations in brackets: Buildings with cross ventilation:- i. North = 18% (15%) ii. East = 18% (18%) iii. South = 15% (15%) iv. West = 11% (18%) Buildings without cross ventilation:- i. North = 18% (15%) ii. East = 18% (11%) iii. South = 15% (11%) iv. West = 11% (11%)	• Several BREEAM award a credit where measures are taken to reduce the risk to health associated with poor air quality. The credit criteria require that: i. In air-conditioned and mixed mode buildings, building air intakes and exhausts are over 10 m apart to minimize recirculation. Air intakes must be over 20 m from sources of external pollution. ii. In naturally ventilated buildings, openable windows and ventilators must be over 10 m from sources of external pollution. • BS 6213 gives guidance on types of joint sealant, their selection and application [W.10].	✓	✓	•	✓	✓	✓	1) City of London Corporation: Housing Design Guide Dec 2020	P120: Glazing must be designed and specified according to facade orientation to minimise energy use as part of a holistic design balancing heat gain, heat loss, and daylight.		✓		✓		✓	✓	✓
Floor insulation	• Insulation should be installed tight to the structure, without air gaps between insulation panels and at edges [FI.1]: i.Perimeter insulation should be continuous and have a minimum thickness of 25mm. ii.Moisture-resistant insulation should be fitted below damp-proof course level and extend to the foundation block/structure. • Air leakage into solid floors can carry moisture and cause interstitial condensation. Install an air barrier on the warm side of the insulation [FI.2]. • Ensure all services (pipes, radiators etc.) and fittings are considered. A schedule of penetrations should be provided, along with suggestions of appropriate air sealants and vapour control materials [FI.2]. • Assess the condition of the void and floor structure prior to installation, ensuring there is no rot, dampness or infestation [FI.3]. • Ensure insulation is not installed over any air bricks to maintain a flow of external air to prevent moisture issues. Consideration: BS5250 Management of Moisture in Buildings: Code of practice should be adhered to in the assessment, design and implementation of solid floor insulation [FI.4] Retrofit Consideration: Assess existing fittings and services that may penetrate the floor insulation.	• Consult Fire Specialist to determine that any proposed insulation meets the required fire regulations for each specific building use. • Minimise all thermal bridges to ensure a surface temperature factor (fRSi) > 0.75. This should be calculated in accordance with BRE's Information Paper 1/062 [FI.6]. • Generally, the following provides an indication of the floor configurations that may be more at risk from cold bridging [FI.3]: i.8-inch joist (200mm) the U-value will not exceed 0.7 and is therefore highly unlikely to be an issue. ii.6-inch joist (150mm) is also unlikely to create an issue (other than in extreme situations where original hardwood joists and floorboards remain). iii.4-inch joist the U-value is likely to exceed 0.7W/m2k, and therefore Building Regulations will not be satisfied. Existing & Listed Consideration: For traditional properties that do not have a damp proof course and have a solid floor, the insulation must not prevent the movement of moisture	• Many existing buildings rely on leaky building fabric to provide sufficient ventilation. • All buildings are designed with chimney breasts, stairs, internal or external walls which are in contact with the ground. This mean solid floor insulation will inherently have thermal bridges. Consider mitigation techniques, such as a small perimeter upstand against the wall or structure that is causing the thermal bridge. Consideration: If installing alongside underfloor heating, ensure these type systems are compatible, including electrical wiring, pipework and any required penetrations are considered. Retrofit Consideration: Ventilation design should be considered when retrofitting further floor insulation. This should be sized to ensure there is sufficient supply and extract ventilation. This ensure occupant's comfort, avoid excess humidity and improve air quality. Consideration: Complete an overheating analysis if retrofitting improved fabric and air tightness. This should be inline with Part O of the Building Regulations [FI.7]. CIBSE TM49 offers specific overheating guidance for properties in London [FI.8] . Residential Consideration: Overheating risk should be mitigated following the principles laid out in PAS 2035 [FI.9]. External shading, whether that be permanent or automated, is the most effective way to reduce solar gains in a room and should be considered first and foremost [FI.10].	• Many materials exist which can be used in floor insulation installations. Consideration of space allowance, cost and desired U-value must be considered for material selection. Below is a list of common floor insulation materials, along with their corresponding lambda values, which determine the levels of heat transfer, where the lower the value, the less heat that is transferred through [FI.3]: i. Stones Wool = 0.032-0.044W/mK ii. Sheep's Wool = 0.038 W/mK iii. Wood Fibre = 0.038 W/mK iv. Glass Wool = 0.032-0.044 W/mK v. PUR = 0.023-0.028 W/mK vi. PIR = 0.023-0.028 W/mK • If replacing at least half a floor, (according to the building regulations as part of the renovation of a thermal element requirement) the structure would have to be insulated to Part L standards whether planned or otherwise [FI.1] Existing & Listed Consideration: When retrofitting insulation in older builds, assess the breathability of the insulation material as this prevents moisture ingress and can prevent the growth of mildew, mould and improve overall air quality.	✓	✓	✓	✓	✓	✓	1) City of London Corporation: Housing Design Guide Dec 2020	1a) Section 6.10: •Comply with British Standards at the time of construction. •Comply with the requirements of the Local Authority Building Control (LABC), including the LABC warranty. •Comply with the project-wide requirements of energy efficiency.		✓		✓		✓	✓	✓
Draught-proofing and air tightness	• Architects and designers need to take responsibility for airtightness early in the design stage, setting an overall strategy for implementation and buildability. • Air tests should be included in the tender specification. The below methodology allows defects in the airtightness to be found before work is covered up and ensure accountability of installation [DP.1]: i. The 1st test is to be completed as soon as the building has been made air tight. ii. The 2nd test is to be completed after all the service penetrations have been made iii. The 3rd on completion of construction • The Approved Documents now refer to CIBSE TM23, rather than the Air Tightness Testing & Measurement Association (ATTMA) standards, as approved methodology for air leakage testing [DP.2]. This TM addresses the air leakage testing of both non-domestic buildings and dwellings. It describes the two main currently available test methods: i. fan pressurisation method ('blower door' test method) ii. low-pressure pulse method ('pulse' method). • Best practice is to install air barriers on the warm side of the insulation [DP.3]	• Airtightness lines should be drawn on plans and details, identifying which materials will form the airtight layer, and methods of joining. Challenging junctions, risks to airtightness should be identified along with how building services interact with the airtightness layer [DP.4] • Airtightness tapes can be used to seal interfaces between two air barriers [DP.3]: i. Tapes are available for almost any surface and junction, although some tapes require an additional adhesive or primer to be applied prior to application. ii. Tapes are best used for linear joints. iii. Tape specifications should be referenced in all drawings. • Penetrations through the air barrier should be limited as far as possible [DP.3]. i. A schedule of penetrations, their dimensions, orientation and the applicable sealing method should be provided. • Reduce the number and complexity of junctions as these all need to be designed and properly installed to be airtight.	• MVHR systems should only be installed in properties with an air permeability of 3 m³/m².hour @50Pa or less. • Improvements to fabric performance and air tightness measures have reduced infiltration and therefore, ventilation in buildings. Therefore, there is an increased risk of overheating [DP.5]. Consideration: Complete an overheating analysis if retrofitting improved fabric and air tightness. This should be inline with Part O of the Building Regulations [DP.6]. CIBSE TM49 offers specific overheating guidance for properties in London [DP.7] Residential Consideration: Overheating risk should be mitigated following the principles laid out in PAS 2035 [DP.9]. External shading, whether that be permanent or automated, is the most effective way to reduce solar gains in a room and should be considered first and foremost [DP.10].	• To construct an airtight construction, there must be an identified air barrier that is joined up to form a complete loop. This does not require to be constructed of the same material [DP.8]. • Airtight constructions can be constructed of different materials within the same design. These materials should be made identifiable on drawings. • Before fitting a glazed construction, the contractor must apply airtightness tape to the sides and top of the window. The tape must be continuous on all 3 sides [DP.1]	✓	✓	✓	✓	✓	✓	1) City of London Corporation: Housing Design Guide Dec 2020	P120: The minimum air-tightness requirement is 3 m3/(h.m2)@50Pa.		✓		✓		✓	✓	✓

GO BACK

HEATING

Overview

Decarbonising energy used to heat in buildings is a key part of the UK Government's Green Growth Strategy and critical in achieving the Government's net zero agenda. In 2021 the Government published its Heat in Buildings Strategy which outlines their ambition to phase out the installation of natural gas boilers beyond 2035 and for new construction this is likely to be implemented in Future Homes and Buildings Standard by 2025.

Decarbonisation of building heat is critical component of CoLC strategy for Net Zero buildings. This section summarises information on currently commercially available building heating technologies, with emerging technologies reviewed in the next section.

Heating systems provide heat from a generation plant or move heat from external sources to serve conditioned spaces or targeted areas. When sized correctly the systems will ensure suitable internal temperature in the spaces are maintained.

Heat generation is usually centralised with heat is distributed throughout a building using water or air as the transfer medium. Heating emitters such as radiators or fan coil units' interface with the distributed water or air to condition the space. Heating controls ensure effective generation and delivery of heat to match occupancy and environmental requirements. These controls can be on the generation, distribution network or heat emitters and can be used to control the entire building or specific zones. Heating can be provided locally by radiant heating to transfer heat / raise temperature in a small, targeted area.

As we move away from fossil fuels, and with an uncertain future for hydrogen heating, the current options for heating technology are:

- Connection to a low carbon heat network,
- Electrification of heat through heat pumps, or
- Direct electric heating, or
- Use of biofuel.

Decisions about which technology or fuel will be most appropriate for a particular project will need to be taken at the outset ensuring that the technology can work effectively in the new construction or refurbishment project. For example, heat pumps work most effectively at lower than traditional heat distribution temperatures and may require additional electrical supply capacity.

The implications of these building modifications on such as cost, and delivery programme will need to be considered when selecting the most appropriate technology. For all projects, the viability of connecting to Citigen district heating network should be considered first followed by the most efficient electric heating options with cost and GHG emissions compared. From this point alternative heating options should be considered at the beginning of the design process using heat decision trees set out in LETI Climate Emergency Design guidance and CIBSE TM53 Refurbishment for non-domestic buildings or similar.

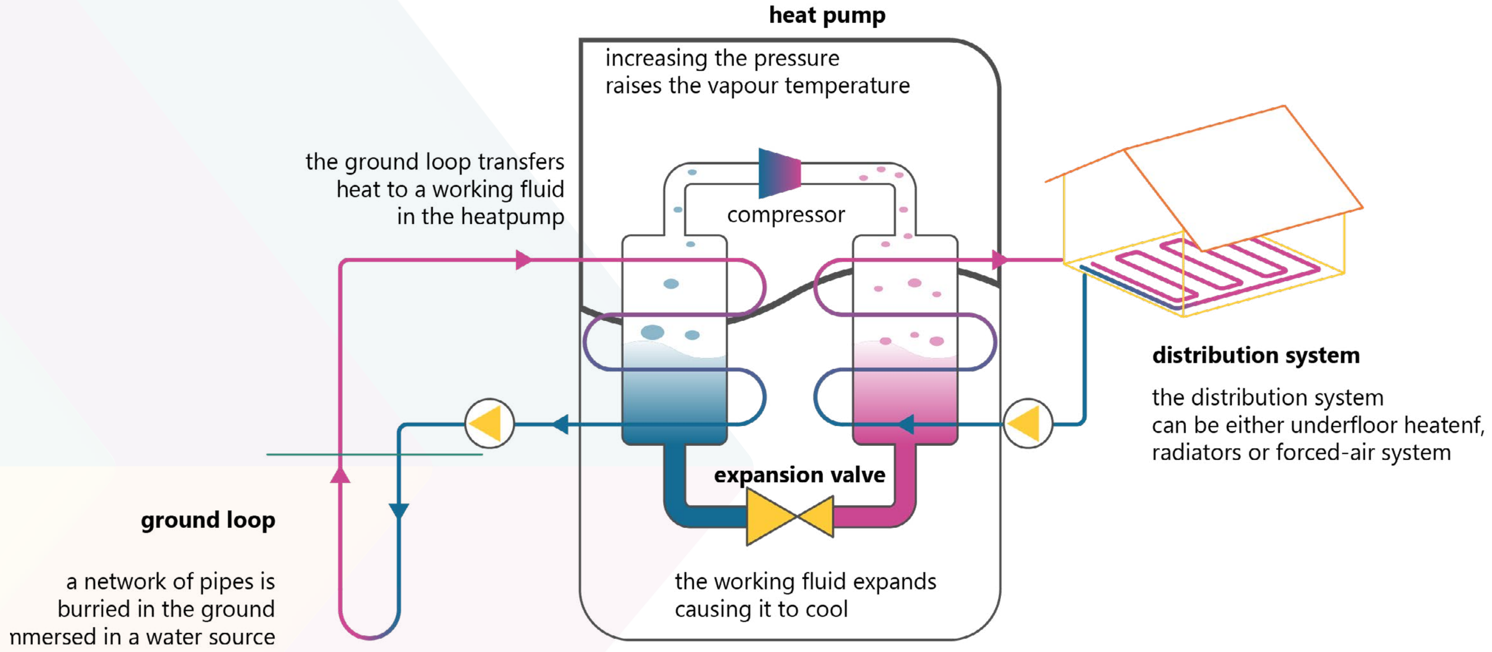


Figure 14 Example Schematic of Ground Source Heat Pumps and the vapour compression cycle

No matter which heating technology is chosen it is important a whole building approach is considered where appropriate to ensure heat demand is reduced alongside the introduction of low carbon heating.

Interdependencies

The inter-dependencies for heating with other building services and fabric are that if lighting systems have been improved, there may be an increased heating load for the building. Additionally improving the building fabric will reduce the required heating load for the building which will support the feasibility of installing a low-temperature heating system such as air source heat pumps (ASHP).

Heat Pumps

All heat pumps use electricity to drive an evaporation / condenser cycle to move heat from one side of the system to another. Heat pumps use the 'vapour compression cycle', the same thermodynamic cycle as refrigerators. The simplest form of this cycle uses four basic components: a compressor, an evaporator, an expansion valve and a condenser.

A heat pump concentrates 'low grade heat' (which in the UK is from around -10°C to 2°C) from the environment into higher grade heat that can be used for space heating and domestic hot water. Heat pumps are most efficient when delivering low temperature hot water (LTHW) to suitable systems such as underfloor heating at 30-45°C, fan coils at 35-55°C, and radiators operating at 45-55°C. High temperature heat pumps are also available which can provide higher distribution temperatures but can be lower in efficiency.

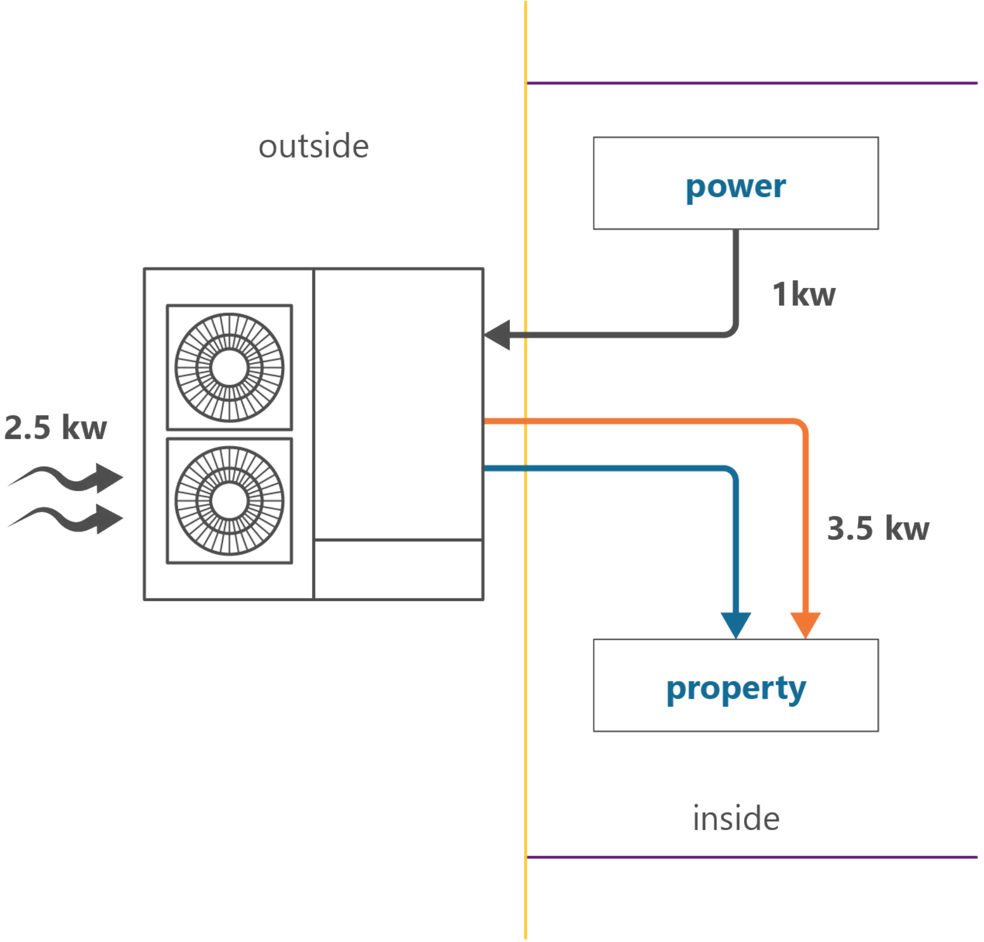


Figure 15 Example Schematic of Air Source Heat Pump

Heat pumps use electricity and therefore the associated GHG emissions are determined by the carbon intensity of the electricity used. Depending on the efficiency of the heat pump and the temperature of the heat supplied the efficiency improvement on electric resistance heating can be from 200%-600% (or more). There are different types of heat pump depending on the source use to extract heat from the environment, this can be from the air, the ground, water, sewers or other waste heat sources. Heat pumps are often referred to by the source of energy that they use.

The level of performance for a heat pump is measured by its Coefficient of Performance (COP). The COP is defined as the ratio of the useful heating provided to the electrical energy input. Note that this is the COP specifically for a heat pump, for a refrigerator the COP is the ratio of the cooling provided to the electrical input.

Another useful measure of the performance of a heat pump can be found by calculating the Seasonal COP (SCOP). This is defined as the ratio of the total useful heating provided over a year to the total electrical consumption.

The driver to use other sources of heat aside from air, such as river, sea, sewer or ground is that the seasonal temperatures are potentially higher (especially in winter when the heat is needed). This improves the SCOP. A higher SCOP means that the heat pump will require less energy (electricity) and therefore have lower running costs and potentially lower GHG emissions.

Air Source Heat Pumps: Air to Water Heat Pumps

Air source heat pump (ASHP) systems use an external unit to extract heat from the air to efficiently provide heating. Air-to-air air source heat pumps eject cooled or warmed air through an indoor unit to condition the room based on design set points and conditions. They are commonly referred to as 'air conditioning units'. The various types of heat pumps are:

- **Split System** – with one 'outdoor' unit and one 'indoor' unit.
- **Multi-split System** – with an 'outdoor' unit connected to one or more 'indoor' units using a common refrigerant circuit with the indoor units individually controlled.
- **Variable Refrigerant Flow (VRF) System** - automatically adjust the flow of refrigerant to each 'indoor' unit so that the heat delivered is matched to the demand.

- **Packaged system** - single factory assembled units that incorporate all the elements of the refrigeration system and air distribution mechanisms for space heating, often referred to as 'roof-top' due to the most common placement of the product.

Air-to-water heat pumps provide heating and cooling to chilled water (CHW) or low temperature hot water (LTHW) distribution systems. These include fan coil units (heating / cooling), radiators (which may need to be resized if refurbishing a building as heat pumps work on lower distribution temperatures than traditional heating systems) and underfloor heating. These can also provide cooling to emitters of chilled beams, fan coil units (which provide heating as well) and soffits.

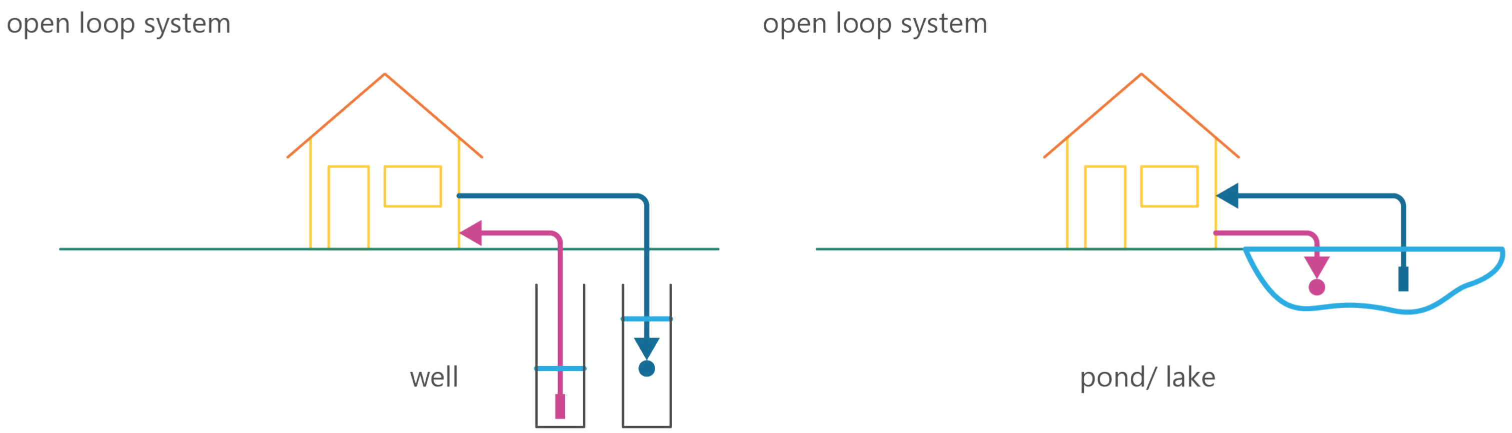


Figure 16 Open Loop Ground Source Heating and Water Source Heating

(Ground / Water Source) Water to Air Heat Pumps: Split (non-VRF), Multi-split (VRF)

Ground Source Heating pumps (GSHP) utilise fluids to absorb heat from the ground.

A water source heat pump takes energy from canals, the sea and rivers. Water is pumped into the system where the latent heat is used to compress a refrigerant.

Ground systems use one of two heat collection methods. There are two types of system:

- an open loop system extracting water from underground and
- a closed loop system.

An open loop system requires access to an adequate water supply or aquifer. A high-level hydrogeological assessment will likely be required to identify the feasibility of an open loop system. A water source heat pump is essentially an open look system but extracting water and heat from surface water as opposed to ground water.

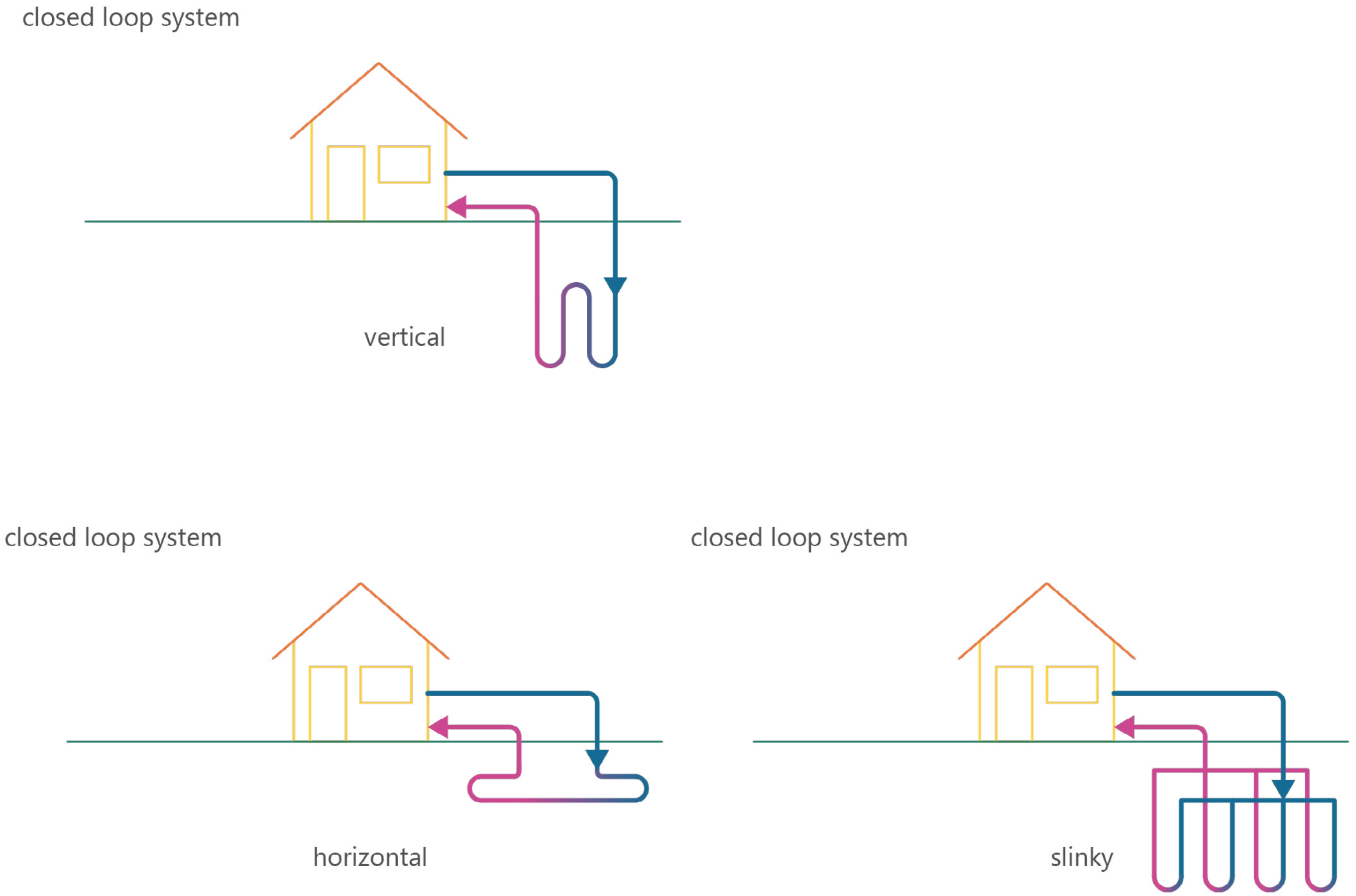


Figure 17 Example of Closed Loop Ground Source Heating

In a closed loop system, an electrically powered heat pump circulates water and antifreeze solution around a loop of pipe, absorbing heat from the ground into the fluid and then passing through a heat exchanger into the heat pump.

There are two distinct types of closed loop system. A horizontal system, where pipes are spread out in trenches in a field buried around 1-3 m below the surface and a vertical borehole system, where pipes route into the ground to a depth of 100-200 m. This also requires enough free land for the boreholes to be drilled and connected to a network, as digging vertically uses the space more efficiently. A typical 75-100 m borehole can provide 3-5 kW of extractable heat depending on the ground conditions. Like ASHP the performance is calculated via SPF. GSHP typically operate with SPF of 3.0 to 4.0 indicating that for each kilowatt of electricity used to drive the pump it will produce a further 3-4 kW of heat.

The relatively consistent ground temperature provides a benefit over air-source heat pumps. The main disadvantage of closed loop ground source heat pumps is that they require the installation of either vertical or horizontal loops to heat exchange with the ground. This adds cost and complexity to a project and additional maintenance concerns when operational.

(Ground / Water Source) Water or Brine to Water Heat Pumps

These are similar to open loop ground or water source heat pumps. Ground or water-to-water heat pumps provides heating and cooling to chilled water (CHW) or low temperature hot water (LTHW) distribution systems. These commonly include chilled beams and soffits (cooling), fan coil units (heating/cooling), radiators and underfloor heating (heating).

Condensing Gas Fired Boilers

A boiler is a closed vessel in which water or other liquid is heated to generate steam or vapor. Energy used to heat the boiler can be from the combustion of fuels or using electricity. The heated liquid or steam generated from the boilers then passes on to a heat distribution system, heat emitters are often under control systems to optimise against environmental and occupancy requirements.

Gas is the most common fuel used for urban boilers due to the accessibility and ability to connect many houses to one supply. Gas boilers heat water which is then pumped round the home or building in the form of central heating or directly to taps. However, fossil fuels such as natural gas will be phased out by the Government in favour of lower carbon heating technologies and fuels. Only where no other options are viable should new gas boilers be specified for CoLC projects.

Condensing gas-fired boilers typically use an additional heat exchanger to extract extra heat by condensing water vapour from the combustion products. This heat can be reused to pre-heat the water entering the boiler resulting in higher efficiencies than non-condensing gas-fired boilers.

Electric Boilers

Electric boilers are like traditional gas boilers, except that water is heated by passing an electric current through a heating element rather than burning gas.

Bivalent Systems (Gas Boiler and ASHP)

A hybrid heat pump refers to a system that uses a heat pump alongside another heat source, typically a fossil fuel or electric boiler. This could be an existing system, or the installation of a new boiler at the same time as the heat pump. These bivalent systems are potentially appropriate where an ASHP project may not be viable alone due to technical constraints to meeting the project delivery requirements. This could be constrained by available electrical power, poor building thermal performance, or inadequate system infrastructure. In the bivalent system, the ASHP is the primary system whilst the gas boiler provides the peak loads. The key benefit is that the majority of a heat can be provided by a low carbon heat source and provide some future proofing for the building. The drawbacks are that additional capital expenditure is required as well a maintenance costs can increase. Careful design is required to link the two systems.

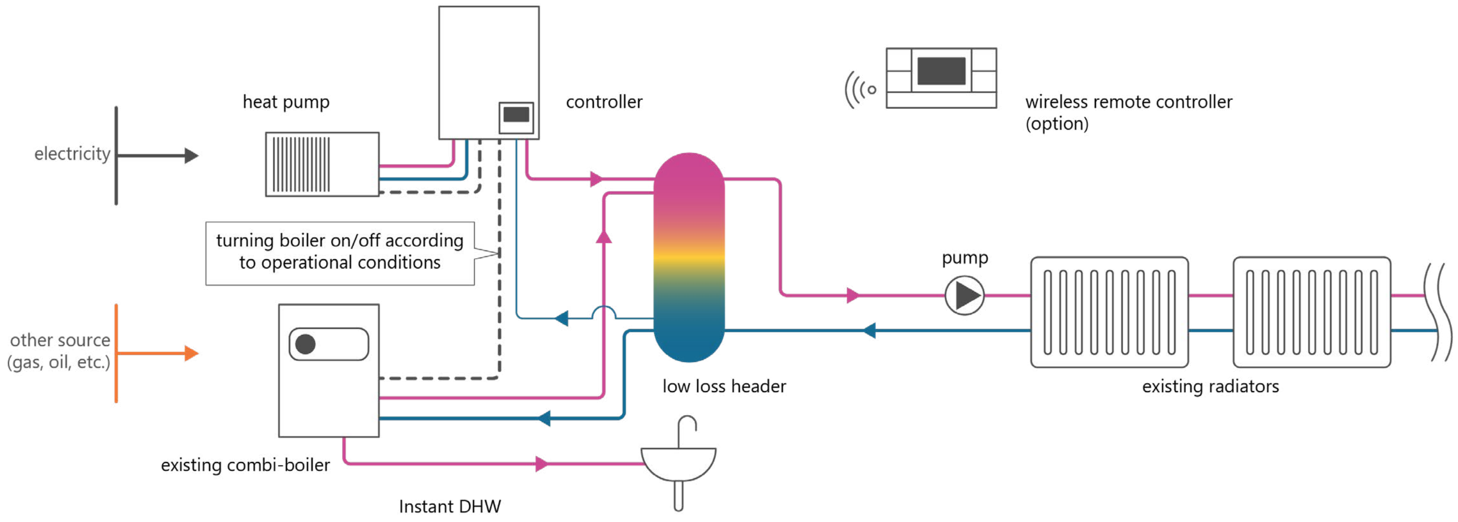


Figure 18 Example schematic of a bivalent system

Electric Convectors

Electricity Convectors are used to heat buildings through convection heating. Electric convectors are 100% energy efficient in the sense that all the incoming electric energy is converted to heat. However, this does not include the primary energy used for the electricity generation. These systems can have good temperature control such as individual thermostats or can be linked for zonal control via a BMS. GHG emissions are determined by consumption and the carbon intensity of grid electricity so can be relatively low in the medium term. However, as this technology uses direct electricity it is much less efficient than using the vapour compression cycle in a heat pump. Therefore, consumer costs and GHG emissions will be higher than if a lower carbon technology is used.

Electric Converters contain a heating coil and inlet / outlet grills, the system may also include a fan, dependent on design and manufacture. Cold air is drawn into the device where it meets a lightweight heating element, and is then passed out by a small, enclosed fan.

The hot air is then circulated, creating a convection current. It offers a rapid heating option for rooms which may be used less frequently. Electric convectors may be either free standing or permanent wall fixtures.

Radiant heating

Radiant heaters work by warming people and objects and not the air. They emit energy that is converted to heat once it hits and is absorbed by the body or object.

Radiant heating is particularly useful in buildings with high air change rates or large volumes that do not require uniform heating throughout, e.g., factories, and intermittently heated buildings with high ceilings.

It was traditionally associated with gas-fired high-temperature, high-roofed industrial applications, however, low temperature radiant panel heating is now used in homes, offices, classrooms, and locations such as hospital patient waiting rooms.

High Temperature Radiant Heaters

High temperature radiant heaters produce virtually 100% radiant heat output from their high surface temperatures. There are three main types:

- Direct gas-fired tubular heaters – comprise a pressurised gas burner and a steel tube through which the flue gases flow radiating heat. Surface temperature may be around 500°C.
- Direct gas-fired radiant plaque heaters – utilise a ceramic element which is directly heated by the gas flame, reaching temperatures of around 800°C.
- Electric quartz lamps – comprise a lamp within a quartz tube, with the filament operating at temperatures exceeding 2,500°C

Low Temperature Radiant Heaters

Low temperature radiant panels are flat metallic surfaces that face into the room, heat output is mostly radiant. There are two main types:

- Low temperature hot water
- Electric infrared.

District Heating Networks

District Heating is a method by which the hot water demands (for space heating (HTG) or domestic hot water (DHW)) of a building is produced at a centralised, offsite location (an Energy Centre) and distributed to the building via a piped network, typically buried underground.

A District Heating Network will serve multiple, distributed buildings (potentially including residential and non-residential use-types) and users and provides the ability to produce and supply thermal energy in an overall more efficient, lower cost and / or lower GHG emissions manner, than if the heat was to be produced at the point-of-use itself (e.g., via domestic gas boilers, or otherwise).

District heating has several potential advantages, including the reduction of overall plant capacity(as large generation plant will be lower capacity than if installed across a number of individual buildings) which enables the introduction of renewable of low carbon fuels across a large area and attracts capital from third party investors and can enable future technology or fuel switching across multiple properties. CoLC currently has the Citigen heat network serving buildings with both heating and cooling. The viability of connecting to this heat network should be considered at an early optioneering stage of the project.

FUTURE HEATING

Introduction

To achieve net zero emissions, we will have to transition away from traditional natural gas boilers for heating homes. Increasing the efficiency of current heating systems will not be enough to reach net zero by 2050. Considerations for future heating are that it needs to provide affordable, secure, and low carbon heat. Electric heat pumps, hydrogen, green gas and shared heat networks will be key technologies for development.

Hydrogen Fuel Heating

Hydrogen will be utilised in several ways in the coming years, Hydrogen produces no greenhouse gases at the point of use meaning it I will play a crucial role in reaching Net zero emissions. Hydrogen can be burnt to produce energy in the same way that natural gas can. This has led to the development of hydrogen ready boilers which can be used for LTHW heating systems.

Hydrogen can also be utilised in a fuel cell to produce heat and power as a Low Carbon micro-CHP system. Fuel cells and hydrogen boilers require a green source of hydrogen to be fully carbon free.

The role of hydrogen in the built environment is still unclear, the Government has indicated an intention to publish a Hydrogen Strategy in 2026. However, it is likely that there will be role in the built environment with research and pilot studies are underway to assess feasibility of either pure hydrogen or blended hydrogen delivered through an upgraded gas network or delivered to the site in bulk.

Hydrogen fuel is named on the basis of its method of generation:

- ‘Grey hydrogen’ when created from natural gas, or methane, using steam methane reformation but without capturing the greenhouse gases made in the process,
- ‘Blue hydrogen’ produced in the same way as grey hydrogen but using carbon capture and storage, and
- ‘Green hydrogen’ which is generated from renewable energy.

Blended Natural Gas

Blending natural gas and hydrogen is an intermediate step towards creating a 100% hydrogen network in the future. The ratio of the mixture is 80:20 natural gas to hydrogen. Mixing this amount of hydrogen into the natural gas network will require no changes to modern natural gas appliances and will therefore have very little impact on the end user.

DOMESTIC HOT WATER

Overview

A Domestic Hot Water System delivers hot water to fixtures / end points, which include sinks, showers, baths, and any appliance where hot water is required within a building.

The two main system types are:

- Centralised: where a central DHW plant serves all, or the majority, of DHW usage in a building. These systems can be combined with the central heating system serving the space heating.
- Decentralised: The hot water supply is separated from the central plant and smaller heaters are located closer to the point-of-use, examples include under sink heaters and instantaneous showers.

These systems can be fuelled by a wide range of fuels, including but not limited to, mains gas, electricity, oil, and biofuels.

Interdependencies

The interdependencies with other building services with domestic hot water are that where there is a centralised systems serving heating and hot water these will be generated from the same heat source. A centralised system also makes it more suitable to use solar thermal hot water systems as hot water storage is required to optimise the system.

Solar Hot Water can be installed alongside conventional solar photovoltaic panels if there is sufficient roof space. Deciding on the most appropriate renewable technology needs to determine through an optioneering process and Best Available Technology Assessment.

Centralised System: Gas-fired Condensing Water Heaters

Gas-fire condensing water heaters produce heat by burning fuel. Condensing boilers work with a 'Flue Gas Recovery System' which recycles the heat from the steam and stops it being lost. As the fuel burns, water vapour, which contains heat, is produced, and subsequently recovered. This increases the efficiency of the system compared to older non-condensing models.

Centralised System: Air to Domestic Hot Water Heat Pumps

Air to Domestic Hot Water Heat Pumps transfer heat from the outdoor air to a domestic hot water tank, using a refrigeration cycle. These systems are electrically fuelled and can be used in both residential and commercial buildings. These systems can also be part of a combined heat pump system producing both space heating and hot water.

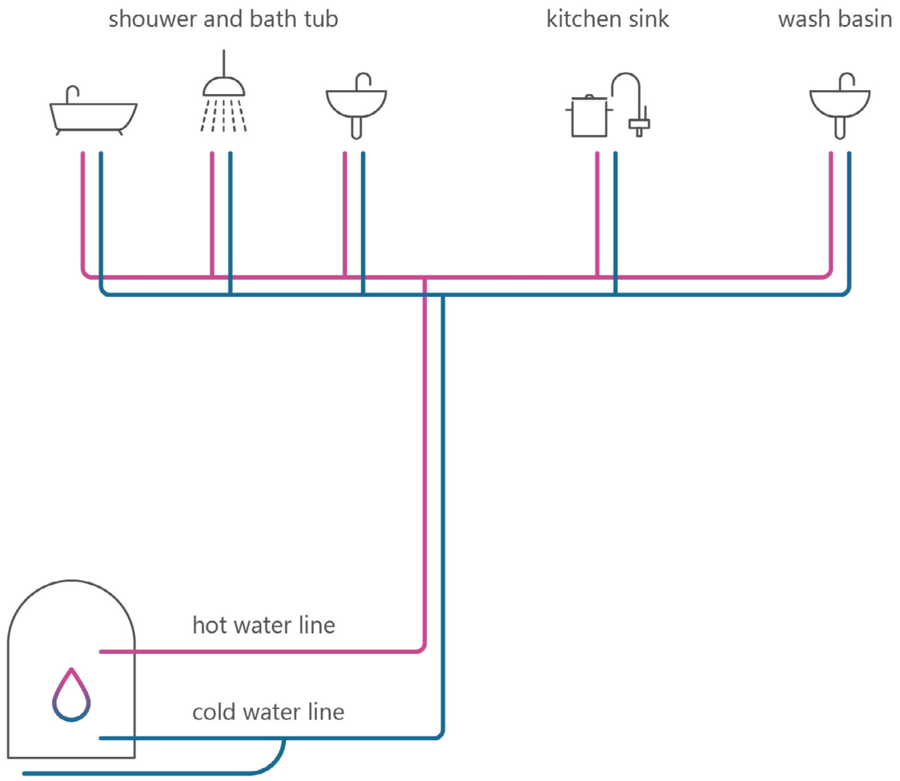


Figure 19 Example schematic of centralised domestic hot water supply

Centralised System: Hot water boilers

A hot water boiler works by using the fuel, such as oil, gas or electricity, to generate hot water. This is then circulated to a storage vessel or transferred directly to the point of usage.

Point of Use Heaters

Point of Use heaters heat the water close to the point of consumption for example, a sink, shower, or bath, where the water is used. These units may be installed anywhere with an adequate water and electrical supply, making them ideal for applications where a centralised system is not practical. These systems may also be used as a back-up or top-up for centralised systems.

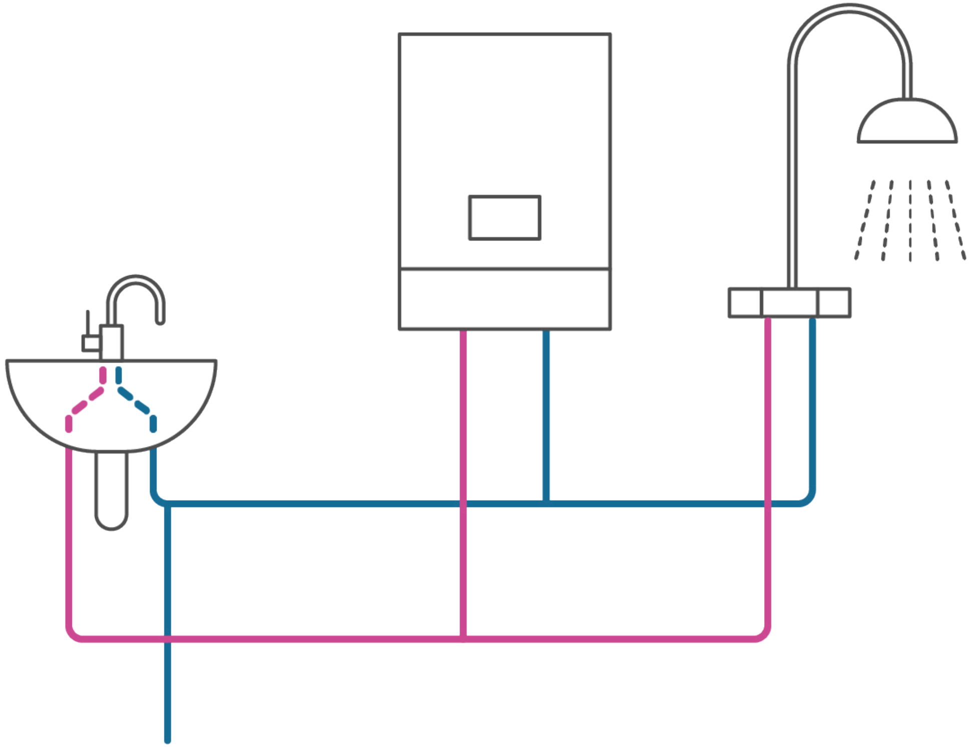


Figure 20 Example schematic of Use domestic hot water supply

Solar Hot Water

Solar hot water systems, also known as 'solar thermal', use solar panels to absorb heat and transfer it water which is circulated for use in the building.

Heat absorbed by the panels is used to pre-heat water that can be fed into a hot water storage cylinder or directly into a combination boiler.

An 'indirect' system works by heating liquid that is not the same as that drawn from the user points. In 'indirect' systems, normally a mixture of water and antifreeze is used and the heat from the sun is transferred to the water in the hot water cylinder by the way of a copper coil.

In a 'direct' system the water heated by the solar collectors goes directly into the DHW cylinder. This is less common in the UK due to issues with freezing and overheating.

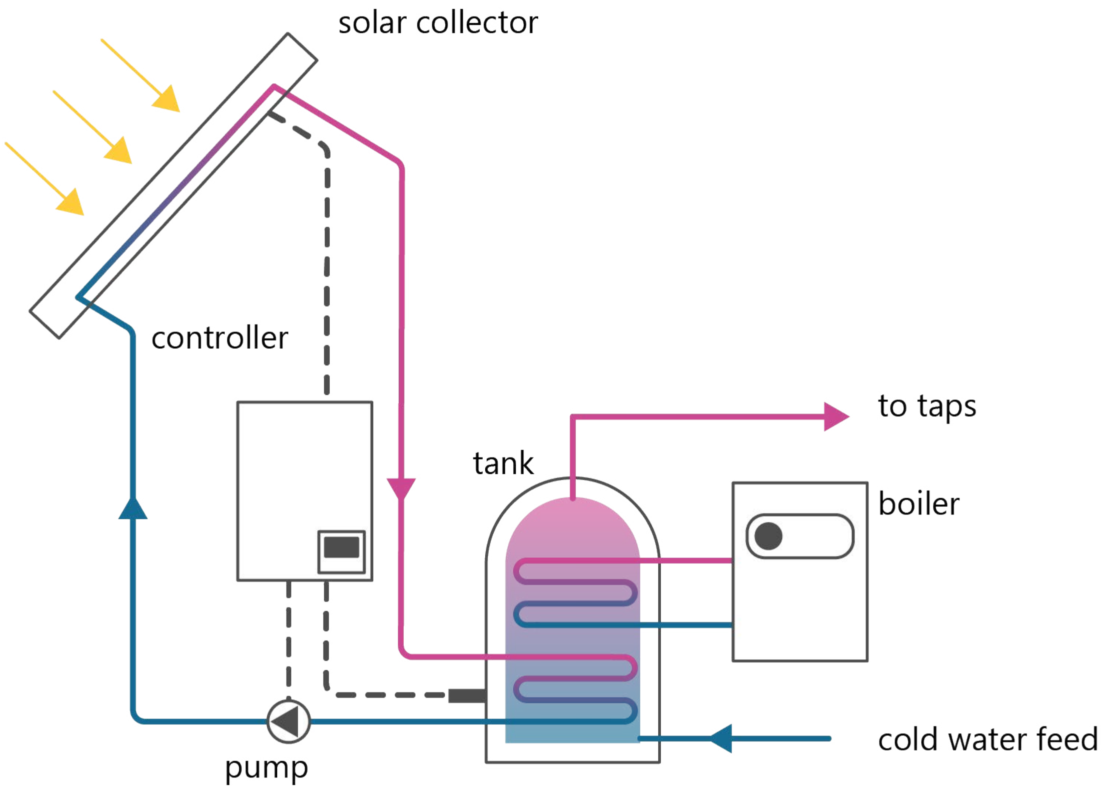


Figure 21 Example schematic of solar thermal system

TECHNOLOGY GUIDE - PERFORMANCE STANDARDS

Requirements	Performance Requirements	Measurement Standards / Test Conditions	Asset Type: New build	Asset Type: Refurb	Asset Type: Listed	Building Type: Residential	Building Type: Commercial	Building Type: Public (e.g. Schools)
Category / Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoLC Standard							
Heating								
Heat pumps Performance Threshold	**Building Regulations: Part L1 Requirements:** •Electrically driven air-to-air heat pumps with an output of 12kW or less should follow Commission Regulation 2016/2281 for air heating products, cooling products, high temperature process chillers and fan coil units. •For other types of heat pump, the Coefficient of Performance (COP) should be both COP ≥ 3.0 for space heating and COP ≥ 2.0 for water heating. •The minimum seasonal energy efficiency ratio of an air conditioner working in cooling mode should be SEER ≥ 4.0 **Building Regulations Part L2 Requirements:** All types of heat pumps in new and existing buildings must have a minimum Coefficient of Performance (COP) of: •2.5 for space heating (except air-to-air with output ≤12kW) •2.0 for domestic hot water The minimum seasonal energy efficiency ratios (SEERs) for comfort cooling are: •Packaged air conditioners SEER ≥ 3.0 •Split and multi-split air conditioners SEER ≥ 5.0 •Variable refrigerant flow/volume (VRF/VRV) systems SEER ≥ 5.0 •Water-to-water chillers <400kW SEER ≥ 5.0 •Water-to-water chillers 400-1500kW SEER ≥ 6.0 •Water-to-water chillers >1500kW SEER ≥ 6.5 •Vapour compression cycle chillers, air-cooled <400kW SEER ≥ 4.0 •Vapour compression cycle chillers, air-cooled >400kW SEER ≥ 4.5	Building Regulations Conservation of fuel and power: Approved Document Part L1 [GN.1] Heating Mode: BS EN 14511-2, tables 3-19, standard rating conditions [C. 2] Cooling Mode: Commission Regulation (EU) No 206/2012 Annex II, average rating conditions [C. 31] Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2] Heating Mode: BS EN 14511-2, tables 3-19, standard rating conditions [C. 2] Cooling Mode: Commission Regulation (EU) No 206/2012 Annex II, average rating conditions [C. 31]	✓	✓	•	✓	✓	✓
Air to Air Heat Pumps: Split (non VRF), Multi-split (non VRF), and VRF heat pumps >12kW Performance Requirements	In Heating Mode, the Seasonal Space Heating Energy Efficiency ($\eta_{s,h}$) should meet as a minimum: •Single split (non-VRF) heat pumps $\eta_{s,h} \geq 165\%$ •Multi-split (non-VRF) heat pumps $\eta_{s,h} \geq 160\%$ •VRF heat pumps $\eta_{s,h} \geq 170\%$ In Cooling Mode, the Seasonal Space Cooling Energy Efficiency ($\eta_{s,c}$) should meet as a minimum: •Single split (non-VRF) heat pumps $\eta_{s,c} \geq 250\%$ •Multi-split (non-VRF) heat pumps $\eta_{s,c} \geq 240\%$ •VRF heat pumps $\eta_{s,c} \geq 260\%$	Heating Mode: Commission Regulation (EU) No 2281/2016 Annex III, tables 16, 21, 26, average rating conditions [HP.22] Cooling Mode: Commission Regulation (EU) No 2281/2016 Annex III, tables 16, 27, average rating conditions [HP.22]	✓	•	•		✓	
Air to Air Heat Pumps: Split, Multi-split, and VRF heat pumps ≤12 kW Performance Requirements	Performance Requirements In Heating Mode, the Seasonal Coefficient of Performance (SCOP) should meet as a minimum: •Single split (non-VRF) heat pumps SCOP≥4.20 •Multi-split (non-VRF) heat pumps SCOP≥4.10 •VRF heat pumps SCOP≥4.30 In Cooling Mode, the Seasonal Energy Efficiency Ratio (SEER) should meet as a minimum: •Single split (non-VRF) heat pumps SEER≥6.40 •Multi-split (non-VRF) heat pumps SEER≥6.30 •VRF heat pumps SEER≥6.50	Heating Mode: Commission Regulation (EU) No 206/2012 Annex II, table 1, average rating conditions [C. 31] Cooling Mode: Commission Regulation (EU) No 206/2012 Annex II, table 1 [C. 31]	✓	•	•		✓	
Air to Air Heat Pumps: Packaged (Rooftop) Performance Requirements	In Heating Mode, the Seasonal Space Heating Energy Efficiency ($\eta_{s,h}$) should meet as a minimum: •Packaged heat pumps $\eta_{s,h} \geq 135\%$ In Cooling Mode, the Seasonal Space Cooling Energy Efficiency ($\eta_{s,c}$) should meet as a minimum: •Packaged heat pumps $\eta_{s,c} \geq 145\%$	Heating Mode: Commission Regulation (EU) No 2281/2016 Annex III, tables 16, 21, 26, average rating conditions [HP.22] Cooling Mode: Commission Regulation (EU) No 2281/2016 Annex III, tables 16, 27, average rating conditions [HP.22]	✓	•	•		✓	
Air to Water Heat Pumps Performance Requirements	In Heating Mode, the Seasonal Space Heating Energy Efficiency ($\eta_{s,h}$), should meet as a minimum: •Low-temperature heat pumps $\eta_{s,h} \geq 155\%$ •Medium and high-temperature heat pumps $\eta_{s,h} \geq 130\%$ •Large irreversible heat pumps $\eta_{s,h} \geq 125\%$ In Cooling Mode, the Seasonal Energy Efficiency Ratio (SEER), for average climate conditions where the product is designed to provide cooling, should meet as a minimum: •Low-temperature heat pumps SEER≥4.50 •Medium and high-temperature heat pumps SEER≥4.50 •Large irreversible heat pumps SEER = N/A	Heating Mode: Commission Regulation (EU) No 813/2013, Annex III Tables 4 and 5 and Table 3 [HP.4] Cooling Mode: BS EN 14825:2016 Table 4, Part load condition A, cooling floor application [HP.23]	✓	✓	•	✓	✓	✓

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Requirements	Performance Requirements	Measurement Standards / Test Conditions	Asset Type: New build	Asset Type: Refurb	Asset Type: Listed	Building Type: Residential	Building Type: Commercial	Building Type: Public (e.g. Schools)
Category / Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoLC Standard							
(Ground Source) Water to Air Heat Pumps: Split (non-VRF), Multi-split (VRF) Performance Requirements	In Heating Mode, the Seasonal Space Heating Energy Efficiency ($\eta_{s,h}$) should meet as a minimum: •Single split (non-VRF) heat pumps $\eta_{s,h} \geq 165\%$ •Multi-split VRF heat pumps $\eta_{s,h} \geq 170\%$ In Cooling Mode, the Seasonal Space Cooling Energy Efficiency ($\eta_{s,c}$) should meet as a minimum: •Single split (non-VRF) heat pumps $\eta_{s,c} \geq 270\%$ •Multi-split VRF heat pumps $\eta_{s,c} \geq 280\%$	Heating Mode: Commission Regulation (EU) No 2281/2016 Annex III, tables 19, 21, 26, water rating conditions [HP.22] Cooling Mode: Commission Regulation (EU) No 2281/2016 Annex III, tables 19, 27, ground coupled rating conditions [HP.22]	•	•	•		✓	✓
(Ground Source) Water or Brine to Water Heat Pumps Performance Requirements	In Heating Mode, the Seasonal Space Heating Energy Efficiency ($\eta_{s,h}$) should meet as a minimum: •Brine to water heat pumps $\eta_{s,h} \geq 175\%$ •Water to water heat pumps $\eta_{s,h} \geq 185\%$ In Cooling Mode, the Seasonal Energy Efficiency Ratio (SEER), for average climate conditions where the product is designed to provide cooling, should meet as a minimum: •Brine to water heat pumps SEER≥5.0 •Water to water heat pumps SEER≥5.0	Heating Mode: Commission Regulation (EU) No 813/2013, Annex III, table 3 [HP.4] Cooling Mode: BS EN 14825:2016 Table 5, Part load condition A [HP.23]	•	•	•	✓	✓	✓
Boilers Performance Threshold	**Building Regulations: Part L1 requirements:** Minimum efficiencies for gas-fired heating systems in new residential: •Wet heating (e.g. radiators or underfloor heating): 92% Minimum efficiencies for gas-fired heating systems in existing residential: •Wet heating (e.g. radiators or underfloor heating): 92%, or in exceptional circumstances in existing residential, SEDBUK 2009 efficiency (78%) **Building Regulations: Part L2 requirements:** Minimum natural gas boiler seasonal efficiency (gross calorific value) in new non-domestic buildings: •Single boiler <2MW output: 93% •Single boiler >2MW output: 88% •Multiple boiler: 88% for any individual boiler and 93% for overall multi-boiler system Minimum natural gas boiler seasonal efficiency (gross calorific value) in existing non-domestic buildings: •Single boiler <400kW output: 91% •Single boiler 401-2MW output: 88% •Single boiler >2MW output: 84% •Multiple boiler: 84% for any individual boiler and 91% for overall multi-boiler system Non-condensing boilers should also be fitted with a flue condensing kit where feasible and where the boiler is likely to be able to operate in condensing mode (e.g. variable temperature circuits)	Building Regulations Conservation of fuel and power: Approved Document Part L1 [GN.1] - As defined by ErP Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2] - The minimum efficiencies are based on documented manufacturers' test data. Equations 6.1 to 6.6 of Part L2 should be used. Efficiencies based on net calorific values should be converted to gross calorific values based on, using the appropriate conversion factor in the Standard Assessment Procedure version 10 Table E14 [GN.4]	✓	✓	•	✓	✓	✓
Gas-fired Performance Requirements	The gross thermal efficiency at test points should meet the Part L requirements as a minimum.	See above.	✓	✓	•	✓	✓	✓
Electric Boilers Performance Requirements	Electric boilers are around 99-100% efficient	N/A	✓	✓	•	✓	✓	✓
Hybrid / Bivalent systems Performance Requirements	See performance requirements for heat pumps and boilers.	N/A	✓	✓	•	✓	✓	✓
Electric Convectors Performance Threshold	**Building Regulations: Approved Document L2** states that Electric resistance heating is assumed to be 100% efficient, therefore no minimum efficiency is set for these types of system.	Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2]	✓	✓	✓	✓	✓	✓
Electric Convectors Performance Requirements	100% efficient at point of use	N/A	✓	✓	•	✓	✓	✓
Radiant heating Performance Threshold	**Building Regulations: Approved Document L2 Requirements:** Heat generator seasonal efficiency should meet (net calorific value): •Luminous radiant heater – un-flued: 86% thermal and 55% radiant •Nonluminous radiant heater – un-flued: 86% thermal and 55% radiant •Non-luminous radiant heater -flued: 86% thermal and 55% radiant •Multi-burner radiant heater: 91% thermal	Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2]	✓	✓	✓	✓	✓	✓
District Heating Performance Threshold/ Requirements	There are no specific performance thresholds for district heating. However Building Regulations: Approved Document L2 Requirement Part L Requirements states that an existing distric heat network that is being connected to a new residential building should not have a CO_2 emission factor for delivered heat to the residential building which is greater than 0.350kgCO_2/kWh or a primary energy factor for delivered heat to the residential building greater than 1.450kWhPE/kWh. For residential buildings, this should be calculated using SAP 1C or taken from the Product Characteristics Database.	Building Regulations Conservation of fuel and power: Approved Document Part L1 [GN.1]	✓	✓	✓	✓	✓	✓

TECHNOLOGY GUIDE - PERFORMANCE STANDARDS

Requirements	Performance Requirements	Measurement Standards / Test Conditions	Asset Type: New build	Asset Type: Refurb	Asset Type: Listed	Building Type: Residential	Building Type: Commercial	Building Type: Public (e.g. Schools)
Category / Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoLC Standard							
Future Heating								
Hydrogen Performance Threshold	There are no currently published performance thresholds for hydrogen heating plant.		✓	✓	✓	✓	✓	✓
Hydrogen Performance Threshold/ Requirements	Performance requirements on the use of hydrogen currently not available. Key areas of performance will be related to conversion in electrolysers, hydrogen purging, tightness and material compatibility, combustion efficiency of boilers, fuel cells and electrolysers, hydrogen installation ventilation and flues, hydrogen pipe sizing and pressure drops, metering and storage and use with new generation plant In order to assure that hydrogen is compliant as a low carbon fuel, producers (and subsequently uses) of low carbon hydrogen must be able to report a GHG emissions intensity of 20gCO2e/MJLHV of produced hydrogen or less. GHG contributions are defined in terms of grams of carbon dioxide equivalent per megajoule of produced hydrogen at lower heating value (gCO2e/MJLHV). [FH9] The UK Low Carbon hydrogen standard outlines the calculations required to meet these targets	BEIS UK Low Carbon Hydrogen Standard Guidance on the greenhouse gas emissions and sustainability criteria 2022 [FH.9]	✓	✓	✓	✓	✓	✓
Blended natural gas Performance Threshold/ Requirements	Performance requirements as per natural gas fired boilers. as and when new standards are released, these should be followed in addition to existing part L requirements	BSI PAS 4444 is a new standard aimed at standardising hydrogen gas appliances. New boilers should be manufactured to this standard and guidance updated as this document is amended in the future It also covers the setting of limit (upper and lower) hydrogen supply pressures and limit voltages. It discusses the possible arrangement of fittings and devices acknowledging the application to hydrogen fired appliances. [FH8]	✓	✓	✓	✓	✓	✓
Low Carbon CHP Performance Threshold/ Requirements	**Building Regulations: Approved Document L1 Requirements: (Residential)** The heating plant emission rate of the micro combined heat and power system (micro-CHP) should be no greater than the emission rate of a regular boiler using the same fuel as the micro-CHP. The heating plant emission rate should be calculated using all of the following: a)The method in DEFRA's Method to Evaluate the Annual Energy Performance of Micro cogeneration Heating Systems in residential buildings. b)The performance data for the micro-CHP packaged according to BSI PAS 67. c)A plant size ratio that uses the nominal heat output of the heating plant divided by the average heat loss of the building when there is a temperature difference of 24.2°C. **Building Regulations: Approved Document L2 Requirements: (Non-Residential)** CHP plant should, under annual operation, have both of the following. a)A minimum CHPQA quality index (QI) of 105. b)Power efficiency greater than 20%. Calculations should take account of the annual average performance of the whole system, including the distribution circuits, all heat generating plants, combined heat and power (CHP), and any waste heat recovery or heat dumping Refer to Quality Assurance for Combined Heat and Power -The CHPQA standard Issue 8 for guidance on calculating CHP quality Index [FH 1]	Building Regulations Conservation of fuel and power: Approved Document Part L1 [GN.1] Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2] Building Regulations: National Calculation Methodology (NCM) Modelling Guide [FH13] CHPQA standard Issue 8 [FH1] BSI PAS 67: (2008) [FH12]	✓	✓		✓	✓	✓

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Requirements	Performance Requirements	Measurement Standards / Test Conditions	Asset Type			Building Type		
			New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)
Category / Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoLC Standard							
Domestic Hot Water								
Domestic Hot Water System Performance Threshold	Building Regulations: Approved Document L2 2021 Requirements (Non-Residential) heat generator seasonal efficiency (gross calorific value): Direct-fired:- • Natural gas = 91% • LPG = 92% Indirect-fired:- • Natural gas, LPG & Oil = 91% Electrically heated = 100% assumed	Building Regulations Conservation of fuel and power: Approved Document Part L1 [GN.1] Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2]	✓	✓	✓	✓	✓	✓
Centralised System: Gas-fired condensing water heaters ≤400kW **Performance Requirements**	Water Heating Energy Efficiency (ηwh) should meet: •3XS-L ≥ 70% •XL ≥ 80% •XXL-4XL ≥ 85%	Load profile Load profile is a given sequence of water draw-offs, as specified in Annex III, Table 1 of Commission Regulation (EU) No 814/2013 "Eco-design requirements for water heaters and hot water storage tanks" - this relates to the 3XS-4XL of the boilers. [CHW.12]	✓	✓	✓	✓	✓	✓
Centralised System: Gas-fired condensing water heaters >400kW Performance Requirements	For non-storage - instantaneous type, gross thermal efficiency should meet: •At 100% load, flow return temperatures of 80/60 °C ≥ 85.6% •At 30% load, return temperature of 30 °C ≥ 93.7% For non-storage - circular type, gross thermal efficiency should meet: •At 100% load, flow/return temperatures of 80/60 °C ≥85.6% •At 30% load, return temperature of 30 °C ≥ 93.7%	For storage: BS EN 89:2000 [CHW.8], BS EN 89:2015 [CHW.9] For non-storage instantaneous: BS EN 303-3:1999 [B.5], BS EN 303-7:2006 [B.9], BS EN 15502-1:2012+A1:2015 [B.10], BS EN 15502-2-1:2012 [B.11], BS EN 483:1999+A4:2007 [B.7], BS EN 677:1998 [B.8], BS EN 26:1998 [CHW.10], BS EN 26:2015 [CHW.11] For non-storage circulator (or multi-pass) type: BS EN 26:1998 [CHW.10], BS EN 26:2015 [CHW.11]	✓	✓	✓	✓	✓	✓
Centralised System: Air to Domestic Hot Water Heat Pumps Performance Requirements	Water Heating Energy Efficiency (ηwh) should meet: • L ≥ 110% • XL ≥ 115% • XXL ≥ 120% • 3XL ≥ 125% • 4XL ≥ 130%	Load profile is a given sequence of water draw-offs, as specified in in Annex III, Table 1 of Commission Regulation (EU) No 814/2013 - this relates to the L-4XL rating of the heat pumps. [CHW.12]	✓	✓	✓	✓	✓	✓
Centralised System: Hot water boilers Performance Requirements	For hot water boilers <70kW, the gross thermal efficiency should meet: •At 30% of maximum nominal output ≥83.8% •At 100% of maximum nominal output ≥ 83.0% For condensing hot water boilers >70kW, the gross thermal efficiency should meet: •At 30% of maximum nominal output ≥ 94.6% •At 100% of maximum nominal output ≥ 89.0% For condensing hot water boilers <= 70kW: •Seasonal Space Heating Energy Efficiency should meet ≥93%	Equals the thermal efficiency of the heater (gross calorific value) when tested to BS EN 15502-2-1:2012 [B.6]	✓	✓	✓	✓	✓	✓
Point of Use Heaters Performance Requirements	Point of Use Heaters are assumed 100% thermally efficient in terms of conversion to heat within the building. However, heat can still be lost in both the unit/storage/distribution piping. Maximum heat loss for hot water cylinders are given in Part L 2021 as [POU.3]: i.50 litres = 1.03 kWh/day ii.100 litres = 1.49 kWh/day	BS EN 15450:2007 provides storage losses for storage vessels less than 200L. [HP. 21]	✓	✓	✓	✓	✓	✓
Solar Hot Water Performance Threshold and Requirements	There are currently no requirements for solar thermal system in current building regulations. The supplier must provide the following parameters to comply: i. Active Area (m2) ii. Zero-loss efficiency iii. First-order Efficiency Coefficient (W/m2K) iv. iii. Second-order Efficiency Coefficient (W/m2K)	Solar collectors introduced to the market after 2017 must comply with BS EN ISO 9806:2017 "Solar energy. Solar thermal collectors. Test methods." [SHW.8]	•	•	•	•	•	•

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Requirements	Technical standards - For references, please refer to the 'Appendix' tab				New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)	City of London Documents and Guidance	Location and Description	Project Management	Mechanical Engineer	Electrical Engineer	Architect	Public Health Engineer	Fire Engineer	Contractor	Building FM / End User
					Asset Type			Building Type			City of London Document Interlinks (TBC)		Key Stakeholders							
Category / Sub-category	Further guidance on design considerations and how the technology category or sub-category should be installed to deliver the performance standard targets										Task Bar	PPG Activities								
Heating	**Key Design and Operation Considerations**		**Compatibility / Future proofing**	**Environmental Impact**																
Heat pumps																				
Air to Air Heat Pumps: Split, Multi-split, VRF and Packaged Heat Pumps	• The ASHP must be at least 1 metre from the property's boundary and the external unit can't protrude more than 1 metre from the outer wall, roof, or chimney for residential developments [HP.13]. • An industry wide rule of thumb is to allow 2m spacing around the heat pump for maintenance [HP.6]. Asses plant space availability. Consult manufacturer to determine space requirements of specific heat pumps • Plantrooms must have sufficient ventilation to avoid the build-up of heat and refrigerant gases, in-case of a leak – this must adhere to BS EN 378 [HP.1]. Manufacturer will specify heat rejection and M&E consultant should review mitigation options. • Heat Pumps have an expected lifespan of 15-20 years [HP.20]. • Equipment containing refrigerants must be labelled in accordance with the EU F-Gas Regulations 517/2014, including any additional 2017 requirements. • Split systems do not require ductwork, and are easier to install. Commercial Consideration: N+1 number of heat generators (where N is the number of generators required to meet the design load) should be designed for centralised systems to provide insurance to plant redundancy. A control strategy should be in place to ensure longevity of equipment and potentially improve seasonal efficiency [HP.15]. Listed Consideration: For listed properties, availability of plant spacing must be more stringently considered. Placing units on external walls and roofs may face strict planning requirements. Assess suitable locations to protect heritage status of building.	• Air-to-Air heat pumps generally operate at 35-55 ˚C [HP.14], • Air-to-air heat pumps can operate for cooling making them suitable for commercial buildings with cooling requirements • CIBSE Guide A provides guidance on operating temperatures in respect to heat losses and set points to ensure the thermal comfort and ensure correct sizing of HVAC systems. • Consult CIBSE Guide H for guidance on control strategy to ensure control of setpoints and avoid parallel heating and cooling of spaces with multiple indoor units. Heat pumps can be controlled centrally controlled, combining multiple units, or individually with hand-help controllers [HP.9]. • Heat exchangers shall have a operating range of -15-45˚C. Refurb & Listed Consideration: Existing buildings may require higher temperature due to heat losses, this can typically be around 65 ˚C. This can be achieved with high temperature heat pumps. To install low temperature heat pumps improvements may need to be made to the building fabric and/or change in size of the heating emitters. Installing a system with lower flow and return rates in an existing building may also require changes to distribution pipework and pumps. Consultation inline with CIBSE Guide A required [HP.12].	• VRF, split & multi-split pumps require piping from the external condenser to the internal cassette, so spatial assessment required. Packaged heat pumps and heat pumps used in conjunction with AHUs require ducting. Consult CIBSE Guide B2 for spatial guidance [HP.5]. • These heat pumps can be used in conjunction with gas wet systems and other heating solution, to provide the cooling requirements of the specific building. • The contractor/designer shall assess the availability of the available electrical services, especially if part of a new build or retrofitting from a gas heating system. Refurb & Listed Consideration: If retrofitting, the existing building may not have space allowance for ducting, this option may not be viable. Conduct spatial requirement assessment.	• Measured from a distance equal to that separating the unit and the next-door property, air-source heat pumps must be below 42 decibels. Consult MCS 020 for guidance on the noise levels acceptable and testing conditions and requirements, devolved rules should also be consulted [HP.8]. For determining external noise criteria, a 24-hour noise survey is typically required. This should set a project specific noise criteria, which may supersede the requirements set out in MCS 020. • Use refrigerants with a GWP of less than 5, or if feasible, use no refrigerants. Several BREEAM credit can be obtained • The design should adhere to BREEAM Credit POL 01, which awards credits through leak detection. • Assess credentials for BREEAM Credit ENE01 awards 9 credits for developments with zero net regulated CO_2 emissions. Listed Consideration: If the building is a listed building, acquire both planning permission and listed building consent.	✓	•	•		✓		1) CoLC Broad Street Place Mechanical Specification 2) City of London Corporation Housing Design Guide Dec 2020	1a) Section M10: Equipment containing refrigerants must be labelled in accordance with the EU F-Gas Regulations 517/2014, including any additional 2017 requirements. 2a) P60: Systems must be designed to the following standards: Microgeneration Certification Scheme Renewable Heat Incentive metering requirements, BS ISO 13612 (BSI, 2014) and BS EN 15450 (BSI, 2007), underfloor heating: BS EN 1264 and BS EN 1264-2 (BSI, 2008).		✓	✓	✓			✓	✓
Air to Water		• The majority of ASHP currently in the marketplace are best suited for use with low temperature systems, such as underfloor heating at 30-45 ˚C and radiators sized to operate at 45-55 ˚C [HP.14]. The air pump should not be specified above 55˚C unless the application requires. If an air to water heat pump system is specified by designers to operate above 55 ˚C, seek assurances from designer about necessity. A high temperature heat pump should be assigned to serve above 55˚C, as low temperature heat pumps suffered drops in efficiencies at these temperatures. • For DHW, if installing a hot water cylinder with a heat pump, the heat pump must be capable of a flow temperature of at least 55 ˚C [HP.7]. • Consult CIBSE Guide H for guidance on control strategy to ensure control of setpoints and avoid parallel heating and cooling of spaces with multiple indoor units. Heat pumps can be controlled centrally controlled, combining multiple units, or controlled locally with room level controllers [HP.9] • CIBSE Guide A provides guidance on operating temperatures in respect to heat losses and set points to ensure the thermal comfort and ensure correct sizing of HVAC systems. • Heat exchangers shall have a operating range of -15-45˚C. Refurb & Listed Consideration: Existing buildings may require higher temperature due to heat losses, this can typically be around 65 ˚C. This can be achieved with high temperature heat pumps. Consultation inline with CIBSE Guide A required [HP.12].	• Temperatures of ASHP wet system tend to not exceed 55˚C, whereas typical gas wet systems tend to operate around 70˚C. M&E consultant to confirm optimal solution of emitter alteration or additional plant to top up temperatures. M&E consultant to assess pipework alteration requirements. • The contractor/designer shall assess the availability of the available electrical services, especially if part of a new build or retrofitting from a gas heating system. • Consult CIBSE CP1 for the design and sizing of a thermal store. This requires an operating model that predicts the heat demand profile on an hourly basis to size the store for optimal performance [HP.17]. • Part L 2022 regulations specify newly built residential wet systems must have pipework and emitters sized for a maximum flow rate of 45˚C and 55˚C for commercial new builds, to ensure the future compatibility with low-temperature systems, like heat pumps [HP.20-21] . Refurb & Listed Considerations: Heat Pump must be able to provide at least 100% of the calculated heat loss without any supplementary heating. In older building, with lesser fabric, this heat loss must be considered [HP.7]. Refer to Fabric Section for guidance on improving the thermal envelope of the building.		✓	✓		✓	✓	✓	1) CoLC Broad Street Place Mechanical Specification 2) City of London Corporation Housing Design Guide Dec 2020	1a) Section M10: Equipment containing refrigerants must be labelled in accordance with the EU F-Gas Regulations 517/2014, including any additional 2017 requirements. 2a) P60: Systems must be designed to the following standards: Microgeneration Certification Scheme Renewable Heat Incentive metering requirements, BS ISO 13612 (BSI, 2014) and BS EN 15450 (BSI, 2007), underfloor heating: BS EN 1264 and BS EN 1264-2 (BSI, 2008).		✓	✓	✓			✓	✓
Ground Source Water to Air Heat Pumps: Split, Multi-split and VRF	• The GSHP must be at least 1 metre from the property's boundary and the external unit can't protrude more than 1 metre from the outer wall, roof, or chimney for residential developments [HP.13]. • An industry wide rule of thumb is to allow 2m spacing around the heat pump for maintenance [HP.6]. Asses plant space availability. Consult manufacturer to determine space requirements of specific heat pumps • Plantrooms must have sufficient ventilation to avoid the build-up of heat and refrigerant gases, in-case of a leak – this must adhere to BS EN 378 [HP.1]. Manufacturer will specify heat rejection and M&E consultant should review mitigation options. • The area required for collectors can be estimated from BS EN 15450 Table A.2 based on the calculated heat demand for the system [HP.18]. Consult MIS-3005 for guidance on obtaining maximum power extraction per unit length of borehole [HP.7] alongside Section 7 of the MGD 007 [HP.19]. • Heat Pumps have an expected lifespan of 15-20 years [HP.20]. • Split systems do not require ductwork, and are easier to install. • GSHP boreholes and water abstraction rates must be approved by the Environment Agency. Key Consideration: The capacity of GSHPs may be limited by borehole flowrates. Sufficient ground investigation should be carried out in order to provide accurate estimates. Borehole testing should be conducted and comply with CIBSE TM51 to ensure optimum design of ground heat exchangers [HP.16]. Listed Consideration: For listed properties, availability of plant spacing must be more stringently considered. Placing units on external walls and roofs may face strict planning requirements. Assess suitable locations to protect heritage status of building.	• Ground-to-Air heat pumps generally operate at 35-55 ˚C [HP.14]. • Ground-to-air heat pumps can operate for cooling making them suitable for commercial buildings with cooling requirements • CIBSE Guide A provides guidance on operating temperatures in respect to heat losses and set points to ensure the thermal comfort and ensure correct sizing of HVAC systems. • Consult CIBSE Guide H for guidance on control strategy to ensure control of setpoints and avoid parallel heating and cooling of spaces with multiple indoor units. Heat pumps can be controlled centrally controlled, combining multiple units, or individually with hand-help controllers [HP.9] Key Consideration: As a general rule, the closer the distribution temperature is to the ground temperature, the higher the COP. Therefore, a site survey should provide indication of whether the heat pump will perform adequately [HP.16]. Refurb & Listed Consideration: Existing buildings may require higher temperature due to heat losses, this can typically be around 65 ˚C. This can be achieved with high temperature heat pumps. Consultation inline with CIBSE Guide A required [HP.12].	• VRF, split & multi-split pumps require piping from the external condenser to the internal cassette, so spatial assessment required. Packaged heat pumps and heat pumps used in conjunction with AHUs require ducting. Consult CIBSE Guide B2 for spatial guidance [HP.5]. • These heat pumps can be used in conjunction with gas wet systems and other heating solution, to provide the cooling requirements of the specific building. • The contractor/designer shall assess the availability of the available electrical services, especially if part of a new build or retrofitting from a gas heating system. • Open loop GSHPs can have a high pumping energy consumption, this can outweigh some of the benefit of the higher efficiencies over air source. Ensure, pumping calculations have been completed prior to assessing energy impact of GSHP system. Refurb & Listed Consideration: If retrofitting, the existing building may not have space allowance for ducting, this option may not be viable. Spatial requirement assessment required.	• Measured from a distance equal to that separating the unit and the next-door property, air-source heat pumps must be below 42 decibels. Consult MCS 020 for guidance on the noise levels acceptable and testing conditions and requirements, devolved rules should also be consulted [HP.8]. For determining external noise criteria, a 24-hour noise survey is typically required. This should set a project specific noise criteria, which may supersede the requirements set out in MCS 020. •Use refrigerants with a GWP of less than 5, or if feasible, use no refrigerants. Several BREEAM credit can be obtained • The design should adhere to BREEAM Credit POL 01, which awards credits through leak detection. • Assess credentials for BREEAM Credit ENE01 awards 9 credits for developments with zero net regulated CO_2 emissions. Listed Consideration: If the building is a listed building, acquire both planning permission and listed building consent.	•	•	•		✓	✓	1) CoLC Broad Street Place Mechanical Specification 2) City of London Corporation Housing Design Guide Dec 2020	1a) Section M10: Equipment containing refrigerants must be labelled in accordance with the EU F-Gas Regulations 517/2014, including any additional 2017 requirements. 2a) P60: Systems must be designed to the following standards: Microgeneration Certification Scheme Renewable Heat Incentive metering requirements, BS ISO 13612 (BSI, 2014) and BS EN 15450 (BSI, 2007), underfloor heating: BS EN 1264 and BS EN 1264-2 (BSI, 2008).		✓	✓	✓			✓	✓
(Ground Source) Water or Brine to Water Heat Pumps		• Typical temperatures in soil at around depths of 4m is from 8-10 ˚C. If installing a closed loop system, the geological and hydrogeological conditions should be predetermined. For open-water systems, aquifers must be present to drill into. CIBSE TM51 outlines the geotechnical and hydrogeological information required to operate a closed loop array, whilst also giving insight to major aquifers [HP.16]. • Consult CIBSE Guide H for guidance on control strategy to ensure control of setpoints and avoid parallel heating and cooling of spaces with multiple indoor units. Heat pumps can be controlled centrally controlled, combining multiple units, or controlled locally with room level controllers [HP.9]. • CIBSE Guide A provides guidance on operating temperatures in respect to heat losses and set points to ensure the thermal comfort and ensure correct sizing of HVAC systems. Key Consideration: As a general rule, the closer the distribution temperature is to the ground temperature, the higher the COP. Therefore, a site survey should provide indication of whether the heat pump will perform adequately [HP.16].	• Temperatures of GSHP wet system tend to not exceed 55˚C, whereas typical gas wet systems tend to operate around 70˚C. M&E consultant to confirm optimal solution of emitter alteration or additional plant to top up temperatures. M&E consultant to assess pipework alteration requirements. • The contractor/designer shall assess the availability of the available electrical services, especially if part of a new build or retrofitting from a gas heating system. • Consult CIBSE CP1 for the design and sizing of a thermal store. This requires an operating model that predicts the heat demand profile on an hourly basis to size the store for optimal performance [HP.17]. • Part L 2022 regulations specify newly built residential wet systems must have pipework and emitters sized for a maximum flow rate of 45˚C and 55˚C for commercial new builds, to ensure the future compatibility with low-temperature systems, like heat pumps [HP.20-21] . • Open loop GSHPs can have a high pumping energy consumption, this can outweigh some of the benefit of the higher efficiencies over air source. Ensure, pumping calculations have been completed prior to assessing energy impact of GSHP system. Refurb & Listed Considerations: Heat Pump must be able to provide at least 100% of the calculated heat loss without any supplementary heating. In older building, with lesser fabric, this heat loss must be considered [HP.7]. Refer to Fabric Section for guidance on improving the thermal envelope of the building.		•	•	•	✓	✓	✓	1) CoLC Broad Street Place Mechanical Specification 2) City of London Corporation Housing Design Guide Dec 2020	1a) Section M10: Equipment containing refrigerants must be labelled in accordance with the EU F-Gas Regulations 517/2014, including any additional 2017 requirements. 2a) P60: Systems must be designed to the following standards: Microgeneration Certification Scheme Renewable Heat Incentive metering requirements, BS ISO 13612 (BSI, 2014) and BS EN 15450 (BSI, 2007), underfloor heating: BS EN 1264 and BS EN 1264-2 (BSI, 2008).		✓	✓	✓			✓	✓
Boilers																				
Condensing gas-fired boilers	Consideration should be given to: • The effect of wind conditions and the dispersal of the plume relative to adjacent wall surfaces, openable windows and neighbouring buildings might require greater separation distances to prevent nuisance and ingress. [B.1] • The positioning and termination of the condensate drain pipe, which should, ideally, run and terminate internally to a soil and vent stack or waste pipe. Alternatively, the condensate may be discharged into the rainwater system or a purpose-made soakaway. All connecting drainage should have a fall of at least 2.5° to the horizontal. If the drainage pipe has an external run the pipe should be insulated against frost. [B.1] • The choice of condensate drainage pipe, which should be run in a standard drain pipe material, e.g. PVC, PVC-U, ABS, PP or PVC-C. Any internal pipework should be of a diameter specified in the boilers manufacturer's instructions. Any external pipework should be kept to a minimum length with a minimum diameter of 22mm, which might be greater than that recommended by the manufacturer in order to minimise the effects of freezing. [B.1] • The manufacturer's instructions and associated data sheets shall be consulted on the siting of the boiler, space should be allowed and ready access provided for installing, operating, services and replacing the burner(s), controls, flue ways, waterways and any other parts that require regular attention. [B.1] • The boiler installation should not cause adjacent spaces to exceed their design temperatures during operation of the boilers. [B.1] • Boilers shall only be sited on walls or floors capable of withstanding temperatures of at least 65°C and supporting the boilers when filled with water. [B.1] Listed Consideration: Identifying spaces for the boiler, ventilation and the flue. The route of the flue needs to avoid damaging vulnerable fabric and flue terminals may need to be painted so that their appearance blends in with the external fabric. An old chimney is a often a good place to run the flue in traditional buildings, although this may require the insertion of a flue liner. [B.3]	• Condensing gas boilers can operate at the traditional 80/60 flow and return temperatures, however, a lower return temperature can lead to greater efficiencies by producing more condensate. This can be achieved by: - Low temperature systems – operating at return water temperatures as low as 30°C through the whole heating season, e.g. condensing boilers in underfloor heating systems, can achieve seasonal efficiencies over 90%. It is often possible to design in a particular low temperature circuit (e.g. underfloor heating in atria) in which to locate the secondary heat exchanger to promote condensation. Some systems are also designed with wide temperature differentials (e.g. ΔT of 20°C) to promote longer periods in the condensing mode. [B.2] - Weather compensated systems – the low return temperatures occurring in 'Standard' 82°C flow temperature weather compensated systems can be used to force condensing boilers into the condensing mode during milder weather. As external temperature rises, flow temperature is decreased, saving energy. Locating the secondary heat exchanger in the variable part of a three-port valve, weather compensated circuit is the most common method. The simplest approach is to directly compensate the boilers. [B.2] - Broadening temperature differentials - operating at 80/50 flow and return temperatures. Condensing boilers can be more expensive than on-condensing boilers, other than low temperature systems, combinations of condensing and non-condensing boilers are normally more cost effective than all condensing boilers. Commonly, 50-75% condensing provides the most economic approach. The most efficient plant should take the base load. [B.2] Key Consideration: The new requirements of Part L state that where a wet system is newly installed, or fully replaced in an existing building, all parts of the system including pipework and emitters should be sized to allow the space heating system to operate effectively and in a manner that meets the heating needs of the dwelling, at a maximum flow temperature of 55°C, preferably lower.	• Requires a minimum controls package: Boilers with an output >100kW should have both of the following: a. Optimum start/stop control with either night setback and/or fresh protection outside occupied periods. b. Either two-stage high/low firing facility in boiler or multiple boilers with sequence control to provide efficient part-load performance. Boilers with an output of more than 500kW should have fully modulating burner controls [B.4] • Compatible with all building types. • 'Hydrogen blend ready' gas condensing boilers are available which are able to accept a 20:80 hydrogen to gas mix. Buildings with these boilers will be able to make use of the existing plant if hydrogen is added to the fuel mix.	• Combustion of fossil fuels leading to climate change. New gas boilers will not be permitted in new buildings from 2025 and should be avoided for other projects where possible • Gas combustion releases Carbon Dioxide emissions as well as other air pollutants, such as Nitrous Dioxide. • Condensate is slightly acidic but is counteracted by general effluent, which is often alkaline – a simple plastic drain can be used. [B.2] • U-traps in the drain are essential to avoid combustion gases escaping into the plant room. [B.2]	✓	✓	•	✓	✓	✓	1) CoLC Air Quality Strategy 2019-2024	1a) P48 All gas boilers will be required to have a NOx rating of <40mgNOx/kWh at 0% O2 as a minimum. Options for tightening these limits by 2020 will be kept under review.		✓	✓	✓			✓	✓
Electric	• No flue required as no combustion of fossil fuels. • Electric boilers have greater freedoms of installation locations than fossil fuel fired boilers.	• Electric boilers can reach the same flow temperatures as fossil fuel fired boilers, and therefore can be used with existing emitters and heat distribution systems. • Electric boilers are silent and require minimal servicing. Residential Consideration: The new requirements of Part L1 state that where a wet system is newly installed, or fully replaced in an existing building, all parts of the system including pipework and emitters should be sized to allow the space heating system to operate effectively and in a manner that meets the heating needs of the dwelling, at a maximum flow temperature of 55°C. Key Consideration: The new requirements of Part L state that where a wet system is newly installed, or fully replaced in an existing building, all parts of the system including pipework and emitters should be sized to allow the space heating system to operate effectively and in a manner that meets the heating needs of the dwelling, at a maximum flow temperature of 55°C, preferably lower.	• Electric boiler systems should comply with all of the following: a. Systems should both: i. have flow temperature control ii. be capable of modulating the power input to the primary water depending on space heating conditions b. Timing and temperature demand controls should be provided. c. If the building has a floor area greater than 150m2, heating should be split into different heating zones and each zone should have separate controls for timing and temperature demand.[B.4] •Electric boilers are an expensive way to heat a space in comparison to an air source heat pump, which may be more than 3x more efficient, and to gas boilers which have a cheaper unit rate (for example 10p/kWh for gas and 35p/kWh for electricity). Key Retrofit consideration: Existing electricity supply infrastructure may not be sufficient for your new requirements if switching from fossil fuel fired heating, and upgrades may be necessary.	• Electric boilers can produce less impact on the environment than other heating systems. • No direct emission of greenhouse gases or air pollutants, however, still consumes electricity from the national grid.	✓	✓	•	✓	✓	✓	1) City of London Planning Advice Note - Whole Lifecycle Carbon Optioneering (March 2022)	1) UK Government is proposing to introduce a new obligatory energy rating disclosure, that aligns with NABERS UK, starting with all offices greater than 1,000m2, from 2022/23. Substituting gas fired heating systems with energy efficient electric alternatives is a very effective way of reducing operational carbon emissions.		✓	✓	✓			✓	✓

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Requirements	Technical standards - For references, please refer to the 'Appendix' tab				New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)	City of London Documents and Guidance	Location and Description	Project Management	Mechanical Engineer	Electrical Engineer	Architect	Public Health Engineer	Fire Engineer	Contractor	Building FM / End User
					Asset Type			Building Type			City of London Document Interlinks (TBC)		Key Stakeholders							
Category / Sub-category	Further guidance on design considerations and how the technology category or sub-category should be installed to deliver the performance standard targets										Task Bar	PPG Activities								
Hybrid Systems	Please refer to the plant requirements for heat pumps and boilers. CIBSE AM17 [HY.3] can be used as guidance to the hourly load model can help in understanding the impact of different secondary heat source sizes when considering factors such as: • Capacity/cost/availability constraints • Whole-life carbon considerations • A heat pump that is sized for a load that is only likely to be exceeded for a certain proportion of hours or when the ambient temperature exceeds or falls below a certain temperature • The level of uncertainty in loads since an undersized heat pump will lead to over-reliance on secondary systems.	• Decisions must be made on whether the heat pump will controlled in Concurrent or Sequential Operation. 1. Concurrent Operation (also known as co-valent or parallel): The heat pump cannot meet 100% of the system load and so is supported by additional heat sources. The return temperature of the heat pump must be within the operational limits of the device and to the desired temperature as combustion systems tend to have a higher flow temperature and therefore a higher return temperature, which may not suit a heat pump. [HY.2] Concurrent Operation can be met by: A.Load Assist: The heat pump runs lead in a baseload configuration, with fossil fuel/electric boilers to assist as the heat demands increase. Consideration must be taken into the primary flow temperature and temperature differentials. A 10K ΔT would not be problematic for most pre-mix condensing boilers, but it can reduce the performance of the heat pump (for example, ASHPs may optimise at 5-7K ΔT). To maximise the boiler efficiency, the return temperature must be kept below 54°C to promote condensing. To control this system, the ASHP charges the thermal store, which then discharges, acting as lead boiler. [HY.1] B.High Delta T Load Assist: The heat pump and boiler operate together in a system in which the temperature differential or set point is above that which the heat pump can provide. This can be achieved via the thermal store method or the injection approach: i.Thermal Store Method: The boiler and heat pump feed into the same thermal store, the heat pump maintains a stratified warm layer at the bottom of the tank to heat the cold return, the boiler's hot layer gives the final lift to reach the target flow temperature. Care should be taken to avoid the boiler being required to top up the tank by less than 10K to avoid a temperature overshoot. The controls should ensure that the boiler is held back until absolutely required.[HY.1] ii.Injection Method: The gas boiler boosts the flow temperature to set points at times when the heat pump is unable to satisfy the demand differential. This may be achieved by the thermal store discharge pump controlling the charge and discharge of the thermal store. Under low load, the store may be charged to system temperatures to give usable heat without the requirement of the boilers. During periods of high demand, the thermal store injection will pre-heat the return for top up by the boilers. Ensuring proper charge/discharge cycling of the store is critical to the performance of this method.[HY.1] 2. Sequential Operation (also known as alternative or bivalent): One heat source is disabled and the other enabled to take 100% of the load. Factors that may trigger a change from one heat source to another in sequential operation include Fuel tariff, External temperature (i.e. predicted load), Instantaneous carbon content of the grid, or a combination of predicted efficiency based on the external ambient temperature and either the fuel cost or carbon content. [HY.2]	• Can incur twice the service and maintenance costs as will be required to maintain two different pieces of equipment. • Can be more expensive to run than fossil fuel boilers alone. • Future-proofed situation to reduce carbon emissions, until technical solution for building is available for building to enable low carbon heating solution without gas or electric secondary system Key Refurb/Listed Consideration: Can work with existing emitters as boilers can be used to top-up flow temperatures.	• Hybrid systems offer the opportunity for important efficiency gains and emission reduction from heating in existing and new commercial premises, however, it is not a long term solution for decarbonisation if the other heat source is a fossil fuelled boiler. • If the UK has contributions from Hydrogen then, Hybrid heating could have long term potential.	✓	✓	•	✓	✓	✓	1) City of London Planning Advice Note - Whole Lifecycle Carbon Optioneering (March 2022)	1) UK Government is proposing to introduce a new obligatory energy rating disclosure, that aligns with NABERS UK, starting with all offices greater than 1,000m2, from 2022/23. Substituting gas fired heating systems with energy efficient electric alternatives is a very effective way of reducing operational carbon emissions.		✓	✓	✓	✓		✓	✓
Electric Convectors																				
Electric Convectors	This system does not require a central plant. Due to this, the system may be suitable for designs with limited plant space. The equipment itself must comply with EcoDesign, Lot 20 legislation, which requires electric heaters to have electronic thermostats with a 24-hour, 7 day timer with either adaptive start or an open window sensor.	• The system design should incorporate heat loss into design calculations. Heat loss calculations for the building based on BS EN 12831-1 [EC.1] and CIBSE's Guide B1 [EC.2] • It should ensure that the room in which it will be in is heated to the design set-point. Varied heating and output rates can occur dependent on design and manufacturer. This can also be controlled with a timer or thermostat. • If installing as a replacement of a non-electronically fuelled heating system, consult with local utility provider to determine if sufficient capacity is electricity is available. Residential consideration: Equipment should comply to BS EN 60335-2-30 which refers to general safety requirements of household electrical appliances, focusing on requirements for room heaters. [EC.3]	• The system can be installed alongside other HVAC systems, ensuring that there is enough space and electrical capacity prior to design and installation. • It does not have a cooling operation, so a colling system is required. • System is suitable for noise sensitive locations due to convectors have no moving parts and use natural air flow rather than forced. • Produces localised heat, although even temperatures throughout the room are difficult to achieve, so cold spots may be present. • Efficiency of the system does not exceed 100%, so user should expect higher heating costs. More efficient systems could be considered if feasible and fits with building function and design. • Electric panel or skirting heaters should have controls for timing and temperature demand. [EC.4]	• Electric convection heaters can produce less impact on the environment than other heating systems. • No direct emission of greenhouse gases or air pollutants, however, still consumes electricity from the national grid.	✓	✓	•	✓	✓	✓	1) City of London Planning Advice Note - Whole Lifecycle Carbon Optioneering (March 2022)	1) UK Government is proposing to introduce a new obligatory energy rating disclosure, that aligns with NABERS UK, starting with all offices greater than 1,000m2, from 2022/23. Substituting gas fired heating systems with energy efficient electric alternatives is a very effective way of reducing operational carbon emissions.		✓	✓	✓			✓	✓
Radiant heating																				
High Temperature Radiant Heaters	•No central plant required for high temperature radiant heaters. However, there are mounting requirements: oRadiant Tube heaters may be mounted at heights between 3.5 and 20m and are mostly used for general area heating, rather than local spot heating. Low-level mounting of these units is avoided to ensure even distribution of heat. [RH.2] oRadiant Plaque heaters must be located where ventilation rates are high to avoid condensation and to dilute flue gases. A cone configuration is available to provide 360° coverage of a particular location. [RH.2] oElectric Quartz heaters are mostly used for local spot heating, mounted at levels between 2 and 4m. [RH.2]	•Surface temperatures for direct gas fired tubular heaters are around 500°C, temperatures for direct gas-fired radiant plaque heaters around 800°C, and the filament in electric quartz heaters operates at temperatures exceeding 2500°C. •If installing electric quartz heaters as a replacement of a fossil fuelled heating system, consult with local utility provider to determine if sufficient electrical capacity is available. Building Type Consideration: This system is most suited to logistics and industrial applications.	• Little maintenance due to no moving parts. • It is good practise to inspect the heater at the beginning of each heating season. • Temperature control is required for each heater, or group of heaters, and time control for the overall system. • Black-bulb radiant heat sensors should be used to achieve good temperature control of the system and should be positioned representatively of the radiant effect of the panels. See the AD L2 for the minimum controls package.	•High-temperature heaters must not be placed where they could ignite flammable dust or vapours or decompose vapours into toxic gases. •Fixtures must be located with recommended clearances to ensure proper heat distribution. Stored materials must be kept far enough to avoid hot spots. Follow manufacturer's recommendations. •Unvented gas heaters inside tight, poorly insulated buildings may cause excessive humidity with condensation on cold surfaces. Proper insulation, vapour barriers, and ventilation prevent these problems. •Combustion heaters in tight buildings may require makeup air to ensure proper venting of combustion gases. •Radiant spot heating and zoning in large undivided areas with variable occupancy patterns provides localized heating just where and when people are working, which reduces the heating cost.	✓	✓			✓					✓	✓	✓			✓	✓
Low Temperature Radiant Panels	•Low temperature hot water radiant panels require a central plant to provide hot water to the panel, typically between 30 and 70°C, this may be supplied by gas or electric boilers, or heat pumps. •These panels can be surface mounted, freely suspended or integrated within a suspended ceiling, and can be linked to each other with pipework joined by push-fit flexible hoses. •These panels are available in a variety of shapes and sizes, typically ranging from widths of 300mm to lengths of 9,000mm, weighing approximately 15kg per sq. m. [RH.3] •Manufacturer's data will quote a average water temperature and a 'room temperature' to enable their equipment to be sized. [RH.3] •Electric infrared radiant panels do not require any central plant.	•Low temperature hot water radiant panels operate with a surface temperature between 30 and 70°C. Infra-red panels tend to operate with surface temperatures around 90°C. •A greater contribution from radiant heat to an occupied space means that a lower air temperature if acceptable, while providing the same comfort levels. If properly controlled, this can result in energy and cost savings. •For operational control, it is important that the room sensors are able to take account of both radiant and air temperatures, and that they are positioned appropriately. •Care needs to be taken to ensure that the asymmetric radiant temperature at head height does not exceed that required for thermal comfort (see CIBSE Guide A). Listed Considerations: The air temperature is eventually heated by convection of the air coming into contact with the warmer surfaces, this results in less temperature fluctuation which is beneficial to historic buildings. Electric infra-red radiant panels usually have a flat metal surface, making them discrete for use within historic buildings.	• For Low temperature hot water radiant panels, water flow control valves require periodic verification that they are operating correctly. • Temperature control is required for each heater, or group of heaters, and time control for the overall system. • Black-bulb radiant heat sensors should be used to achieve good temperature control of the system and should be positioned representatively of the radiant effect of the panels.[RH.3] • Electric radiant panels generally do not require any ongoing maintenance or servicing. • Electric radiant heaters should have automatic zone or occupancy control through presence detection. [RH.4]	•Radiant spot heating and zoning in large undivided areas with variable occupancy patterns provides localized heating just where and when people are working, which reduces the heating cost.	✓	✓	✓	✓	✓	✓				✓	✓	✓			✓	✓
District Heating																				
District Heating	• The Heat Networks Code of practice (CP1 2020) [DH.2] contains guidance and an exhaustive list of all the technical standards and requirements for the design, delivery and operation of a district heating network, including all plant and equipment in the centralised heat energy centre, the piping network itself, the network/building interface connection points (substations) and in-building heat emitter technologies. CP1 2020 should be referred to as the central source for all technical standards for a district heating network, and connection to it. Further guidance for London can be found in the London Heat Network Manual [DH.3] • When considering the connection of a building to a district heat network, dependant on building type, an appropriate thermal exchange mechanism (primary/secondary interface) should be specified and installed. Equally, the in-building thermal distribution (tertiary) system and heat emitters should be designed and selected with respect to the operating conditions (namely flow/return temperature and pressure) of the district heating network. If possible, facilitating the ability of a building to connect to a heat network in future (via installation of appropriate tertiary systems and thermal interface mechanisms) should be ensured •For single dwellings or small individual properties connected to a heat network, and where direct connection (without hydraulic interface) is possible and preferred, an appropriate heat interface unit (thermal exchange mechanism) should be selected and installed •For collections of dwellings (served by a communal heating system) or large properties (i.e. non-residential spaces) connected to a heat network, a thermal substation (incorporating plate heat exchangers and secondary distribution & water treatment plant and equipment) should be installed or allowed for.	• CP1 2020 [DH.2] provides specific guidance for the specification, design, installation and commissioning of the district heating systems. New district heat networks or community heating systems should meet both of the following: a. The design temperature difference for the community heating primary circuit should be a minimum of 20°C. Heat pump-led community heating systems may, however, need to run at a lower temperature difference. b. Variable volume control systems should be used to reduce the volume of water and the pressure difference required from the pumps under part load. • For wet heating systems, the maximum design flow rate into the dwelling's heating system should be limited by suitable control and balancing valves to maintain the overall balance in the network and to avoid excessive pumping energy. • For new district heat networks or community heating systems, the domestic hot water system should have variable volume controls to maintain low return temperatures in the primary community heating circuit. • District heat networks and community heating systems should be designed to accommodate heat meter(s) for each dwelling • If the building is heated through a district heat network or community heating system, the effective rated output should be based on the capacity of the equipment installed in the building, making reasonable assumptions for the operation of the district heat network or community heating system, including flow temperatures.	• An assessment for the connection to Citigen heating and cooling network should be undertaken as part of the optioneering assessment for a new build or refurbishment project where relevant.	Environmental considerations for the heat network will be the responsibility of the heat network provider. However the current and future carbon intensity of the heat network (kgCO2/kWh) is an important comparable metric to ensure the building project will be on course to achieve net zero targets.	✓	✓	✓	✓	✓	✓				✓	✓	✓			✓	✓

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Requirements	Technical standards - For references, please refer to the 'Appendix' tab			
Category / Sub-category	Further guidance on design considerations and how the technology category or sub-category should be installed to deliver the performance standard targets			
Future Heating	**Key Design and Operation Considerations**		**Compatibility / Future proofing**	**Environmental Impact**
Hydrogen				
Hydrogen	Storage: • For outdoor installations weather protection may be required. Hydrogen storage cylinders and vessels located outdoors need to be protected from extreme temperatures (below 20°C and above 50°C). Permanently installed hydrogen vessels must be provided with substantial supports, constructed of non-combustible material securely anchored to firm foundations of combustible material and protected from accidental impact, e.g. from a vehicle. [FH7] When high pressure storage is used, it should be designed and built to an appropriate design code or standard and located in a secure openair compound • Where necessary, adequate allowance or protection against corrosion or other chemical attack must be provided, taking due account of the intended and reasonably foresee enable use. Hydrogen must be stored or handled under pressure compatible materials, e.g. special alloy steels, are used for pipe work, vessels, etc • In electrolyser fed systems, venting facilities for hydrogen and oxygen should be separate and isolated from each other. • Hydrogen cannot be detected by human senses, therefore, leak detection must be properly installed. When using hydrogen in confined spaces, the employment of a hydrogen detection system for early detection of leaks is essential to facilitate the activation of alarms, safety operations and where necessary, the safe evacuation of people. • Storage of Hydrogen is regulated by The Planning (Hazardous Substances) Regulations 2015 and/or the Control of Major Accident Hazards Regulations 2015 ("COMAH"), depending on the quantities involved. The operator must have in place various strategies, including safety plans, emergency plans and a Major Accident Prevention Policy Distribution: • Pipe routing should reflect consideration of factors such as risk from impact damage, formation of flammable mixtures in poorly ventilated areas, heat sources etc. Consequently, where pipe work passes through enclosed ducts, cavity walls etc, there should be no mechanical joints. Piping should preferably be routed above ground; if underground pipe work is unavoidable, it should be adequately protected against corrosion. [FH7]	Hydrogen Generation- Electrolysis: • The manufacturer shall specify the physical environment conditions for which the hydrogen generator is designed. These shall include indoor or outdoor operation, the ambient temperature range, and the barometric and humidity specifications. [FH10] • The manufacturer shall specify, as outlined in IEC 60204-1, the electrical input rating for the hydrogen generator in volt-amperes (VA) or watts (W) and hertz. [FH10]	• Hydrogen is an emerging technology and as such, design standards and codes are changing. Particular attention should be paid to ensure compliance with the latest standards. As Hydrogen is still in it infancy for wider usage, compatibility with existing, more established technologies will become more mature.	The hydrogen generator shall be suitable for the intended installation environment as classified in IEC 60529. Where a hazard from ingress of solid foreign objects and/or ingress of water exists, as a minimum the hydrogen generator shall: a) meet the IP22 rating as defined in IEC 60529 for indoor, industrial use b) meet the IP34 rating as defined in IEC 60529 for indoor, residential use c) meet the IP44 rating as defined in IEC 60529 for outdoor use Where a hazard from ingress of solid foreign objects and/or ingress of water exists at hydrogen and oxygen vents, these shall meet the IP22 rating as defined in IEC 60529 [FH10]
Blended natural gas	• CIBSE guide A gives guidance on boiler plant sizing, this is largely dependent on building characteristics and heat load for such building. The rate of heat loss is required to be calculated along with other factors to correctly determine the size of the boiler plant. [FH2] • Reference Standard for low pressure hydrogen utilisation - IGEM/H/1 with amendments June 2022 acts as a reference document in understanding hydrogen application in domestic buildings and smaller nondomestic buildings. it discusses safety, material selection and comparisons between natural gas and hydrogen. This should be referred to assist with plant design. [FH3]	• Please refer to Gas fired Boiler standards	• Compatible with all building types - hydrogen ready boilers should be preferred when new installation is undertaken - ensuring compliance with Part L building regulations	
Low Carbon CHP	Air Supply: • Air is required in the engine for combustion, general cooling and ventilation. The supply of cooling and combustion air may be satisfied using either common or separate systems. • The plant room must have sufficient natural ventilation. In the case of larger engines, separate fresh air supply ducting may be required in order to obtain sufficiently cool combustion air. Engine power output falls as charge air temperature increases. Care must, therefore, be taken with the location of combustion air intakes. [FH4] Electrical Connection: • The CHP unit's generator (at 415 volts or 11 kilovolts, 50 Hz and three phase) must be connected to the site's electrical distribution system at an appropriate location. This may be via a spare breaker cubicle on an existing bus-bar or a new bus-section • There are requirements to be met when connecting a generator to any part of the public electricity supply are contained in Electricity Association publication. When connecting a generator to any part of the public electricity supply certain requirements needs to be met which are available in Electricity Association publications[FH4] • In order to connect the CHP plant to one of the UK's electricity distribution networks, you must apply to the local Distribution Network Operator (DNO) by following the G59 connection procedure. [FH14] Exhaust System: • As engines are often located in basements, and exhaust outlets are typically at roof level, careful consideration must be given to exhaust duct routing and insulation to contain heat, vibration and noise. Care must be taken to ensure that exhaust gases are not recirculated into the building or engine intake systems. Guidance on the avoidance of recirculation may be found in the CIBSE Technical Memorandum on Minimising Pollution at Air Intakes. • Ventilation air from the engine enclosure must be exhausted. Whether existing plant room systems are used or an independent system is installed will depend on the volume flow rate required for engine ventilation and on permitted temperatures in surrounding areas. [FH4] General Requirements: • The plant must be sited where it can remain for a long period of time without disrupting or obstructing normal site use, either initially or in the future. There must be sufficient space to allow access for maintenance purposes and also to house any auxiliary equipment. • The CHP plant may require the installation of a new chimney, and this should be taken into account when choosing the plant location [FH4].	• The exact operating parameters will depend on the configuration of the CHP system and what fuel is used etc. However, the utilisation of the liberated heat from a CHP unit will consist, in the first instance of: - Hot exhaust gases - Hot water from the CHP cooling system. • This heat can be recovered through appropriate heat exchangers as: - Low temperature hot water (LTHW) at <100ºC. - High temperature hot water (HTHW) at 150-200ºC (from exhaust heat only in the case of an engine). Steam (from exhaust heat only in the case of an engine). - Warm air. • The precise configuration will be determined by the end application. For certain processes, direct use of hot exhaust gas is appropriate. • CHP plant should have a control system that, as a minimum, ensures that the CHP unit operates as the lead heat generator. Metering should be provided that measures all of the following. a)Hours run. b)Electricity generated. c)Fuel supplied to the CHP unit. • The electricity generated by any combined heat and power (CHP) or trigeneration scheme should always be credited using the appropriate CO2 emission and primary energy 'heat network' specific factors from Table 32 in the Building Regulations National Calculation Methodology Modelling Guide [FH 13]	• Low Carbon CHP can be future proofed by implementing carbon neutral renewable fuel sources, these fuel sources should consist of solid biomass, liquified biofuel and gaseous biofuel [FH4], these fuels still have associated carbon emissions but result in a net zero output through carbon absorption during the growing phase. • Existing Gas engine CHP systems can be converted with minimum impact, to run on renewable gaseous fuel as aforementioned, but also utilise hydrogen as and when this becomes readily available into the market. • CHP can work alongside other renewable technologies and energy storage as part of a hybrid energy solution. Gas engines can be adapted to run on renewable fuels such as hydrogen as they become more viable, meaning investments can be made safely for new or existing facilities • CHP systems require larger plant space and hence are better suited for large commercial , office buildings and light industrial applications • Micro CHP systems incorporating smaller engines and Fuel cells are suitable for smaller buildings i.e. residential • Guidance in BG02/ 2007 should be followed when installing CHP systems into existing buildings [FH11]	• NOx emissions should be in line with BREEAM Pol 2 requirements [FH5] • Reciprocating engines and their auxiliaries will generate noise that must be attenuated to acceptable levels. The degree of attenuation will depend on the target limits of noise to be achieved: -in plant room -in adjacent areas -at air inlets and exhaust outlets -at nearby buildings. • CHP suppliers should be able to provide noise data for the units which are external to the acoustic enclosure and the exhaust air terminations. Most small-scale CHP units will be supplied within acoustic enclosures, which in many cases will be adequate to achieve all required noise targets [FH6]

	Asset Type			Building Type			City of London Document Interlinks (TBC)		Key Stakeholders							
	New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)	City of London Documents and Guidance	Location and Description	Project Management	Mechanical Engineer	Electrical Engineer	Architect	Public Health Engineer	Fire Engineer	Contractor	Building FM / End User
							Task Bar	PPG Activities								
Hydrogen	•	•	•	•	•	•				✓	✓	✓	✓	✓	✓	✓
Blended natural gas	✓	✓	✓	✓	✓	✓				✓		✓		✓	✓	✓
Low Carbon CHP	✓	✓		✓	✓	✓	1) CoLC Air Quality Strategy 2019-2024	1a) P.49 Where non-combustion technologies are not feasible and combustion plant is installed the NOx emissions from Combined Heat and Power (CHP) plant will be required to meet the following emission limits: 50mg/Nm3 (and 25mg/Nm3 for turbocharged CHP) at reference O2.		✓	✓	✓			✓	✓

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Requirements	Technical standards - For references, please refer to the 'Appendix' tab			
Category / Sub-category	Further guidance on design considerations and how the technology category or sub-category should be installed to deliver the performance standard targets			
Domestic Hot Water	Key Design and Operation Considerations		Compatibility / Future proofing	Environmental Impact
Centralised Systems	• Hot water storage systems should be designed and installed in accordance with BS 6700:2006 /2009 [CHW.3-4] • Systems over 500 litres capacity will generally be bespoke designs for specific projects and as such are inappropriate for approval by a third party accredited product conformity certification scheme [CHW.3]. • Domestic hot water systems should be sized for the anticipated domestic hot water demand of the building, based on BS EN 12831-3. Systems should not be significantly oversized [CHW.6]. New Build Consideration: Where in-use data is not available, DHW design should be based on an accurate assessment of the number and types of points of use and anticipated consumption within the property. Existing Consideration: Peak demands should be assessed by the customer from a combination of data on fuel use, boiler use and building simulation modelling [CHW.2].	• CIBSE TM13 indicates that hot water should be stored above 60 ˚C with a distribution temperature between 55-60˚C [CHW.1]. • For combustion-heated DHW systems, the system shall be equipped with time controls which are independent of space heating circuits and electronic temperature controls. • Electrically heated DHW systems should be equipped with thermostatic control to interrupt the electrical supply when either the setpoint storage is reached or the system temperature gets too high [CHW.6]. • Centralised electrically fuelled centralised systems should be equipped with seven-day time control and the facility to boost the temperature by using an immersion heater in the storage cylinder [CHW.6]. Residential Consideration: Approved Document L1 able 4.5 provides maximum daily heat loss for a hot water cylinder [CHW.5]. Commercial + Public Consideration: Approved Document L2 able 4.7 provides maximum daily heat loss for a hot water cylinder [CHW.6]	• The contractor/designer shall assess the available capacity of electrical services, especially if part of a new build or retrofitting from a gas heating system. • Consult CIBSE CP1 for the design and sizing of a thermal store. This requires an operating model that predicts the heat demand profile on an hourly basis to size the store for optimal performance [CHW.2]. • Centralised systems can be used in conjunction with other decentralised technologies, such as POU heaters and instantaneous water heaters (see Point of Use Heaters Section for more information). Consideration: Centralised heat pump systems may require supplementary reheat or have the heat pump designed with an expansion kit to increase the temperatures.	• BREEAM credits are awarded where the following criteria is met: a. all water systems in the building are designed in accordance with measures outlined in Health and Safety Executive publication, Health and Safety: Legal Series: Legionnaires' disease. The control of Legionella bacteria in water systems. Approved Code of Practice and guidance on regulations [CHW.7]. b. No humidification is specified or only steam humidification is specified. • Designers should consult CIBSE TM13 to demonstrate that the design of a centralised heating system meets the requirement of the Health & Safety document. This evidence must be provided by the designer prior to detailed design stage in order to achieve the BREEAM credits [CHW.1]. • Key control mechanisms for controlling the growth of legionella, as outlined in L8 - Control of Legionnaires include [CHW.7]: - Maintaining a safe water temperature of below 20°C or above 45°C so Legionella bacteria can't grow - Avoiding water stagnation, which may also encourage the growth of bacteria - Using water treatment techniques such as chlorination or UV disinfection
Point of Use Heaters	• Point of Use (POU) hot water generation systems are fed with a direct cold-water supply and are able to continuously supply DHW at anything from 0.2 l/min for a 3kW handwash unit to 'multi-point' heater serving several outlets at 50-60 degrees [POU.1] • An adequate water and electrical supply should be available prior to the installation of a POU heater. • The water heater should be situated close to the draw-off points and should have a storage capacity no greater than 100 litres [POU.2] • DHW should be sized based on the calculated anticipated demand. This should be based on BS EN 12831-3 or the Chartered Institute of Plumbing and Heating Engineering's Plumbing Engineering Services Design Guide. Systems should not be significantly oversized [POU.3].	• Several BREEAM models typically require showers to have a measured flow rate not exceeding 9 L/ minute for a water pressure of 0.3 MPa (3 bar equivalent), assuming a delivered water temperature of 37°C. • Maximum heat loss for hot water cylinders are given in Part L as [POU.3]: i.50 litres = 1.03 kWh/day ii.100 litres = 1.49 kWh/day • Key standards such as HSE ACoP L8 Legionnaires' Disease: The control of legionella bacteria in water systems, require DHW to be supplied to at least 50˚C. i.However, for certain applications, BRE IP 14/03 [POU.4] states temperatures should not exceed 46˚C. Or bath taps, where the Building Regulations Approved Document G states that temperature should not exceed 48 ˚C [POU.5].	• POU heaters can be used in conjunction with centralised water heating systems. The following situations are some examples of where a POU system is more suitable than a centralised system: i.Where fixtures are distant from other fixtures ii.Low daily hot water usage iii.Remote bathrooms • POU heaters are not suitable back-ups for solar water heaters or geothermal heat pumps, as they will not be able to support the full hot water demand of a household when the solar or geothermal units are not operating.	• Several BREEAM models award credits where low water use fittings, aimed at minimizing the consumption of potable water in sanitary applications, are used. Compliance requirements vary between models. The types of fittings to consider include showers. Refer to the particular BREEAM Technical Standard, dependent upon the project type, for further details. • Consult Approved Document G for guidance on temperature limits to control legionella bacteria in domestic hot water systems [POU.1]. • Electric instantaneous water heaters should comply with the provisions of BS EN 60335-2-35:2002 Specification for safety of household and similar electrical appliances [POU.6].
Solar Hot Water	• Part L1 provides guidance for solar water heating system smaller than 20m ^{2} with a storage volume less than 440l [SHW.1]. i. Electrical input power of the primary pump should be less than the higher of the following: 50W or 2% of the peak thermal power of the collector. ii. The dedicated storage volume should be either of the following: 25 litres for every 1m ^{2} of the net absorber area of the solar collector or a volume equivalent to at least 80% of the daily DHW demand (defined by SAP). • A glycol solution may be required to prevent freezing in the winter. The percentage of glycol in the mixture used in an indirect system to be calculated based on the worst case winter temperature. Residential Consideration: The intended occupancy and their DHW use can be derived from discussion with clients and use of standard references. Where unknown, DHW use at 50ºC per day can be assumed as (38 + 25N) litres per day where N is the number of occupants [SHW.2]	• Where shading is unavoidable, a shadow greater than 10% of the collector area passing across the collector in less than an hour between May and October can be considered acceptable [SHW.2]. New Build Consideration: modelling software packages allow assessing of shading and design should minimise potential shading Existing Consideration: a site visit is prerequisite for assessing shading • The collector fixing surface can be a pitched roof, flat roof, vertical wall, balustrade or ground mount [SHW.2]. New Build Consideration: assess locations for collectors based on as-built drawings Existing Consideration: conduct a site visit to assess location optimisation. • In above-roof installations, the combined structural loadings of wind and snow can create component loading varying from +2kN through to suction lift of -1kN [SHW.2] New Build Consideration: Ideally the location for a solar collecting surface will have a easily removable covering for pipe/cable & support access. A clearance gap above 2 metres must be maintained for installation and maintenance. Existing Consideration: A site visit to survey the roof condition should be conducted prior to retrofitting solar collector panels.	• If used in conjunction with a heat pump, refer to the relevant heat pump section for relevant technical standards. • As solar energy is not a continuous form of energy, this system must be used in conjunction with other heating technologies. This includes, but is not limited to, gas boilers, heat pumps and immersion heaters. • Solar Assisted Heat Pumps (SAHP) combines an air-to-water heat pump with a solar collector panel. Usually, the solar collector and heat pump are linked directly, sharing the same refrigeration circuit. • Non-domestic properties commonly use an additional storage vessel that acts as a preheated feed to traditional hot water systems. • To be eligible for the Enhanced Capital Allowance Scheme [SHW.5], products must either: i. Use collectors that comply with the requirements of BS EN 12975:2022 [SHW.6]; or ii. Be sold as a complete, ready to install, fixed configuration, solar thermal system that complies with the requirements of BS EN 12976-1:2021 [SWH.7]. Retrofitting Consideration: Flats are logistically harder to retrofit than a single dwelling and often require agreement from tenants, leaseholders and freeholders [SHW.4].	• If the property is not in a Conservation Area or a listed building, there is no requirements for Planning Permission for the installation of the solar thermal system as long as it adheres to the following [SHW.3]: i.The system must not protrude more than 200mm from the surface of the roof ii.Collectors should not be installed above the highest part of the roof iii.If installed on a flat roof, the collectors must be situated at least 1m from the edge of the roof and protrude not more than 1m from the surface. iv.If located in a Conservation Area and/ or a Listed Building, Listed Building consent will be required. Arrays will not be permitted on the face of the building visible from a public road

Requirements	Asset Type: New build	Asset Type: Refurb	Asset Type: Listed	Building Type: Residential	Building Type: Commercial	Building Type: Public (e.g. Schools)	City of London Document Interlinks (TBC): City of London Documents and Guidance (Task Bar)	City of London Document Interlinks (TBC): Location and Description (PPG Activities)	Key Stakeholders: Project Management	Mechanical Engineer	Electrical Engineer	Architect	Public Health Engineer	Fire Engineer	Contractor	Building FM / End User
Centralised Systems	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓		✓	✓
Point of Use Heaters	✓	✓	✓	✓	✓	✓	1) City of London Corporation Housing Design Guide Dec 2020	1a) P.66: •Instantaneous generated Domestic Hot Water (DHW) systems (combi-boilers or Hydraulic Interface Units (HIU's)) are preferred to indirect systems with storage. •The minimum DHW generation temperature shall be 50°C, the designer is required to document the approach taken to mitigating the risks of legionella. • DHW storage must be >60°C. DHW distribution pipework shall be kept as short as possible to prompt delivery of hot water, (<30s). • Thermostatic mixers are required on all showers and baths.		✓	✓	✓	✓		✓	✓
Solar Hot Water	•	•	•	•	•	•				✓	✓	✓	✓		✓	✓

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COOLING

Overview

Cooling is a process of removing heat from internal spaces and rejecting heat to external ambient air or rejecting to local waste heat reuse systems. The systems shall be sized to ensure suitable internal temperature and humidity are maintained, and minimise the energy required to cool the spaces. There are different types of cooling equipment available on the market using different heat transfer mediums to transfer heat from internal to external. Some systems allow designers to adopt combinations of different indoor cooling unit types, whereas others are restricted by the choice of the external units.

Large full building cooling systems generally warrant the use of a central cooling plant and circulate water (which is cost effective and flexile for easy future adaptation) requiring large central plant areas and regular maintenance. These systems (Air Cooled Chillers, Water Cooled Chillers and Cooling Towers) should be considered if there is space available to house roof top equipment (Air Cooled Chillers and Cooling Towers) and internal central plumbing plant and riser pipework to distribute water to areas requiring cooling. Water Cooled Chillers can be housed in internal plant rooms and used with Cooling Towers or alternative waste heat systems to reject heat into.

Smaller refrigerant systems such as DX (Direct Expansion, single split), VRF and Hybrid VRF Systems which are generally smaller but easily scalable should be considered for areas where refurbishment works are confined to specific areas, the building is to be phased or house multiple tenants where sharing cooling systems are not acceptable. These units have restricted choice of internal in-room cooling equipment options and shorter operating life, however, are cheaper, lower maintenance and easy to install and replace. Only VRF and HVRF systems allow for concurrent heating and cooling in the areas served between each individual unit, and HVRF systems allow for a mixture of water to permit greater choice in indoor units to be selected and minimises the amount of refrigerant used.

Interdependencies

There are several interdependencies between cooling requirements and other building services and fabric. These interdependencies are that cooling needs to link with building controls for efficient operation and prevent simultaneous heating and cooling; where feasible the consideration of re-use of waste heat from cooling plant; cooling flow and return temperatures will impact on the design of cooling distribution systems and where ventilation systems; improvements in lighting will reduce cooling loads in a building and improvements to building fabric or solar shading will reduce cooling requirement.

Further calculations shall be undertaken to avoid oversizing equipment with respect to the other building services and fabric.

Water-cooled Chillers

Water cooled chiller is a type of refrigeration system which uses water as a secondary refrigerant. Heat is transferred from one closed water circuit to another, where the later circuit is at elevated temperatures. This is achieved through a refrigerant circuit where refrigerant in a liquid phase absorbs heat from a cooler water source and rejects heat as a liquid refrigerant to a warmer water source. They are used for larger, more complex, heating, ventilating, air conditioning, and refrigeration (HVACR) applications.

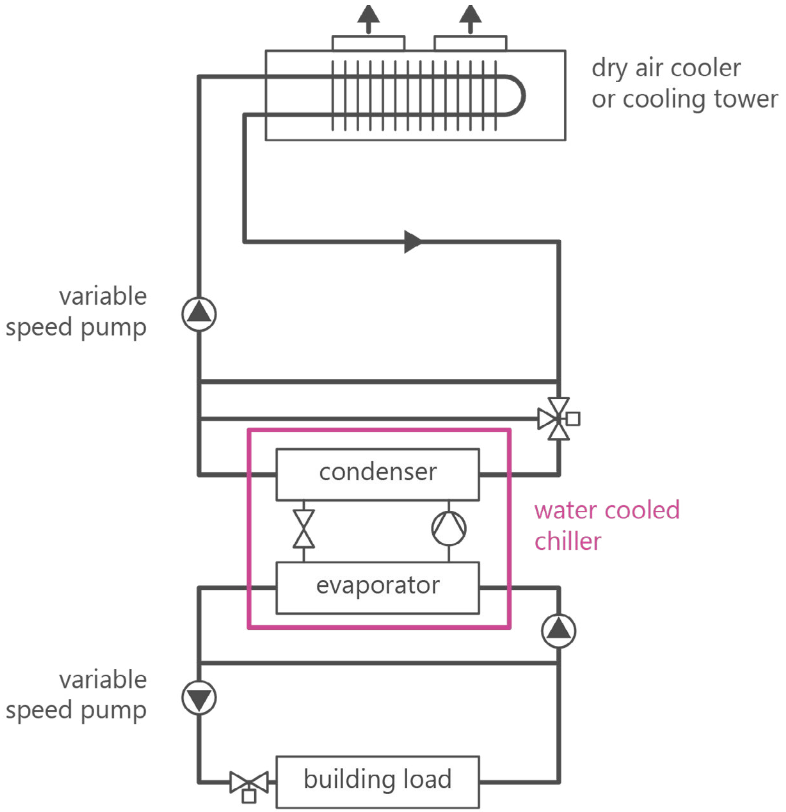

Figure 22 Example schematic of Chiller coupled with Dry Air Cooler or Cooling Tower Heat Rejection Plant

Cooling Tower

A cooling tower is designed to remove heat from a building or facility by spraying water down through the tower to exchange heat with the inside of the building. Air entering from the sides of the tower passes through the falling water where it exchanges heat and some of the water evaporates. Heat and evaporated water flow out the top of the tower in the form of a fine cloud-like mist. The cooled water can then be returned to the building to absorb heat for the spaces.

DX Split Systems

A DX (Direct Expansion) unit is a cooling system comprising an outdoor condenser unit where air passes over hot gas refrigerant and rejects heat to the passing air flow. This results in a cold liquid phase refrigerant medium to serve a single indoor unit (in a single split system) or multiple units (in a multi split system). Units usually only provide cooling and are not configured to provide heat recovery between spaces (unlike VRF or reverse cycle units). Indoor units operate with fixed refrigerant coil temperatures, with indoor cooling intensity controlled via airflow at the terminal (Fan Coil Unit) level.

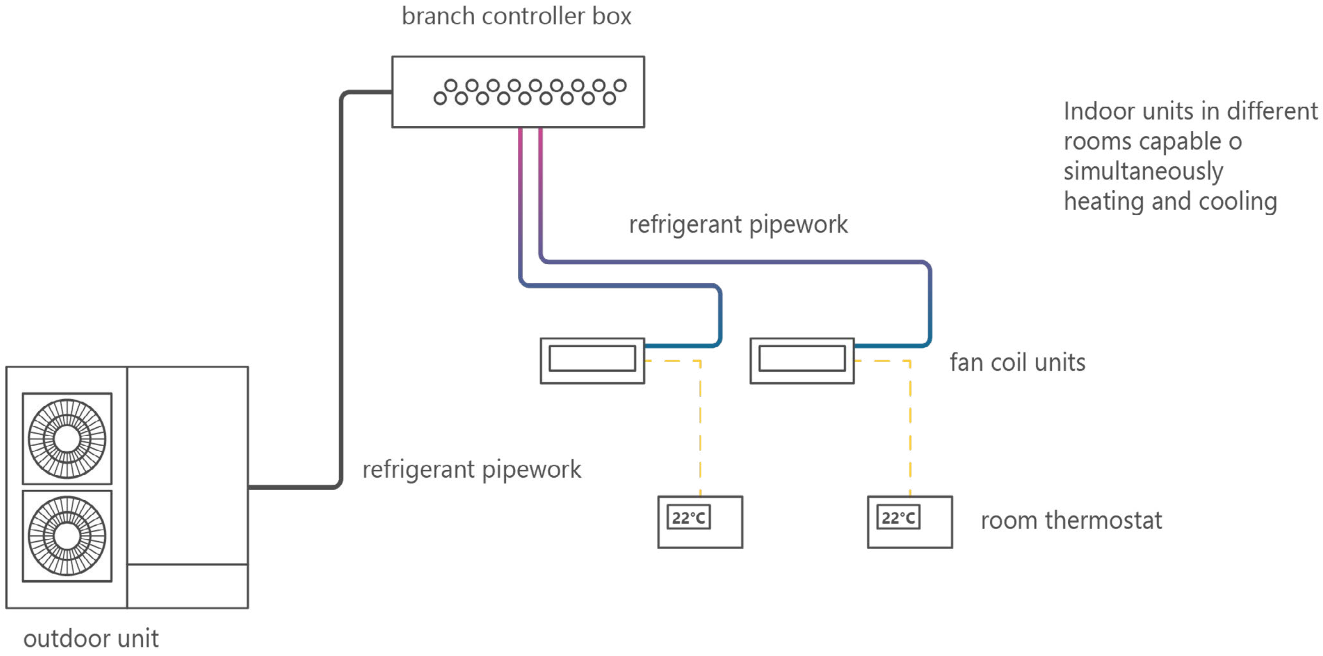

Figure 23 Example schematic VRF Cooling System

VRF Systems

VRF Systems are systems comprising multiple indoor units served and connected to an outdoor unit. Air is rejected or absorbed by air flow passing over finned tubing containing refrigerant and changing the refrigerant's phase. As VRF units are generally fitted with reverse cycle valve arrangements, the systems allowing heating or cooling by reversing the flow of refrigerant, thereby controlling if the outdoor unit rejects and absorbs heat. A control system monitors the indoor set point, room temperature, and adjusts the direction and flow of refrigerant among indoor units to satisfy the temperature requirements of each space.

Hybrid VRF Systems

Hybrid VRF Systems are systems comprising multiple indoor units served and connected to an outdoor unit. Air is rejected or absorbed by airflow passing over finned tubing containing refrigerant and changing the refrigerant's phase. As VRF units are generally fitted with reverse cycle valve arrangements, the systems allow heating or cooling application by reversing the flow of refrigerant, thereby controlling if the outdoor unit rejects and absorbs heat. However, different from a standard VRF unit, a Hybrid VRF unit uses less refrigerant, with termination to a heat exchanger system that exchanges the heat locally to a heat exchanger, and then uses circulating water to serve multiple indoor units.

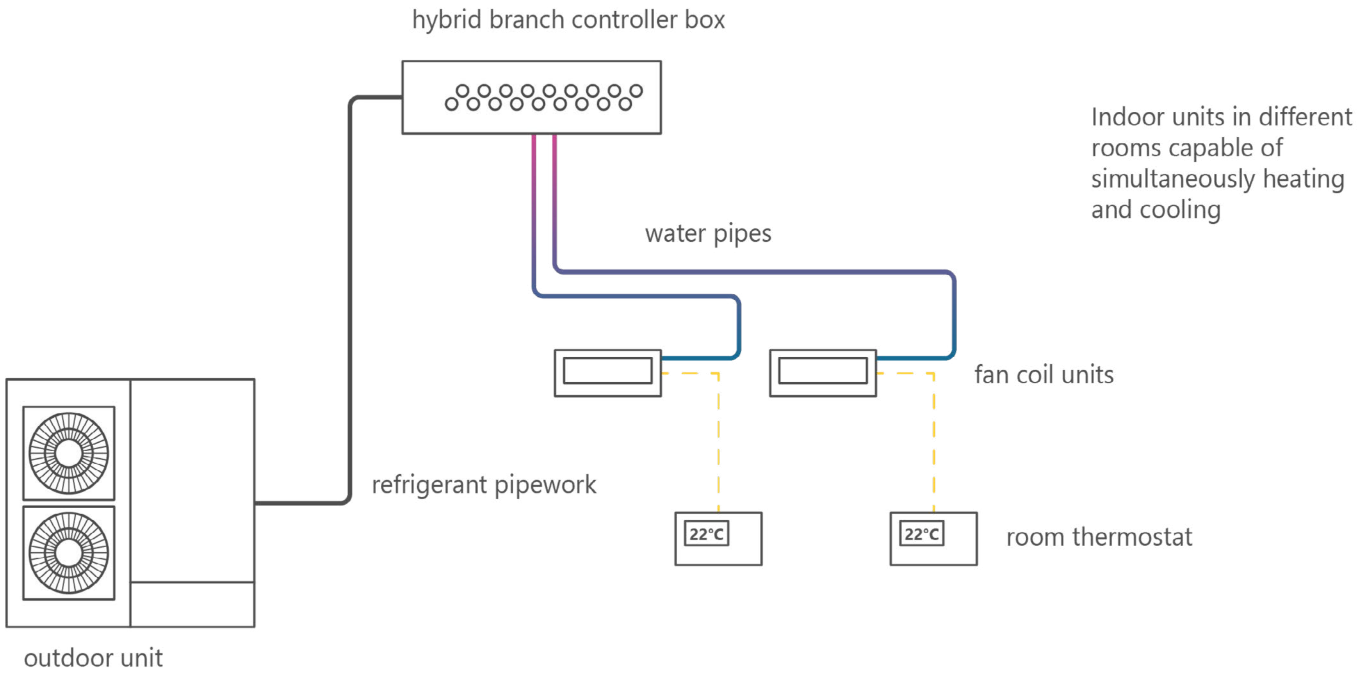

Figure 24 Example schematic hybrid VRF system

TECHNOLOGY GUIDE - PERFORMANCE STANDARDS

Requirements	Performance Requirements	Measurement Standards / Test Conditions	New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)
			Asset Type			Building Type		
Category / Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoLC Standard							
Cooling								
Chillers Performance Threshold	**Building Regulations: Approved Document L2 2021 Requirements (Non-Residential):** Cooling unit SEER:- Water-to-water chillers <400kW = 5.0 Water-to-water chillers 400–1500kW = 6.0 Water-to-water chillers ≥1500kW = 6.5 Vapour compression cycle chillers, air-cooled <400kW = 4.0 Vapour compression cycle chillers, air-cooled ≥400kW = 4.5	Building Regulations Conservation of fuel and power: Approved Document Part L1 [GN.1] Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2]	✓	✓	✓	✓	✓	✓
Air-cooled Chillers Performance Requirements	Apart from meeting Building Regulations: Approved Document L2 2021 Requirements, the unit should be able to provide cooling to 7°C at External temperatures of 2°C at 50% duty [C.2] and have the following system efficiency when operating in offices – Chiller SEER : >=5.5 [C.3]	For to comply with the Tier 2 (2021) EcoDesign SSCE comfort cooling limits. [C.5]	✓	✓	•		✓	
Water-cooled Chillers Performance Requirements	**Energy Technologies List [C.x]:** Products shall have a Seasonal Space Cooling Energy Efficiency ($\eta_{S,C}$) or Seasonal Energy Performance Ratio (SEPR) that is greater than or equal to the following: For water cooled comfort chillers that provide cooing only: • Below <400kW capacity: ≥230% • Between 400kW and 1500kW: ≥310% • Between 1500kW and 2000kW: ≥320% For water cooled comfort chillers that provide heating and cooling (reverse cycle water cooled chillers): • Below <400kW capacity: ≥220% • Between 400kW and 1500kW: ≥270% • Between 1500kW and 2000kW: ≥284% Where the seasonal space cooling energy efficiency ($\eta_{S,C}$) is defined as the ratio between the reference annual cooling demand pertaining to the cooling season for a product and the annual energy consumption for cooling, corrected by contributions accounting for temperature control and the electricity consumption of ground water pumps, where applicable. Simultaneous heating and cooling products shall have a cooling Energy Efficiency Ratio (EER) and heating Coefficient of Performance (COP) greater than or equal to: • Below <400kW capacity: ≥8.0 • Between 400kW and 1500kW: ≥9.0 • Between 1500kW and 2000kW: ≥9.1 Where cooling energy efficiency ratio (EER) is the ratio of the net cooling capacity to the effective power input when the product is cooling at full load. Additionally, the system should be able to provide cooling to 7°C at External temperatures of 2°C at 50% duty [C.2] and have system efficiency measures for Offices with an SEER : >=5.5 [C.3].	For to comply with the Tier 2 (2021) EcoDesign SSCE comfort cooling limits. [C.5]	✓	✓	✓	•	✓	✓
Cooling Tower Performance Threshold and Requirement	**ASHRAE 90.1[2]** The minimum efficiency per ASHRAE Standard 90.1 for induced draft open cooling towers applied to comfort cooling is 8.68 m3/hr/kW @ 35/29.5/23.8. There are no efficiency requirements for non-comfort cooling applications.	BS EN 14705:2005 [C.36] This Standard specifies requirements, test methods and acceptance tests for thermal performances pumping head verification of wet cooling towers and plume abatement for wet/dry cooling towers. – manufactured cooling towers should conform to this. CTI Certification (eurovent REC 9-12) [C.37] Certification means that the cooling tower has been tested under operating conditions and found to perform as rated by the manufacturer under those circumstances. It assures the buyer that the tower is not intentionally or inadvertently undersized by the manufacturer. The range of the certified thermal operating conditions shall not extend beyond the certified characteristics as per CTI STD-201, these being: Entering wet bulb temperature: 10°C to 32.2°C (50°F to 90°F) Cooling range > 2.2°C (4°F) Cooling approach > 2.8°C (5°F) Process fluid temperature < 51.7°C (125°F) Barometric pressure: - 91.4 to 105.0 kPa (27" to 31" Hg) Minimum thermal energy efficiency targets for open wet cooling towers are defined for the temperatures as per CTI Certification.	✓	•	•		✓	✓

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Requirements	Performance Requirements	Measurement Standards / Test Conditions	Asset Type: New build	Asset Type: Refurb	Asset Type: Listed	Building Type: Residential	Building Type: Commercial	Building Type: Public (e.g. Schools)
Category / Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoLC Standard							
DX Split Systems **Performance Threshold and Requirement**	Performance Threshold: Building Regulations: Approved Document L2 2021 Requirements (Non-Residential): Cooling unit SEER:- Packaged air conditioners SEER ≥ 3.0 Split and multi-split air conditioners SEER ≥ 5.0 For domestic applications, the minimum seasonal energy efficiency ratio of an air conditioner working in cooling mode should be SEER≥ 4.0 As per Part L, systems using heat recovery and capable of heating and cooling shall use the SEER for specific application. Performance Requirements: Products shall have a Seasonal Primary Energy Ratio (SPER) that is greater than or equal to the following: Greater than 1.72 for cooling (1.3 for heating). Where the seasonal primary energy ration (ηS,C) is defined as the ratio between the reference annual cooling or heating demand pertaining to the cooling or heating season for a product and the annual energy consumption for cooling, corrected by contributions accounting for temperature control and the electricity consumption of ambient temperatures, where applicable. System efficiency measures for Offices – Chiller SEER : >=5.5	ETL [BMS.1]: Units selected to have a Conformity Assessment mark. A Conformity Assessment mark is a new UK regulatory regime has now come into force in 31st December 2020 for manufactured goods being placed on the GB market and previously covered by the EU's CE marking (and similar markings). For to comply with the Tier 2 (2021) EcoDesign SSCE comfort cooling limits. Provide energy labels to products under 12 kW to allow customer to view and compare energy efficiency data between similar products [C.38]	✓	✓	•		✓	✓
VRF System Performance Threshold	Building Regulations: Approved Document L2 2021 Requirements (Non-Residential): Cooling unit SEER:- • Variable refrigerant flow/volume (VRF/VRV) systems SEER ≥ 5.0 • For domestic applications, the minimum seasonal energy efficiency ratio of an air conditioner working in cooling mode should be SEER≥ 4.0 For VRF Systems, the SEER is for the full system including indoor units, outdoor units and power input for control. As per Part L, systems using heat recovery and capable of heating and cooling shall use the SEER for specific application.	Building Regulations Conservation of fuel and power: Approved Document Part L1 [GN.1] Building Regulations Conservation of fuel and power: Approved Document Part L2 [GN.2]	✓	✓	•	✓	✓	✓
VRF Systems Performance Requirements	Products shall have a Seasonal Primary Energy Ratio (SPER) that is greater than or equal to the following: Greater than 1.72 for cooling (1.3 for heating) Where the seasonal primary energy ration (ηS,C) is defined as the ratio between the reference annual cooling or heating demand pertaining to the cooling or heating season for a product and the annual energy consumption for cooling, corrected by contributions accounting for temperature control and the electricity consumption of ambient temperatures, where applicable. System efficiency measures for Offices – Chiller SEER : >=5.5	ETL [BMS.1]: Units selected to have a Conformity Assessment mark. A Conformity Assessment mark is a new UK regulatory regime has now come into force in 31st December 2020 for manufactured goods being placed on the GB market and previously covered by the EU's CE marking (and similar markings). For to comply with the Tier 2 (2021) EcoDesign SSCE comfort cooling limits. Provide energy labels to products under 12 kW to allow customer to view and compare energy efficiency data between similar products [C.38]	✓	✓	•	•	✓	✓
Hybrid VRF Systems Performance Requirements	Products shall have a Seasonal Primary Energy Ratio (SPER) that is greater than or equal to the following: Greater than 1.72 for cooling (1.3 for heating) Where the seasonal primary energy ration (ηS,C) is defined as the ratio between the reference annual cooling or heating demand pertaining to the cooling or heating season for a product and the annual energy consumption for cooling, corrected by contributions accounting for temperature control and the electricity consumption of ambient temperatures, where applicable. System efficiency measures for Offices – Chiller SEER : >=5.5	ETL [BMS.1]: Units selected to have a Conformity Assessment mark. A Conformity Assessment mark is a new UK regulatory regime has now come into force in 31st December 2020 for manufactured goods being placed on the GB market and previously covered by the EU's CE marking (and similar markings). For to comply with the Tier 2 (2021) EcoDesign SSCE comfort cooling limits. Provide energy labels to products under 12 kW to allow customer to view and compare energy efficiency data between similar products [C.38]	✓	✓	•	✓	✓	✓

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TECHNOLOGY GUIDE - TECHNOLOGY STANDARDS

Requirements	Technical standards - For references, please refer to the 'Appendix' tab			
Category / Sub-category	Further guidance on design considerations and how the technology category or sub-category should be installed to deliver the performance standard targets			
Cooling	Key Design and Operation Considerations		Compatibility / Future proofing	Environmental Impact
Air cooled chillers	• Chillers are to be mounted externally and sufficient ambient airflow to reject heat generated by the building load. Ideally, these should be mounted at roof level. • The chilled water load shall be shared by more than one chiller unit, ensuring that in the event of single unit failure a minimum of 65% of the design demand shall still be available. • Space for two Air Cooled Chillers to provide 100% of design cooling load as duty plus additional standby at equal size) to be typically 30m² + 0.05m²/kW [C.7]. Access for maintenance and airflow to be in accordance with the manufacturer's guidelines. • This allowance does not include for additional plant such as pumps and ancillary plant items. • A height of the plant should be typically 2m + 70mm/kW [C.7]. This assumes a 300mm base for anti-vibrational mounts. • Where other heat rejection plant equipment or walls and obstruction that will impact the heat dissipation from the units, a CFD analysis will be recommended to analyse the airflow. This could involve increasing the height of the discharge stacks to dissipate heat away. • Allowance for half the width access to sides of unit to assist in tube/fin removal (cleaning) as part of regular maintenance (typically 1m). Clear access at control panel of at least 800mm for maintenance and access of Compressor. • Plant to be maintained in accordance to the requirements set out in HVCA SFG/20 (References 09-02: 12-01, 12-02, 12-03) [C.13] Electrical allowance for three phase 400V/50Hz power supply to serve equipment. All equipment and controls shall be suitably IP rated for external usage. Commercial Consideration: N+1 number of heat rejection units (where N is the number of units required to meet 100% of the design load) should be designed for centralised systems to provide insurance to plant redundancy. A control strategy should be in place to ensure longevity of equipment and potentially improve seasonal efficiency [C.9]. Listed Consideration: For listed properties, availability of plant spacing must be more stringently considered. Placing units on external walls and roofs may face strict planning requirements. Assess suitable locations to protect heritage status of building.	• Majority of Air Cooled Chillers are sized to produce chilled water at 6°C, and sized for a difference between the supply and return air of 6°C. • System distribution for differential temperature of 6K to allow for increase in system temperature due to heat gains in distribution, and therefore are commonly 7°C /14°C flow/return temperature. • Cooling terminal units selected are sufficient to serve cooling coils in AHUs and FCUs to cool air (and can provide dehumidification). • Majority of Free Cooled Chillers are sized to produce chilled water at elevated temperatures to maximise the period of operation where the compressor is not required to operate, therefore increasing efficiency of the cooling system. Here, the system operates at temperatures of 12°C flow and sized for a difference between the supply and return air of 6K. Cooling terminal units are normally selected to provide cooling at cooler surfaces in space (chilled beams / chilled panels, underfloor cooling) using above the dew point temperature of the spaces. • Provide sub metering for chillers serving a common distribution circuit more than 20kW [C.10]. • Internal cooling to be designed on sound design assumptions for functional areas: i. CIBSE C design criteria to be used to size building cooling system. ii. Cooling for spaces should be based on design criteria listed in CIBSE Guide A on operating temperatures in respect to heat losses and set points to ensure the thermal comfort and ensure correct sizing of HVAC systems. iii. Cooling for offices to be designed to 24°C ± 2°C [C.11]. iv. Spaces to be designed to prevent overheating in line with Building Regulations for Overheating [C.12]. • Where installed, free cooling to be enabled when external temperatures are≤15°C. • Systems requiring cooling across heating and cooling seasons shall consider using free cooing chillers. • Consideration for variable temperature systems to save power and raise the free cooling threshold. • A climate class system that ranges from T1 to T3 is used in air conditioning to classify the ambient temperature of different climates around the world and the suitability of a product to operate in that climate. T1: moderate climate, ac/chiller: 18–43°C, heat pumps: -7 to 43°C. T2: cold climate, ac/chiller: 10–35°C, heat pumps: -7 to 35°C. T3: hot climate, ac/chiller: 21–52°C, heat pumps: -7 to 51°C. • Chillers and Heat pumps manufactured or supplied to the UK fall under the T1 Moderate Climate region. All units shall be capable of achieving 100% cooling duty at 43°C. CIBSE Guide B recommends chillers are selected with a maximum ambient temperature of 40°C [C.9]. • Designer to check the noise levels from the Chillers are acceptable, considering locally occupied areas. This includes checking for vibration to the slab. Where the cooling system will operate at night set back cooling strategy, the designer shall check separately for night-time noise levels.	• Units to be selected to operate with lower global warming potential to avoid being affected by proposed phase outs under European F-Gas Regulations. Refer to Components\Refrigeration for further selections. • The designer shall consider designing a cooling system which enables heat recovery from return chilled water pipework to reuse heat and reduce cooling duty for the plant. • Consider packaged solutions which have the benefit of reduced on-site installation time. Packaged units include controls and a built-in hydronic kit and inverter drive circulation pump(s) to enable a building to be connected to the power supply and flow/return pipes ready for use and future replacement. • Where buildings are anticipated to reach full occupancy in later stages, consideration to a modular Chiller system that will allow a phased installation. Future units to be able to benefit from latest technologies and improved efficiencies. • Systems connected to chiller systems provide better futureproofing with regards to phase out of refrigerants due to the decoupled chilled water and refrigerant based system allows the refrigerant based chiller unit to be replaced in isolation for compliance to potential future F-gas regulations. • Indicative life expectancy of an installed Chiller is expected to be 20-25 years, and can achieve longer life should the plant be suitably sized and maintained [C.14]. • Natural ventilation should be prioritised over active or mechanical cooling systems in line with the GLA's cooling hierarchy. BSRIA BG1/2010 [C.19] provides guidance and more detailed explanations of different system types. BS EN 14511 (BSI, 2013) [C.20] provides standards for cooling systems. BS EN 1264 (BSI, 2008) provides relevant standards and BSRIA BG4/2011 [C.21] provides guidance. • Chilled water or Hybrid VRF systems are preferred for multi residential situations. Residential Consideration: connect residential units to ATL (Ambient Temperature Loop) district heating schemes, which allow heat to be rejected directly to common distribution from local compact Water Source Heat Pumps, providing cooling potential to residential units without central cooling plant or duplicate district heating & cooling systems. Residents near CitiGen shall explore potential to connect to system below the streets of London's square mile.	• Chilled water system recommended to be used with glycol due to external pipework, as an alternative to providing electric trace heating. [best practice] Where glycol is used, the system shall be designed with the correct performance criteria for heat capacity, density, and viscosity of the glycol mixture. • Designer to check for requirement for appropriate coatings and materials located in salty atmosphere that can rapidly corrode the air-cooled condensers. The chillers should be corrosion resistant and have weatherproof motors. • Refrigerant leak detection integral to the unit to be provided. • For eligibility for 3 Credits under Pol01, which is split into two parts; impact of refrigerants (two credits) & leak detection (one credit) [C.4]. An R32 Chiller should: -Have a Direct Effect Life CO2 equivalent emissions (DELC) of less than or equal to 100 kgCO2(equiv)/kW [2 Credits for Pol-01] [C.16] -Be hermetically sealed with a tested leakage rate of less than 3g/year [additional 1 credit for Pol-01] R32 Chillers eligible for two credits due to the direct effect life cycle CO2 equivalent emissions (DELC) of ≤100 kgCO2e/kW and 1 credit due to all systems being hermetically sealed, with a tested leakage rate of less than 3g/year. [C.4] • Use refrigerants with a GWP of less than 5, or if feasible, use no refrigerants. Several BREEAM credit can be obtained • Assess credentials for BREEAM Credit ENE01 awards 9 credits for developments with zero net regulated CO2 emissions. • Measured from a distance equal to that separating the unit and the next-door property, condensers must be below 42dB. Consult MCS 020 for guidance on the noise levels acceptable, devolved rules should also be consulted [C.15].
Water cooled chillers	• Water Cooled Chillers can be installed internally, coupled with additional heat rejection plant (Dry Air Cooler, Cooling Tower, Ambient Loop Systems, Industrial Process Water, District Cooling Schemes etc.) • Allowance for half the width access to sides of unit to assist in tube/fin removal (cleaning) as part of regular maintenance and access of Compressor. • Plantrooms must have sufficient ventilation to avoid the build-up of heat and refrigerant gases, in-case of a leak – this must adhere to BS EN 378 [C.8]. Manufacturer will specify heat rejection and M&E consultant should review mitigation options. Commercial Consideration: N+1 number of heat rejection plant (where N is the number of units required to meet 100% of the design load) should be designed for centralised systems to provide insurance to plant redundancy. A control strategy should be in place to ensure longevity of equipment and potentially improve seasonal efficiency [C.9]. Electrical allowance for three phase 400V/50Hz power supply to serve equipment. Listed Consideration: For listed properties, availability of plant spacing must be more stringently considered. Placing units on external walls and roofs may face strict planning requirements. Assess suitable locations to protect heritage status of building.	• The operating temperatures for Water Cooled Chillers are to be selected with confirmation of operating parameters from the manufacturer to ensure that the required cooling chilled water temperatures can be satisfied to serve system. The design engineer to check impact of changing system CHW flow and return temperatures on cooling coils in AHUs and FCUs to cool air (and can provide dehumidification) and/or terminal units are normally selected to provide cooling at cooler surfaces in space (chilled beams / chilled panels, underfloor cooling) using above the dew point temperature of the spaces. • Provide sub metering for chillers serving a common distribution circuit more than 20kW [C.10]. • Internal cooling to be designed on sound design assumptions for functional areas: i. CIBSE C design criteria to be used to size building cooling system. [C.17] ii. Cooling for spaces should be based on design criteria listed in CIBSE Guide A on operating temperatures in respect to heat losses and set points to ensure the thermal comfort and ensure correct sizing of HVAC systems.[C.18] iii. Cooling for offices to be designed to 24°C ± 2°C [C.11]. iv. Spaces to be designed to prevent overheating in line with Building Regulations for Overheating [C.12]. • Designer to check the noise levels from the Chillers are acceptable, considering locally occupied areas. This includes checking for vibration to the slab. • Plant to be maintained in accordance to the requirements set out in HVCA SFG/20 (References 09-02: 12-01, 12-02, 12-03) [C.13]	• Units to be selected to operate with lower global warming potential to avoid being affected by proposed phase outs under European F-Gas Regulations. Refer to Components\Refrigeration for further selections. • The designer shall consider designing a cooling system which enables heat recovery from return chilled water pipework to reuse heat and reduce cooling duty for the plant. • Consider packaged solutions which have the benefit of reduced on-site installation time. Packaged units include controls and a built-in hydronic kit and inverter drive circulation pump(s) to enable a building to be connected to the power supply and flow/return pipes ready for use and future replacement. • Where buildings are anticipated to reach full occupancy in later stages, consideration to a modular Chiller system that will allow a phased installation. Future units to be able to benefit from latest technologies and improved efficiencies. • Systems connected to chiller systems provide better futureproofing with regards to phase out of refrigerants due to the decoupled chilled water and refrigerant based system allows the refrigerant based chiller unit to be replaced in isolation for compliance to potential future F-gas regulations. • Indicative life expectancy of an installed Chiller is expected to be 20-25 years, and can achieve longer life should the plant be suitably sized and maintained [C.14]. • Natural ventilation should be prioritised over active or mechanical cooling systems in line with the GLA's cooling hierarchy. BSRIA BG1/2010 [C.19] provides guidance and more detailed explanations of different system types. BS EN 14511 (BSI, 2013) [C.20] provides standards for cooling systems. BS EN 1264 (BSI, 2008) provides relevant standards and BSRIA BG4/2011 [C.21] provides guidance. • Chilled water or Hybrid VRF systems are preferred for multi residential situations. Residential Consideration: connect residential units to ATL (Ambient Temperature Loop) district heating schemes, which allow heat to be rejected directly to common distribution from local compact Water Source Heat Pumps, providing cooling potential to residential units without central cooling plant or duplicate district heating & cooling systems. Residents near CitiGen shall explore potential to connect to system below the streets of London's square mile.	• Refrigerant leak detection integral to the unit to be provided. • R32 Chillers eligible for two BREEAM credits due to the direct effect life cycle CO2 equivalent emissions (DELC) of ≤100 kgCO2e/kW and 1 credit due to all systems being hermetically sealed, with a tested leakage rate of less than 3g/year. [C.4] For eligibility for 3 Credits under Pol01, which is split into two parts; impact of refrigerants (two credits) & leak detection (one credit) [C.4]. An R32 Chiller should: - Have a Direct Effect Life CO2 equivalent emissions (DELC) of less than or equal to 100 kgCO2(equiv)/kW [2 Credits for Pol-01] [C.16] - Be hermetically sealed with a tested leakage rate of less than 3g/year [additional 1 credit for Pol-01] • Use refrigerants with a GWP of less than 5, or if feasible, use no refrigerants. Several BREEAM credit can be obtained • Assess credentials for BREEAM Credit ENE01 awards 9 credits for developments with zero net regulated CO2 emissions. Listed Consideration: If the building is a listed building, water cooled chillers are internal plant that can be accommodated, provided that a design for the hot sink heat rejection circuit is piped to associated plant or network system to reject or reuse the heat. The use of Water to Water shall enable district cooling or cooling with other running water services to operate without roof plant.
Cooling Tower	• Cooling Towers are mounted externally, ideally at roof level, with sufficient air flow to help cool the water. • The location of the cooling tower should receive careful consideration. There should be sufficient free space around the tower to allow free flow of air both to the inlet and from the discharge outlet. The siting of the cooling tower should be such that the discharge air is not close to fresh air inlets and does not produce condensation upon nearby buildings and in the surrounding area. • The tower should be sited as far away as possible, upwind of smokestacks and other sources of pollution. Where local atmospheric air pollution is unavoidable, filters may be provided for cooling-tower air inlets. The tower location should be carefully studied in relation to the noise created by the air and water. [C.9] • Local fire regulations should be consulted when a tower is to be installed, particularly if any hazard or opportunity for ignition of the tower is present. • Where cooling towers need to be site-performance tested for confirmation of compliance with design conditions, the relevant standard for the UK is BS 4485-2 [C.23] • The Notification of Cooling Towers and Evaporative Condensers Regulations[C.24] requires that the local authority is notified of all cooling towers and evaporative condensers. Requiring CoLC is informed in writing if cooling towers or evaporative condenser are proposed. Exemptions for systems that contain no water that's exposed to air, no water supply connected or no electrical supply connected. Changes to cooling tower or evaporative condenser must also require CoLC to be informed in writing immediately. • BSRIA BG 9 [C.25] gives guidance on space and weight requirements of cooling tower plant for example; A total cooling load of 1500kW is satisfied by a forced draught cooling tower requiring an installation area of 50m2 and installation height of 4.7m, refer to this document for further guidance. Listed Consideration: For listed properties Plant space can be limited – Cooling towers are typically located on the roof of a building, Structural limitations will apply.	• Cooling Towers require appropriate measures as described in Legionnaires' disease: The control of Legionella bacteria in water systems to be in place to prevent or control the risk of legionella. Otherwise, other measures need to be put in place to prevent or control the risk from legionella and must be as equally effective. [C.27] • Evaporative cooling towers and condensers require meticulous water treatment and maintenance which some users and/or operators may be unwilling or incapable of providing. [C.9] • It is the designer's responsibility under the Construction (Design and Management) Regulations (CDM Regulations) to ensure that future that future maintenance of the plant can be carried out safely. • BSRIA BG8 provides guidance on rough performance (figure 23) to be followed for sizing a cooling tower for UK summertime. [C.26] • The designer can maximise the opportunity for free cooling by selecting a cooling system that requires air or chilled water at a relatively high temperature. For example, chilled ceilings and beams generally require chilled water at between 13 °C and 18 °C	• The designer shall consider designing a cooling system which enables a higher return chilled water pipework to best enable all year around free cooling and better Cooling Tower efficiencies. • Compatible with larger office buildings, schools, hospitals, and larger industrial buildings. Typically, not suitable for smaller buildings. • Indicative life expectancy of an installed Cooling Towers are beyond 25 years, and can achieve longer life should the plant be suitably sized and maintained [C.14]. • Better airflow management to control plumes of evaporated water mist from impacting building roof fabric or other local features. Generally, this system shall not be suitable for listed buildings unless the system is modelled to prevent moisture pooling on historic and sensitive fabric. • Natural ventilation should be prioritised over active or mechanical cooling systems in line with the GLA's cooling hierarchy. BSRIA BG1/2010 [C.19] provides guidance and more detailed explanations of different system types. BS EN 14511 (BSI, 2013) [C.20] provides standards for cooling systems. BS EN 1264 (BSI, 2008) provides relevant standards and BSRIA BG4/2011 [C.21] provides guidance. Residential Consideration: connect residential units to ATL (Ambient Temperature Loop) district heating schemes, which allow heat to be rejected directly to common distribution from local compact Water Source Heat Pumps, providing cooling potential to residential units without central cooling plant or duplicate district heating & cooling systems. Residents near CitiGen shall explore potential to connect to system below the streets of London's square mile. Chilled water or Hybrid VRF systems are preferred for multi residential situations.	• Any system that contains water at between 20°C and 45°C is at risk of supporting colonies of Legionella bacteria. [C.9] If the system has the means of creating and disseminating breathable water droplets or aerosols it is at risk of causing exposure to Legionella bacteria, the cause of a potentially fatal disease in humans. Cooling and heat rejection systems that incorporate a cooling tower or evaporative condenser are thus at particular risk of supporting the bacteria that could cause Legionella infection. [C.27] • Relevant regulations that must be complied with include: - Management of Health and Safety at Work Regulations 1999 - Control of Substances Hazardous to Health Regulations 1999 (COSHH) - The Notification of Cooling Towers and Evaporative Condensers Regulations 1992 • Practical guidance on complying with these regulations is given by the HSC Approved Code of Practice and Guidance L8[C.29] and CIBSE TM13[C.28] • It is not currently included specifically within any BREEAM certification requirements to reduce or limit the volume of water used during cooling tower process. However, there are credits available for the reduction of water consumption (Wat 04 Water Efficient Equipment) for all major processes, but the onus is on the designer to identify these. • Cooling Towers are heavy consumers of water (of which may require demineralisation). Designers shall investigate where water saving measures can be identified to increase cycles of water usage.

	Asset Type			Building Type			City of London Document Interlinks (TBC)		Key Stakeholders							
Requirements	New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)	City of London Documents and Guidance	Location and Description	Project Management	Mechanical Engineer	Electrical Engineer	Architect	Public Health Engineer	Fire Engineer	Contractor	Building FM / End User
Category / Sub-category							Task Bar	PPG Activities								
Air cooled chillers	✓	✓	•		✓		1) City of London Corporation Housing Design Guide Dec 2020 2) CoLC Climate Action Strategy 2020-2027	1) The checklist in the GLA's Energy Assessment Guidance is intended to assist designers to identify potential overheating risk in residential accommodation early on in the design process. It should be used at concept stage and should trigger the incorporation of passive measures within the building envelope and services design to mitigate overheating and reduce cooling demand in line with London Plan. 2)In line with the CoLC Climate Action Strategy 2020-2027, the systems shall maximise the use of renewable, aim for BREEAM Excellent Rating.		✓	✓	✓			✓	✓
Water cooled chillers	✓	✓	✓	•	✓	✓	CoLC Climate Action Strategy 2020-2027	In line with the CoLC Climate Action Strategy 2020-2027, the systems shall maximise the use of renewable, aim for BREEAM Excellent Rating.		✓	✓	•			✓	✓
Cooling Tower	✓	•	•		✓	✓	1) City of London Corporation Housing Design Guide Dec 2020 2) CoLC Climate Action Strategy 2020-2027	1) The checklist in the GLA's Energy Assessment Guidance is intended to assist designers to identify potential overheating risk in residential accommodation early on in the design process. It should be used at concept stage and should trigger the incorporation of passive measures within the building envelope and services design to mitigate overheating and reduce cooling demand in line with London Plan. 2)In line with the CoLC Climate Action Strategy 2020-2027, the systems shall maximise the use of renewable, aim for BREEAM Excellent Rating.		✓	✓	✓	✓		✓	✓

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Requirements	Technical standards - For references, please refer to the 'Appendix' tab				Asset Type: New build	Asset Type: Refurb	Asset Type: Listed	Building Type: Residential	Building Type: Commercial	Building Type: Public (e.g. Schools)	City of London Document Interlinks (TBC): City of London Documents and Guidance	City of London Document Interlinks (TBC): Location and Description	Key Stakeholders: Project Management	Key Stakeholders: Mechanical Engineer	Key Stakeholders: Electrical Engineer	Key Stakeholders: Architect	Key Stakeholders: Public Health Engineer	Key Stakeholders: Fire Engineer	Key Stakeholders: Contractor	Key Stakeholders: Building FM / End User
Category / Sub-category	Further guidance on design considerations and how the technology category or sub-category should be installed to deliver the performance standard targets										Task Bar	PPG Activities								
DX Split Systems	• DX Units Systems comprise of an external Condenser (located externally, ideally at roof level or high level on wall), refrigerant piping and indoor cooling units with coils. • To allow for spacing as recommended by the manufacturer to ensure sufficient airflow and access to components. Where other heat rejection plant equipment or walls and obstruction that will impact the heat dissipation from the units, a Computational Fluid Dynamic (CFD) analysis will be recommended to analyse the airflow. • Space allowance for internal units (Branch Controller Boxes) and indoor units to be coordinated with Architectural designs. • Vertical and total equivalent distances from outdoor unit, branch controller boxes and indoor units to be checked and agreed against manufacturers recommendations. • Allowance for half the width access to sides of unit to assist in tube/fin removal (cleaning) as part of regular maintenance (typically 1m). Clear access at control panel of at least 800mm for maintenance and access of Compressor. • Consider the provision of optional extras when installing plant in noise and acoustic sensitive locations – this includes the potential for a 300mm base for anti-vibrational mounts, acoustic screen selected based on insertion losses calculated by an acoustician, or attenuation kit over unit. • Plantrooms and risers must have sufficient ventilation to avoid the build-up of heat and refrigerant gases, in-case of a leak – this must adhere to BS EN 378 [C.8]. Manufacturer will specify heat rejection and M&E consultant should review mitigation options. • DX units have an expected lifespan of 12-15 years [C.14]. When correctly installed it should require very little maintenance and be expected to last beyond 15 years. Commercial Consideration: N+1 number of cooling heat rejection units (where N is the number of units required to meet the design load) should be designed for centralised systems to provide insurance to plant redundancy where this is essential (such as systems serving IT comms rooms, or critical health care setting rooms). A control strategy should be in place to ensure longevity of equipment and potentially improve seasonal efficiency. Listed Consideration: For listed properties, availability of plant spacing must be more stringently considered. Placing units on external walls and roofs may face strict planning requirements. Assess suitable locations to protect heritage status of building. Heat Stress Considerations: Consideration to selecting units which are either oversized to ensure units are capable of providing the elevated cooling demand when external temperatures exceed 35degC. Layout of external plant and siting of equipment to consider strategies to draw in cooler air and avoid recirculation to avoid elevated temperatures beyond the manufacturers capability during future intense peak summer temperatures.	• Majority of units operate within a defined and non-adjustable coil temperatures, dictated by the refrigerant used. Care and attention to be undertaken for evaporating temperatures for units where dehumidification is not to be undertaken (rooms with pure sensible cooling such as IT comms rooms, or units without condensate drip trays). • Cooling terminal units are normally selected to provide cooling at cooler surfaces in space (chilled beams/ chilled panels, underfloor cooling) using above the dew point temperature of the spaces. • Provide sub metering for systems available through manufacturer supplied controllers, to be linked to a building BMS system. • Internal cooling to be designed on sound design assumptions for functional areas: i. CIBSE C design criteria to be used to size building cooling system. [C.17] ii.Cooling for spaces should be based on design criteria listed in CIBSE Guide A on operating temperatures in respect to heat losses and set points to ensure the thermal comfort and ensure correct sizing of HVAC systems. [C.18] iii.Cooling for offices to be designed to 24°C ± 2°C [C.11] iv.Spaces to be designed to prevent overheating in line with Building Regulations for Overheating. • Where installed, free cooling to be enabled when external temperatures are <=15°C. i.Systems requiring cooling across heating and cooling seasons shall consider using free cooling chillers. ii.Consideration for variable temperature systems to save power and raise the free cooling threshold • A climate class system that ranges from T1 to T3 is used in air conditioning to classify the ambient temperature of different climates around the world and the suitability of a product to operate in that climate. T1: moderate climate, ac/chiller: 18–43°C, heat pumps: -7 to 43°C. T2: cold climate, ac/chiller: 10–35°C, heat pumps: -7 to 35°C. T3: hot climate, ac/chiller: 21–52°C, heat pumps: -7 to 51°C. • Chillers and Heat pumps manufactured or supplied to the UK fall under the T1 Moderate Climate region. All units shall be capable of achieving 100% cooling duty at 43°C. CIBSE Guide B recommends chillers are selected with a maximum ambient temperature of 40°C. [C.9] • Designer to check the noise levels from the condensers are acceptable, considering locally occupied areas. This includes checking for vibration to the slab. Where the cooling system will operate at night set back cooling strategy, the designer shall check separately for night-time noise levels. • Plant to be maintained in accordance to the requirements set out in HVCA SFG/20 (References 09-02: 12-01, 12-02, 12-03) [C.13] • CIBSE Guide A provides guidance on operating temperatures in respect to heat losses and set points to ensure the thermal comfort and ensure correct sizing of HVAC systems. [C.18] • Consult CIBSE Guide H for guidance on control strategy to ensure control of setpoints and avoid parallel heating and cooling of spaces with multiple indoor units. [C.30]	• Units to be selected to operate with lower global warming potential to avoid being affected by proposed phase outs under European F-Gas Regulations. Refer to Components\Refrigeration for further selections. • The designer shall consider selection of a cooling system which enables heat recovery where simultaneously heating and cooling is anticipated. • Where buildings are anticipated to reach full occupancy in later stages, consideration to a modular cooling plant that will allow a phased installation. Future units to be able to benefit from latest technologies and improved efficiencies. • Systems connected to chiller systems provide better futureproofing with regards to phase out of refrigerants due to the decoupled chilled water and refrigerant based system allows the refrigerant based chiller unit to be replaced in isolation for compliance to potential future F-gas regulations. • VRF, split & multi-split pumps require piping from the external condenser to the internal cassette, so spatial assessment required. • Natural ventilation should be prioritised over active or mechanical cooling systems in line with the GLA's cooling hierarchy. BSRIA BG1/2010 [C.19] provides guidance and more detailed explanations of different system types. BS EN 14511 (BSI, 2013) [C.20] provides standards for cooling systems. BS EN 1264 (BSI, 2008) provides relevant standards and BSRIA BG4/2011 [C.21] provides guidance. • Chilled water or Hybrid VRF systems are preferred for multi residential situations. Refurb & Listed Consideration: If retrofitting, the existing building may not have space allowance for pipe trays, this option may not be viable. Conduct spatial requirement assessment. Commercial Consideration: Systems are suitable for industrial and commercial units to manage local equipment gains. Units are generally not suitable for domestic or areas where heating and cooling dual purpose units are preferred (such as office areas, schools or residential zones). Units serving comms rooms in commercial buildings shall ensure suitable units selected to avoid condensation.	• Chilled water system recommended to be used with glycol due to external pipework, as an alternative to providing electric trace heating. [best practice] Where glycol is used, the system shall be designed with the correct performance criteria for heat capacity, density, and viscosity of the glycol mixture. • Designer to check for requirement for appropriate coatings and materials located in salty atmosphere that can rapidly corrode the air-cooled condensers. The chillers should be corrosion resistant and have weatherproof motors. • Refrigerant leak detection integral to the unit to be provided. • R32 Chillers eligible for two BREEAM credits due to the direct effect life cycle CO2 equivalent emissions (DELC) of ≤100 kgCO2e/kW and 1 credit due to all systems being hermetically sealed, with a tested leakage rate of less than 3g/year. (7) • For eligibility for 3 Credits under Pol01, which is split into two parts; impact of refrigerants (two credits) & leak detection (one credit). An R32 Cooling Plant should: - Have a Direct Effect Life CO2 equivalent emissions (DELC) of less than or equal to 100 kgCO2(equiv)/kW [2 Credits for Pol-01] - Be hermetically sealed with a tested leakage rate of less than 3g/year [additional 1 credit for Pol-01] • Use refrigerants with a GWP of less than 5, or if feasible, use no refrigerants. Several BREEAM credit can be obtained • Assess credentials for BREEAM Credit ENE01 awards 9 credits for developments with zero net regulated CO2 emissions. • Measured from a distance equal to that separating the unit and the next-door property, ground-source heat pumps must be below 42dB. Consult MCS 020 for guidance on the noise levels acceptable, devolved rules should also be consulted [H.8]. • Hybrid VRF systems use a more environmentally-friendly refrigerant, and less of it. Hybrid VRF uses less refrigerant than its equivalent VRF system (typically 25%), where connections to internal units are replaced with water. This helps to reduce demand for refrigerant manufacture and lowers the risk of leaks. Listed Consideration: If the building is a listed building, acquire both planning permission and listed building consent.	✓	✓	✓		✓	✓	1) City of London Corporation Housing Design Guide Dec 2020 2) CoLC Climate Action Strategy 2020-2027	1) The checklist in the GLA's Energy Assessment Guidance is intended to assist designers to identify potential overheating risk in residential accommodation early on in the design process. It should be used at concept stage and should trigger the incorporation of passive measures within the building envelope and services design to mitigate overheating and reduce cooling demand in line with London Plan. 2)In line with the CoLC Climate Action Strategy 2020-2027, the systems shall maximise the use of renewable, aim for BREEAM Excellent Rating.		✓	✓	•			✓	✓
VRF Systems	• VRF Units Systems comprise of an external Condenser units (can be called Outdoor Units, located externally, ideally at roof level or high level on wall), refrigerant piping, indoor Branch Controller Boxes, and indoor cooling units with coils. • To allow for spacing as recommended by the manufacturer to ensure sufficient airflow and access to components. Where other heat rejection plant equipment or walls and obstruction that will impact the heat dissipation from the units, a Computational Fluid Dynamic (CFD) analysis will be recommended to analyse the airflow. • Space allowance for internal units (Branch Controller Boxes) and indoor units to be coordinated with Architectural designs. Various options and configurations are feasible with this technology. • Vertical and total equivalent distances from outdoor unit, branch controller boxes and indoor units to be checked and agreed against manufacturers recommendations. • Allowance for half the width access to sides of unit to assist in tube/fin removal (cleaning) as part of regular maintenance (typically 1m). Clear access at control panel of at least 800mm for maintenance and access of Compressor. • To consider the provision of optional extras when installing plant in noise and acoustic sensitive locations – this includes the potential for a 300mm base for anti-vibrational mounts, acoustic screen selected based on insertion losses calculated by an acoustician, or attenuation kit over unit. • Plantrooms and risers must have sufficient ventilation to avoid the build-up of heat and refrigerant gases, in-case of a leak – this must adhere to BS EN 378 [C.8]. Manufacturer will specify heat rejection and M&E consultant should review mitigation options. • VRF units have an expected lifespan of 12-15 years [C.14]. When correctly installed it should require very little maintenance and be expected to last beyond 15 years. Commercial Consideration: N+1 number of cooling heat rejection units (where N is the number of units required to meet the design load) should be designed for centralised systems to provide insurance to plant redundancy where this is essential (such as systems serving IT comms rooms, or critical health care setting rooms). A control strategy should be in place to ensure longevity of equipment and potentially improve seasonal efficiency. Listed Consideration: For listed properties, availability of plant spacing must be more stringently considered. Placing units on external walls and roofs may face strict planning requirements. Assess suitable locations to protect heritage status of building. Heat Stress Considerations: Consideration to selecting units which are either oversized to ensure units are capable of providing the elevated cooling demand when external temperatures exceed 35degC. Layout of external plant and siting of equipment to consider strategies to draw in cooler air and avoid recirculation to avoid elevated temperatures beyond the manufacturers capability during future intense peak summer temperatures.	• Majority of units operate within a defined and non-adjustable coil temperatures, dictated by the refrigerant used. Care and attention to be undertaken for evaporating temperatures for units where dehumidification is not to be undertaken (rooms with pure sensible cooling such as IT comms rooms, or units without condensate drip trays). • Cooling terminal units are normally selected to provide cooling at cooler surfaces in space (chilled beams/ chilled panels, underfloor cooling) using above the dew point temperature of the spaces. • Provide sub metering for systems available through manufacturer supplied controllers, to be linked to a building BMS system. • Internal cooling to be designed on sound design assumptions for functional areas: i. CIBSE C design criteria to be used to size building cooling system. [C.17] ii.Cooling for spaces should be based on design criteria listed in CIBSE Guide A on operating temperatures in respect to heat losses and set points to ensure the thermal comfort and ensure correct sizing of HVAC systems. [C.18] iii.Cooling for offices to be designed to 24°C ± 2°C [C.11] iv.Spaces to be designed to prevent overheating in line with Building Regulations for Overheating. • Where installed, free cooling to be enabled when external temperatures are <=15°C. i.Systems requiring cooling across heating and cooling seasons shall consider using free cooling chillers. ii.Consideration for variable temperature systems to save power and raise the free cooling threshold • A climate class system that ranges from T1 to T3 is used in air conditioning to classify the ambient temperature of different climates around the world and the suitability of a product to operate in that climate. T1: moderate climate, ac/chiller: 18–43°C, heat pumps: -7 to 43°C. T2: cold climate, ac/chiller: 10–35°C, heat pumps: -7 to 35°C. T3: hot climate, ac/chiller: 21–52°C, heat pumps: -7 to 51°C. • Chillers and Heat pumps manufactured or supplied to the UK fall under the T1 Moderate Climate region. All units shall be capable of achieving 100% cooling duty at 43°C. CIBSE Guide B recommends chillers are selected with a maximum ambient temperature of 40°C. [C.9] • Designer to check the noise levels from the condensers are acceptable, considering locally occupied areas. This includes checking for vibration to the slab. Where the cooling system will operate at night set back cooling strategy, the designer shall check separately for night-time noise levels. • Plant to be maintained in accordance to the requirements set out in HVCA SFG/20 (References 09-02: 12-01, 12-02, 12-03) [C.13] • CIBSE Guide A provides guidance on operating temperatures in respect to heat losses and set points to ensure the thermal comfort and ensure correct sizing of HVAC systems. [C.18] • Consult CIBSE Guide H for guidance on control strategy to ensure control of setpoints and avoid parallel heating and cooling of spaces with multiple indoor units. [C.30]	• Units to be selected to operate with lower global warming potential to avoid being affected by proposed phase outs under European F-Gas Regulations. Refer to Components\Refrigeration for further selections. • The designer shall consider selection of a cooling system which enables heat recovery where simultaneously heating and cooling is anticipated. • Where buildings are anticipated to reach full occupancy in later stages, consideration to a modular cooling plant that will allow a phased installation. Future units to be able to benefit from latest technologies and improved efficiencies. • Systems connected to chiller systems provide better futureproofing with regards to phase out of refrigerants due to the decoupled chilled water and refrigerant based system allows the refrigerant based chiller unit to be replaced in isolation for compliance to potential future F-gas regulations. • VRF, split & multi-split pumps require piping from the external condenser to the internal cassette, so spatial assessment required. • The dual purpose heating and cooling systems are preferred for occupied areas (such as office areas, schools or residential zones). • Natural ventilation should be prioritised over active or mechanical cooling systems in line with the GLA's cooling hierarchy. BSRIA BG1/2010 [C.19] provides guidance and more detailed explanations of different system types. BS EN 14511 (BSI, 2013) [C.20] provides standards for cooling systems. BS EN 1264 (BSI, 2008) provides relevant standards and BSRIA BG4/2011 [C.21] provides guidance. • Chilled water or Hybrid VRF systems are preferred for multi residential situations. Refurb & Listed Consideration: If retrofitting, the existing building may not have space allowance for pipe trays, this option may not be viable. Conduct spatial requirement assessment.	• Chilled water system recommended to be used with glycol due to external pipework, as an alternative to providing electric trace heating. [best practice] Where glycol is used, the system shall be designed with the correct performance criteria for heat capacity, density, and viscosity of the glycol mixture. • Designer to check for requirement for appropriate coatings and materials located in salty atmosphere that can rapidly corrode the air-cooled condensers. The chillers should be corrosion resistant and have weatherproof motors. • Refrigerant leak detection integral to the unit to be provided. • R32 Chillers eligible for two BREEAM credits due to the direct effect life cycle CO2 equivalent emissions (DELC) of ≤100 kgCO2e/kW and 1 credit due to all systems being hermetically sealed, with a tested leakage rate of less than 3g/year. (7) • For eligibility for 3 Credits under Pol01, which is split into two parts; impact of refrigerants (two credits) & leak detection (one credit). An R32 Cooling Plant should: - Have a Direct Effect Life CO2 equivalent emissions (DELC) of less than or equal to 100 kgCO2(equiv)/kW [2 Credits for Pol-01] - Be hermetically sealed with a tested leakage rate of less than 3g/year [additional 1 credit for Pol-01] • Use refrigerants with a GWP of less than 5, or if feasible, use no refrigerants. Several BREEAM credit can be obtained • Assess credentials for BREEAM Credit ENE01 awards 9 credits for developments with zero net regulated CO2 emissions. • Measured from a distance equal to that separating the unit and the next-door property, ground-source heat pumps must be below 42dB. Consult MCS 020 for guidance on the noise levels acceptable, devolved rules should also be consulted [H.8]. • Hybrid VRF systems use a more environmentally-friendly refrigerant, and less of it. Hybrid VRF uses less refrigerant than its equivalent VRF system (typically 25%), where connections to internal units are replaced with water. This helps to reduce demand for refrigerant manufacture and lowers the risk of leaks. Listed Consideration: If the building is a listed building, acquire both planning permission and listed building consent.	✓	✓	✓	•	✓	✓	1) City of London Corporation Housing Design Guide Dec 2020 2) CoLC Climate Action Strategy 2020-2027	1) The checklist in the GLA's Energy Assessment Guidance is intended to assist designers to identify potential overheating risk in residential accommodation early on in the design process. It should be used at concept stage and should trigger the incorporation of passive measures within the building envelope and services design to mitigate overheating and reduce cooling demand in line with London Plan. 2)In line with the CoLC Climate Action Strategy 2020-2027, the systems shall maximise the use of renewable, aim for BREEAM Excellent Rating.		✓	✓	•			✓	✓
Hybrid VRF Systems	• HVRF Units Systems comprise of an external Condenser units (can be called Outdoor Units, located externally, ideally at roof level or high level on wall), refrigerant piping, indoor Hybrid Branch Controller Boxes, water pipework, and indoor cooling units with water coils. • Hybrid VRF systems uses a combination of refrigerant and water to do this, instead of just refrigerant like standard VRF units. Therefore this provides the benefits of using water systems, and not requiring the management of refrigerant in tenant areas and lowers the risk of leaks. • To allow for spacing as recommended by the manufacturer to ensure sufficient airflow and access to components. Where other heat rejection plant equipment or walls and obstruction that will impact the heat dissipation from the units, a Computational Fluid Dynamic (CFD) analysis will be recommended to analyse the airflow. • Space allowance for internal units (Branch Controller Boxes) and indoor units to be coordinated with Architectural designs. • Various options and configurations are feasible with this technology. • Vertical and total equivalent distances from outdoor unit, branch controller boxes and indoor units to be checked and agreed against manufacturers recommendations. • Allowance for half the width access to sides of unit to assist in tube/fin removal (cleaning) as part of regular maintenance (typically 1m). Clear access at control panel of at least 800mm for maintenance and access of Compressor. • To consider the provision of optional extras when installing plant in noise and acoustic sensitive locations – this includes the potential for a 300mm base for anti-vibrational mounts, acoustic screen selected based on insertion losses calculated by an acoustician, or attenuation kit over unit. • Plantrooms and risers must have sufficient ventilation to avoid the build-up of heat and refrigerant gases, in-case of a leak – this must adhere to BS EN 378 [C.8]. Manufacturer will specify heat rejection and M&E consultant should review mitigation options. • Hybrid systems currently available on the market utilised R32 which is a flammable gas. As a result, risers and voids containing pipework with R32 should be ventilated to dilute any flammable gasses. • VRF units have an expected lifespan of 12-15 years [C.14]. When correctly installed it should require very little maintenance and be expected to last beyond 15 years. Commercial Consideration: N+1 number of cooling heat rejection units (where N is the number of units required to meet the design load) should be designed for centralised systems to provide insurance to plant redundancy where this is essential (such as systems serving IT comms rooms, or critical health care setting rooms). A control strategy should be in place to ensure longevity of equipment and potentially improve seasonal efficiency. Listed Consideration: For listed properties, availability of plant spacing must be more stringently considered. Placing units on external walls and roofs may face strict planning requirements. Assess suitable locations to protect heritage status of building. Heat Stress Considerations: Consideration to selecting units which are either oversized to ensure units are capable of providing the elevated cooling demand when external temperatures exceed 35degC. Layout of external plant and siting of equipment to consider strategies to draw in cooler air and avoid recirculation to avoid elevated temperatures beyond the manufacturers capability during future intense peak summer temperatures.	• Majority of units operate within a defined and non-adjustable coil temperatures, dictated by the refrigerant used. Care and attention to be undertaken for evaporating temperatures for units where dehumidification is not to be undertaken (rooms with pure sensible cooling such as IT comms rooms, or units without condensate drip trays). • Cooling terminal units are normally selected to provide cooling at cooler surfaces in space (chilled beams/ chilled panels, underfloor cooling) using above the dew point temperature of the spaces. • Provide sub metering for systems available through manufacturer supplied controllers, to be linked to a building BMS system. • Internal cooling to be designed on sound design assumptions for functional areas: i. CIBSE C design criteria to be used to size building cooling system. [C.17] ii.Cooling for spaces should be based on design criteria listed in CIBSE Guide A on operating temperatures in respect to heat losses and set points to ensure the thermal comfort and ensure correct sizing of HVAC systems. [C.18] iii.Cooling for offices to be designed to 24°C ± 2°C [C.11] iv.Spaces to be designed to prevent overheating in line with Building Regulations for Overheating. • Where installed, free cooling to be enabled when external temperatures are <=15°C. i.Systems requiring cooling across heating and cooling seasons shall consider using free cooling chillers. ii.Consideration for variable temperature systems to save power and raise the free cooling threshold • A climate class system that ranges from T1 to T3 is used in air conditioning to classify the ambient temperature of different climates around the world and the suitability of a product to operate in that climate. T1: moderate climate, ac/chiller: 18–43°C, heat pumps: -7 to 43°C. T2: cold climate, ac/chiller: 10–35°C, heat pumps: -7 to 35°C. T3: hot climate, ac/chiller: 21–52°C, heat pumps: -7 to 51°C. • Chillers and Heat pumps manufactured or supplied to the UK fall under the T1 Moderate Climate region. All units shall be capable of achieving 100% cooling duty at 43°C. CIBSE Guide B recommends chillers are selected with a maximum ambient temperature of 40°C. [C.9] • Designer to check the noise levels from the condensers are acceptable, considering locally occupied areas. This includes checking for vibration to the slab. Where the cooling system will operate at night set back cooling strategy, the designer shall check separately for night-time noise levels. • Plant to be maintained in accordance to the requirements set out in HVCA SFG/20 (References 09-02: 12-01, 12-02, 12-03) [C.13] • CIBSE Guide A provides guidance on operating temperatures in respect to heat losses and set points to ensure the thermal comfort and ensure correct sizing of HVAC systems. [C.18] • Consult CIBSE Guide H for guidance on control strategy to ensure control of setpoints and avoid parallel heating and cooling of spaces with multiple indoor units. [C.30]	• Units to be selected to operate with lower global warming potential to avoid being affected by proposed phase outs under European F-Gas Regulations. Refer to Components\Refrigeration for further selections. • The designer shall consider selection of a cooling system which enables heat recovery where simultaneously heating and cooling is anticipated. • Where buildings are anticipated to reach full occupancy in later stages, consideration to a modular cooling plant that will allow a phased installation. Future units to be able to benefit from latest technologies and improved efficiencies. • Systems connected to chiller systems provide better futureproofing with regards to phase out of refrigerants due to the decoupled chilled water and refrigerant based system allows the refrigerant based chiller unit to be replaced in isolation for compliance to potential future F-gas regulations. • VRF, split & multi-split pumps require piping from the external condenser to the internal cassette, so spatial assessment required. • The dual purpose heating and cooling systems are preferred for occupied areas (such as office areas, schools or residential zones). • Use of water distribution to serve terminal units would allow future flexibility of replacing the Hybrid system with modern at end of life without requiring works to replace all pipework and indoor units. • Natural ventilation should be prioritised over active or mechanical cooling systems in line with the GLA's cooling hierarchy. BSRIA BG1/2010 [C.19] provides guidance and more detailed explanations of different system types. BS EN 14511 (BSI, 2013) [C.20] provides standards for cooling systems. BS EN 1264 (BSI, 2008) provides relevant standards and BSRIA BG4/2011 [C.21] provides guidance. • Chilled water or Hybrid VRF systems are preferred for multi residential situations. Refurb & Listed Consideration: If retrofitting, the existing building may not have space allowance for pipe trays, this option may not be viable. Conduct spatial requirement assessment.	• Chilled water system recommended to be used with glycol due to external pipework, as an alternative to providing electric trace heating. [best practice] Where glycol is used, the system shall be designed with the correct performance criteria for heat capacity, density, and viscosity of the glycol mixture. • Designer to check for requirement for appropriate coatings and materials located in salty atmosphere that can rapidly corrode the air-cooled condensers. The chillers should be corrosion resistant and have weatherproof motors. • Refrigerant leak detection integral to the unit to be provided. • R32 Chillers eligible for two BREEAM credits due to the direct effect life cycle CO2 equivalent emissions (DELC) of ≤100 kgCO2e/kW and 1 credit due to all systems being hermetically sealed, with a tested leakage rate of less than 3g/year. (7) • For eligibility for 3 Credits under Pol01, which is split into two parts; impact of refrigerants (two credits) & leak detection (one credit). An R32 Cooling Plant should: - Have a Direct Effect Life CO2 equivalent emissions (DELC) of less than or equal to 100 kgCO2(equiv)/kW [2 Credits for Pol-01] - Be hermetically sealed with a tested leakage rate of less than 3g/year [additional 1 credit for Pol-01] • Use refrigerants with a GWP of less than 5, or if feasible, use no refrigerants. Several BREEAM credit can be obtained • Assess credentials for BREEAM Credit ENE01 awards 9 credits for developments with zero net regulated CO2 emissions. • Measured from a distance equal to that separating the unit and the next-door property, ground-source heat pumps must be below 42dB. Consult MCS 020 for guidance on the noise levels acceptable, devolved rules should also be consulted [H.8]. • Hybrid VRF systems use a more environmentally-friendly refrigerant, and less of it. Hybrid VRF uses less refrigerant than its equivalent VRF system (typically 25%), where connections to internal units are replaced with water. This helps to reduce demand for refrigerant manufacture and lowers the risk of leaks. Listed Consideration: If the building is a listed building, acquire both planning permission and listed building consent.	✓	✓	✓	✓	✓	✓	1) City of London Corporation Housing Design Guide Dec 2020 2) CoLC Climate Action Strategy 2020-2027	1) The checklist in the GLA's Energy Assessment Guidance is intended to assist designers to identify potential overheating risk in residential accommodation early on in the design process. It should be used at concept stage and should trigger the incorporation of passive measures within the building envelope and services design to mitigate overheating and reduce cooling demand in line with London Plan. 2)In line with the CoLC Climate Action Strategy 2020-2027, the systems shall maximise the use of renewable, aim for BREEAM Excellent Rating.		✓	✓	•		✓	✓	✓

VENTILATION

Overview

Ventilation is the drawing of outside air into a building (supply) and / or the ejection of inside air to the outside (extract).

A well-designed ventilation system can help a building:

- Maintain a comfortable temperature
- Expel airborne impurities and odours
- Purify the air intake to remove outside pollutants
- Reduce moisture build-up and mould growth, leading to higher occupant wellbeing and satisfaction

The two main types of ventilation are:

- **Natural Ventilation:** Natural forces drive air through building openings, such as, windows, doors, chimneys and wind towers etc. Natural ventilation rates depend on climate, building design and activity. Natural ventilation has the benefit of not requiring an energy input, however, there is no consistency or certainty in the ventilation rates at a given time.
- **Mechanical Ventilation:** Mechanical ventilation systems circulate fresh air using ducts and fans. Mechanical ventilation requires energy to drive the system, however, can lead to greater control of ventilation in a well-insulated building. Mechanical ventilation is also necessary when additional air is required to ventilate a space, for example sufficient fresh air in offices, or when air needs to be removed from a space, such as in toilets, which would not adequately be achieved by natural ventilation.

This category also includes humidification and dehumidification systems which are usually integrated within the ventilation system which regulates moisture content of air.

Interdependencies

The ventilation system often needs to work in conjunction with the other building services – with heating and or cooling and where needed (de)humidification delivered through the ventilation plant to maintain building comfort and environmental condition. Ventilation systems are therefore aligned closely with building controls such as the Building Management system (BMS). Improving lighting will decrease the internal gains of a building, increasing the heating load which may impact ventilation requirements.

There is a relationship between building airtightness, ventilation requirements and building fabric. New constructions should be built with high levels good fabric performance and airtightness to minimise heat loss. As a result, mechanical ventilation will be required which should be specified with heat recovery.

Well-designed thermal envelopes reduce localised surface condensation and interstitial condensation (a type of condensation that may occur within an enclosed wall, roof or floor cavity structure, which can create dampening).

Air Handling/ Mechanical Ventilation

An Air-Handling Unit (AHU) is used to circulate and recondition air as part of a ventilation, heating and/or cooling system. AHU takes in fresh air from outside and conditions it through filtration, heating, and cooling and then this air is distributed into the building. Heat can be recovered from returning to air which can reduce energy consumption, cost and carbon emissions. AHUs are available in a range of sizes, with various capabilities, but typically comprise an insulated box housing; filter racks or chambers, a fan (or blower), and sometimes heating elements, cooling elements, sound attenuators and dampers.

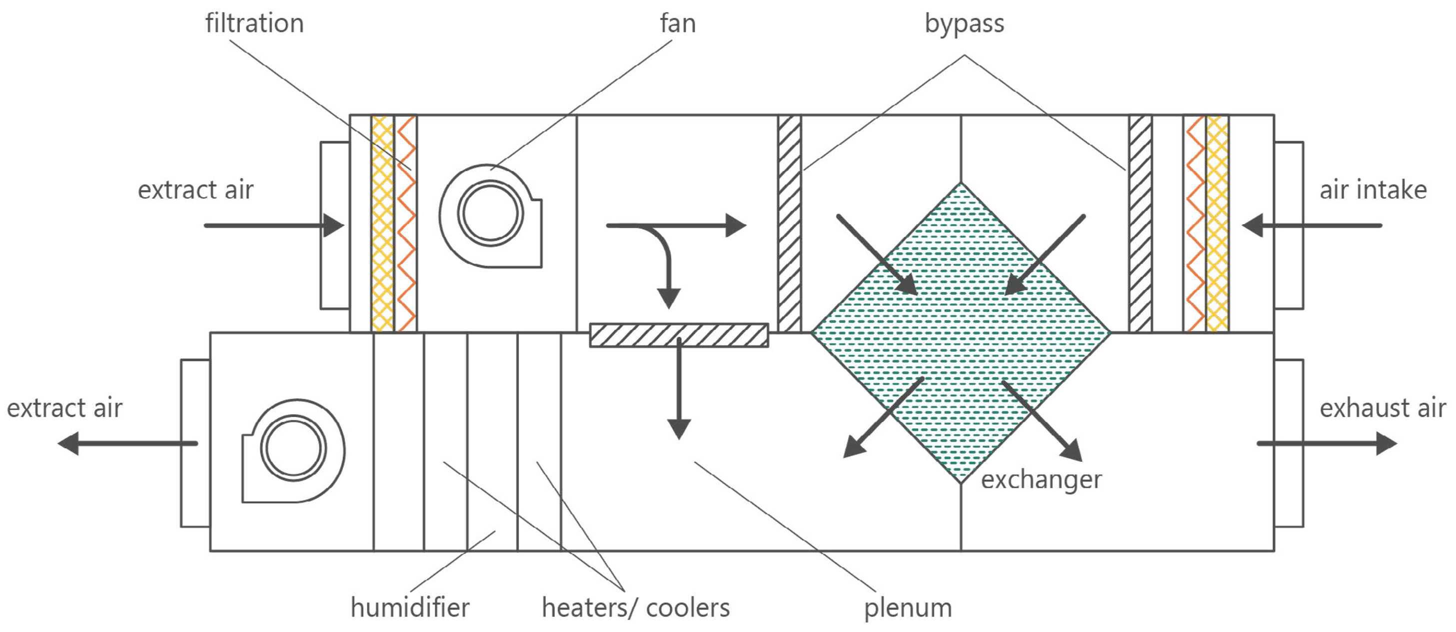

Figure 25 Example schematic of Air Handling Unit

Extract Only Ventilation

Mechanical Extract Ventilation refers to both centralised and de-centralised extract systems. These systems provide ventilation using a multi-point extract or single fan. Mechanical Extract Ventilation help protect buildings from mould, damp and condensation; hence they are often found in kitchens, WCs and shower rooms.

Heat Recovery

The main objective of a heat exchanger is the recover the energy that would otherwise be ejected by an extract ventilation system. A heat recovery unit comprises a directly driven fan, an exhauster and a heat exchanger.

Ground Air Heat Exchanger

Ground-air heat exchangers (also known as 'earth tubes') offer an innovative method of heating and cooling a building and are often used on zero carbon / PassivHaus buildings. Incoming ventilation air is simply drawn through 1.5 m deep underground pipes which pre-heats the air in the winter and pre-cools the air in the summer.

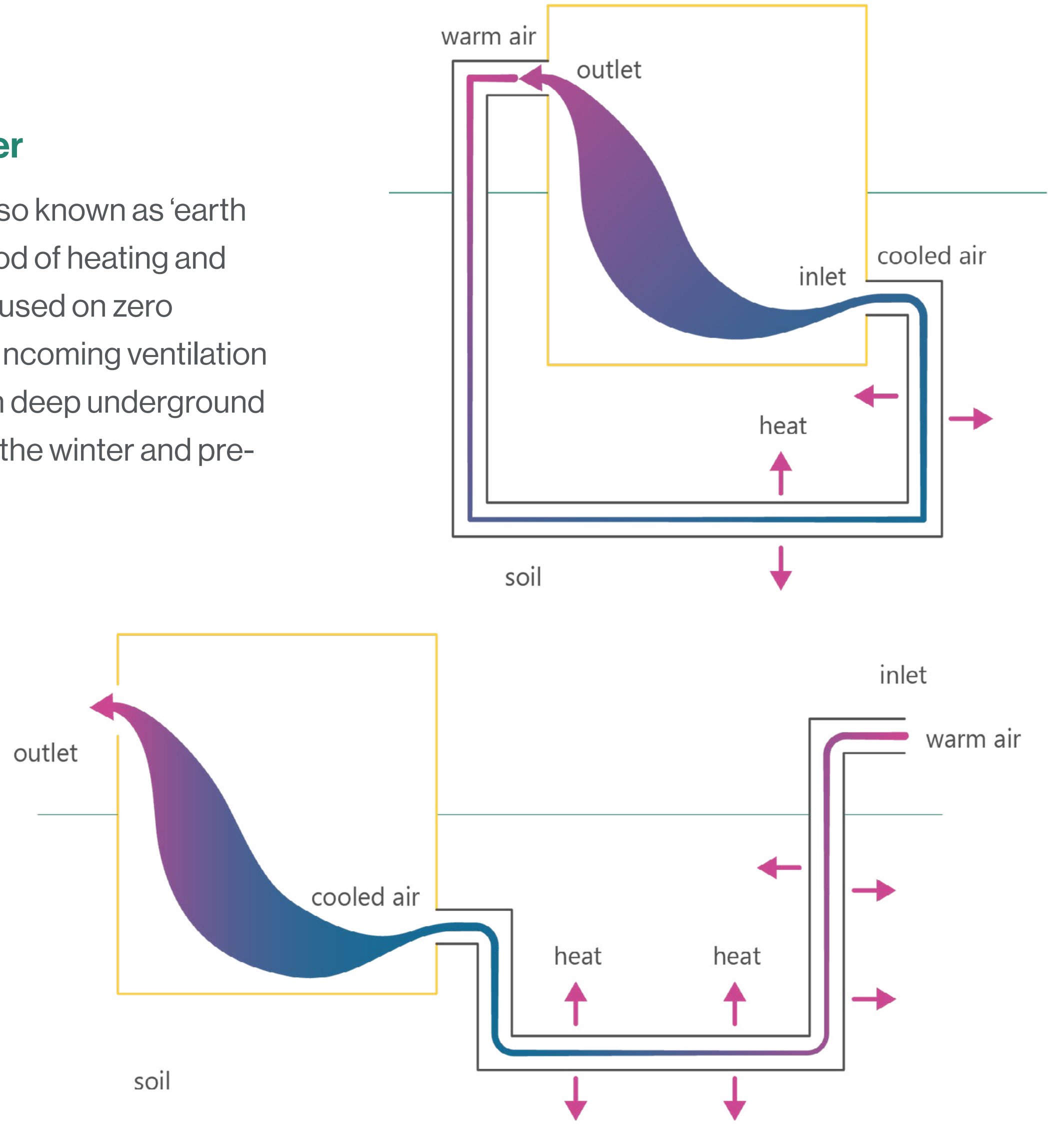

Figure 26 Example schematic of an Ground-Air Heat Exchanger

Dehumidification

High humidity promotes fungal growth and increases the release of volatile organic compounds. This can lead to respiratory illnesses, mental distress and damage to the building. The ideal relative humidity is 40-70%, although it is recommended to be below 60% in domestic dwellings, or any building fitted with mechanical air conditioning. CoLC has museums and galleries where the stability of the internal environment is a vital and basic factor in the preservation of art and objects, requiring temperature and humidity to be strictly controlled. Museums and galleries need to actively control the environment around exhibits, as temperature and relative humidity can fluctuate significantly daily. This requires constant operation of the humidification system, which therefore needs to be reliable and responsive.

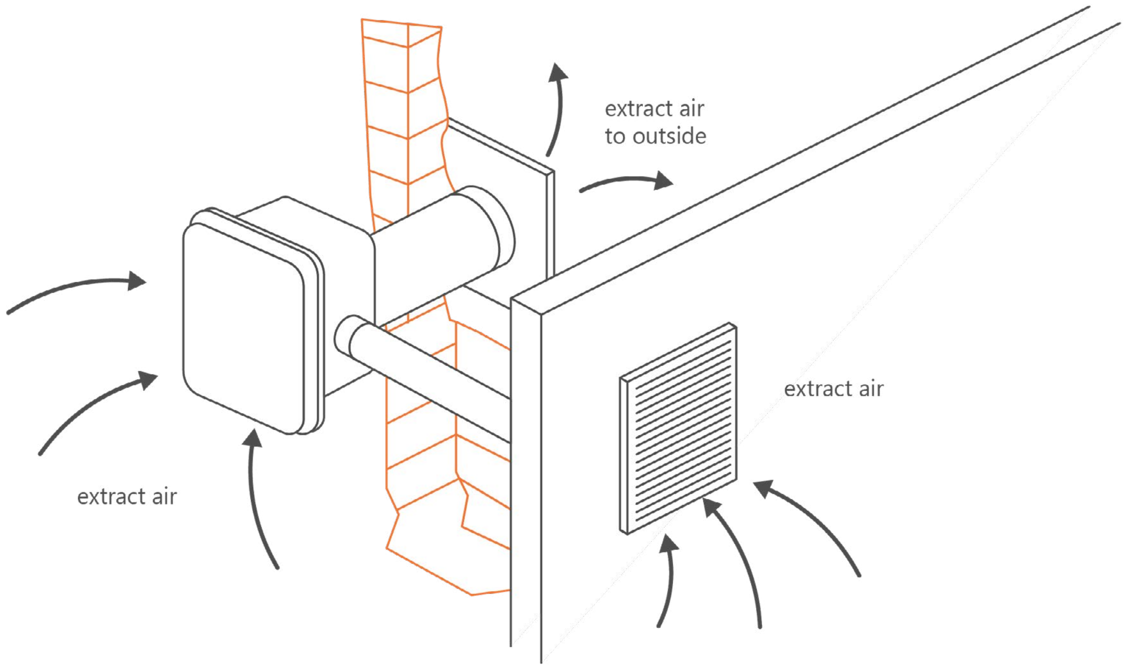

Figure 27 Example schematic of Localised Extract Fan

Humidity can be controlled by limiting sources of moisture, increasing ventilation, or removing moisture through dehumidification. Electrically powered dehumidification units, running on a closed cycle, draw air from a given space, heat and dry it, and then return it to the same space. The moisture from the air can be collected and taken to drain where necessary.

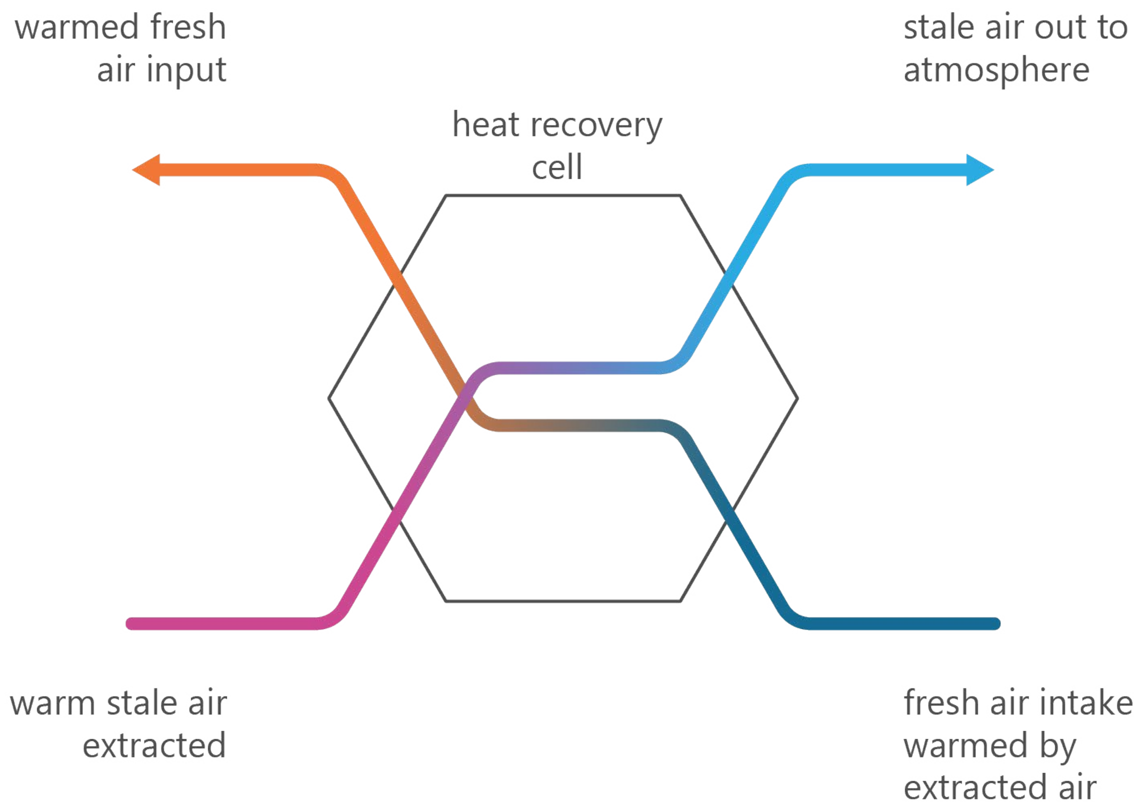

Figure 28 Example schematic heat recovery

TECHNOLOGY GUIDE - PERFORMANCE STANDARDS

Requirements	Performance Requirements	Measurement Standards / Test Conditions	Asset Type: New build	Asset Type: Refurb	Asset Type: Listed	Building Type: Residential	Building Type: Commercial	Building Type: Public (e.g. Schools)
Category / Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoLC Standard							
Ventilation								
Air Handling/ Mechanical Ventilation Performance Threshold and Requirements	• Central balanced mechanical ventilation system with heating and cooling: Maximum SFP = 1.6 W/(l.s) for new buildings. • Central balanced mechanical ventilation system with heating and cooling: Maximum SFP = 2.2 W/(l.s) for existing buildings. • Central balanced mechanical ventilation system with heating only: Maximum SFP = 1.5 W/(l.s) for new buildings. • Central balanced mechanical ventilation system with heating only: Maximum SFP = 1.8 W/(l.s) for existing buildings Extending SFP for additional components: •Additional return filter for heat recovery: +0.1 W/(l.s) •HEPA Filter: +1.0 W/(l.s) •Heat Recovery – thermal wheel system: +0.3 W/(l.s) •Heat Recover – other systems: +0.3 W/(l.s) •Humidifier / Dehumidifier: +0.1 W/(l.s) Specific fan powers (SFP) in air distribution systems in new buildings (existing buildings are provided in brackets) should be no more than: •Central balanced mechanical ventilation system with heating and cooling 2.0 (2.6) •Central balanced mechanical ventilation system with heating only 1.9 (2.2) •All other central balanced mechanical ventilation systems 1.5 (2.0) •Zonal supply system where fan is remote from zone, such as ceiling void or roof-mounted units 1.1 (1.4) •Zonal extract system where fan is remote from zone 0.5 (0.5) •Zonal balanced supply and extract ventilation units, such as ceiling void or roof units 2.3 (2.3) •Local balanced supply and extract ventilation system, such as wall/ roof units 2.0 (2.0) •Local supply or extract ventilation units, such as window/wall/roof units (e.g. toilet extract) 0.3 (0.4) •Other local ventilation supply or extract units 0.5 (0.5) •Fan assisted terminal variable air volume (VAV) unit 0.5 (0.5) •Fan coil unit (rating weighted average) 0.4 (0.4) •Kitchen extract, fan remote from zone with grease filter 1.0 (1.0)	Specific fan power is a function of the system resistance that the fan has to overcome to provide the required flow rate. BS EN 13779 Table A8 provides guidance on system pressure drop. [V1] Specific fan power is a function of the system resistance that the fan has to overcome to provide the required flow rate. BS EN 13779 Table A8 provides guidance on system pressure drop [CP4]	✓	•	•	✓	✓	✓
Extract only ventilation Performance Threshold and Requirement	Specific fan powers (SFP) in air distribution systems in new buildings (existing buildings are provided in brackets) should be no more than: •Zonal extract system where fan is remote from zone 0.5 (0.5) •Local supply or extract ventilation units, such as window/wall/roof units (e.g. toilet extract) 0.3 (0.4) •Other local ventilation supply or extract units 0.5 (0.5) •Kitchen extract, fan remote from zone with grease filter 1.0 (1.0) The maximum SFP may be increased where any of the following components are included in the installation: •High-efficiency particulate air (HEPA) filter +1.0 •Humidifier/dehumidifier +0.1 •Active chilled beams +0.3 •Transpired solar collector +0.3	Specific fan power is a function of the system resistance that the fan has to overcome to provide the required flow rate. BS EN 13779 Table A8 provides guidance on system pressure drop. [CP4]	✓	✓	•	✓	✓	✓
Heat recovery Performance Threshold and Requirements	Ventilation systems that provide supply and extract ventilation should be fitted with a heat recovery system where technically feasible. •Specific fan power for zonal supply and extract ventilation units with heat recovery should be 1.9 W/(l-s) for new buildings and existing buildings •Specific fan power for zonal supply and extract ventilation units with heat recovery should be 1.6 W/(l-s) for new buildings and existing buildings The Building Regulations Part L Non-Domestic Compliance Guide provides the following minimum dry heat recovery efficiencies for the following systems: • Plate heat exchanger: 50% • Heat pipes: 60% • Thermal wheel = 65% • Run around coil = 45% Part L1 of The Building Regulations states that all ventilation systems which provide both supply and extract within the same unit should have a heat recovery system with a minimum efficiency of 73%	•BS EN 15232:2012 Ventilation for buildings. Air handling units. Rating and performance for units, components, and section [V2] •BS EN 13053:2006+A1:2011 Application of a heat recovery system [HR.9] •BS EN 308:1997 Heat exchangers. Test procedures for establishing the performance of air-to-air flue gases heat recovery devices [HR.8]	✓	✓	•	✓	✓	✓
Ground Sourced Air Heat Exchanger Performance Threshold and Requirements	Performance of a ground-air heat exchanger is a function of the following: • air flow rate • temperature of the outside air • temperature of the inside • temperature of the ground As these are external factor, COP standards are not provided in building regulations, as of yet.	NA	•	•	•	•	•	•
Dehumidification Performance Threshold and Requirements	The ideal relative humidity is 40-70%, although it is recommended that it should be below 60% in homes or in any building where it can be controlled by mechanical air conditioning [DEH.2]. Reporting of performance shall be in line with BS EN 810:1997. The output shall be based on requirements of building activity and size. Levels of humidity depends on building usage and moisture production. Approved Document F1 produces the required maximum indoor air relative humidity for new residential, for the following moving average period: • 1 month = 65% • 1 week = 75% • 1 day = 85% For commercial developments, the dehumidification requirements will depend on building/room activity.	CIBSE TM 40 [DEH.1] Testing of performance should be against BS EN 810:1997 [DEH.3]	✓	•	•	✓	✓	✓

TECHNOLOGY GUIDE - TECHNOLOGY STANDARDS

Requirements	Technical standards - For references, please refer to the 'Appendix' tab			
Category / Sub-category	Further guidance on design considerations and how the technology category or sub-category should be installed to deliver the performance standard targets			
Ventilation	**Key Design and Operation Considerations**		**Compatibility / Future proofing**	**Environmental Impact**
Air Handling/ Mechanical Ventilation Performance	• An AHU generally requires filters to help condition the air prior to the air being supplied to the indoor spaces: The type of filters include: i. HEPA filters are efficient at removing airborne bacteria and can remove viruses from the air. ii. Bag filters provide a medium to high efficiency of filtration iii. Panel filters provide a minimum low efficiency filtration iv. Electrostatic filters use highly charged electrodes that ionise the air v. Carbon filters remove smells and gases • Consult BS EN 16798-3:2017 for advice on the location of intake opening and the position relative to the exhaust openings [AHU.1] • Consult BS EN 13053 Section 6 for the requirements around weatherproofing equipment within AHUs [AHU.2]. • To limit air leakage, AHUs should be manufactured to be reasonably airtight. This requires compliance with Class L2 air leakage, given in BS EN 1886:2007 [AHU.3]. • Ventilation systems that provide supply and extract ventilation should be fit with a heat recovery system where feasible. • Cleaning of ductwork must be considered in the design and installation phase. Guidance is provided in BS EN 15780:2011 [AHU.4]. • For area requirements of an AHU early in the design phase, consult BSRIA Rule of Thumb [AHU.5]. • For external AHUs, consult electrical engineer for the required ingress protection rating (IP) based on the fans located and weather exposure. • Where urban traffic is a source of pollution, the ventilation intakes should be as high as possible or on the less polluted side of the building. Listed Consideration: AHUs are commonly placed on rooftops, ensure this is feasible within the boundaries of planning permission.	• Air Handling Units should be capable of achieving a specific fan power at 25% of design flow rate no greater than that achieved at 100% design flow rate [AHU.3]. Residential Consideration: Part L stipulates that for a ventilation system that provides both supply and extract ventilation within the same unit, the unit should be fitted with a heat recovery system with a minimum efficiency of 73% [AHU.6]. Non-Domestic Consideration: The Non-Domestic Compliance Guide states a minimum hear recovery efficiency for the following heat recovery systems [AHU.7]: i.Plate heat exchanger = 50% ii.Heat pipes = 60% iii.Thermal wheel = 65% iv.Run around coil = 45% All systems should use thermal wheel heat recovery where feasible.	• Heating and cooling can be generated within the AHU itself, or it can be provided by connecting to the building's space heating system and chillers. • Heat pumps can be used in conjunction with AHUs, allowing heat and cooling to be produced using highly efficient systems, reducing the overall energy impact of the building. • For flooding prevention, which may impact intake/exhaust ducts at low level, consult the CoLC Pluvial/Fluvial Modelling and Intervention Measures for flooding. Listed and Refurb Consideration: AHU require ductwork to circulate the conditioned air. Ensure there is adequate space availability to facilitate this ductwork. This system may not be compatible for listed buildings or where there are planning restrictions. Retrofit Consideration: To reduce energy consumption, convert a Constant Air Flow system to a Variable Air Flow system if economically feasible. The critical components are the supply air terminal devices, which must have good controlling properties, a low noise level and provide a comfortable air flow and temperature pattern in the room within the variable volume flow range considered.	• To maintain sufficient Indoor Air Quality (IAQ), this first design consideration should be to place ventilation intakes away from sources of pollution, such as air exhausts, roads etc. The next step should be the implementation of filters. However, this can lead to higher energy consumption and noise generation. Consult the Institute of Air Quality Management Guidance on Air Quality for assessing IAQ and mitigation routes [AHU.10]. • Designers should consult CIBSE Technical Memoranda TM13 [AHU.8]: Minimising the risk of Legionnaire's disease to demonstrate that a design meets the requirements of the Health and Safety Executive's document. • BREEAM awards credits where the risk of waterborne and airborne legionella contamination has been minimized. The credit criteria require that: i. All water systems in the building are designed in compliance with the measures outlined in the Health and Safety Executive publication, Health and Safety: Legal Series: Legionnaires' disease. The control of Legionella bacteria in water systems. Approved Code of Practice and guidance on regulations [AHU.9]. ii. Or no humidification is specified or only steam humidification is provided.
Extract only fans	• Fans are available as window, wall or ceiling mounted, but are most effective when located at a high level, away from a source of fresh air such as an internal door. In a kitchen, the ideal location for extract ventilation is with a cooker hood [EOF.1]. • Ceiling mounted fans should be ducted directly outside. However, ductwork lengths as little as 1m can impact performance due to pressure losses. Consult manufacturer on pressure drops of selected equipment [EOF.1]. • Fans should be located not to produce drafts or intake combustion products from open-flue applications. Guidance is provided in Part J of the Building Regulations [EOF.2]. • Rigid ducts should be used wherever possible. Where necessary, flexible ducts may be used for final connections, but their lengths should be kept to a minimum. All flexible ductwork should meet the standards of BSRIA's BG 43/2013 [EOF.3] • When exhaust air is ducted and discharged at a single point, it is possible to recover heat with a run-around coil [EOF.1] • For external fans, consult electrical engineer for the required ingress protection rating (IP) based on the fans located and weather exposure. • Where urban traffic is a source of pollution, the ventilation intakes should be as high as possible or on the less polluted side of the building.	• Excessive under-pressures will lead to high fan energy consumption and could cause back-draught from flued appliances in adjacent spaces. A risk assessment should be conducted to highlight any problems. Part F of the Building Regulations provides guidance on avoiding back-draught in extract systems [EOF.4]. • Make up air entering the space cannot be heater or filtered [EOF.5]. Residential Consideration: Part F of the Building Regulations provides minimum extract rates (l/s) for residential rooms for both intermittent extract systems and continuous systems (values given in brackets) [EOF.4]: - Kitchen (cooker hood extracted to outside) =30 (13) - Kitchen (no cooker hood or cooker hood does not extract to the outside) = 60 (13) - Utility Room = 30 (8) - Bathroom = 15 (8) - Sanitary accommodation = 6 (6)	• BREEAM credits are available where room depths in occupied spaces exceed 15m, design calculations produced by an appropriate ventilation design tool, i.e. a type recommended in CIBSE Applications Manual AM 10, must be used to demonstrate that the ventilation strategy can provide adequate cross flow of air to maintain the required thermal comfort conditions and ventilation rates [EOF.6]. • As a general rule, the intake louvre should be separated from exhaust terminals and other potential sources of pollutions by a minimum of 1m. Increased separation may be required based on activity of room exhaust and other nearby pollutants [EOF.7]. • For flooding prevention, which may impact intake/exhaust ducts at low level, consult the CoLC Pluvial/Fluvial Modelling and Intervention Measures for flooding.	• Mechanical ventilation systems, including both continuous and intermittent mechanical ventilation, should be designed and installed to minimise noise. This includes doing all of the following [EOF.4]: i.Correctly sizing and joining ducts. ii.Ensuring that equipment is appropriately and securely fixed, such as using resilient mountings where noise carried by the structure of the building could be a problem. • Consult Building Regulations Part E for issues regarding sound proofing [EOF.8]. Passivhaus provides special standards for residential applications, this covers [EOF.9]: - <35dBA in the installation or plant room - <25dBA in living areas - <30dBA in functional rooms like the kitchen
Heat recovery	• The type of airflow regulation for MVHR should be constant volume. This provides content air flow rate regardless of changes to system pressure. This provides a balance between the supply and extract flows. • Consult the manufacturer for spatial requirements around the MVHR to allow for routine maintenance, without excessive disruption to the system's operation. • Filters should be accessible without the need for tools. • Use rigid ducts where feasible to reduce system pressure. Flexible ducts should be used only for connections to MVHR units and diffusers. • Minimise bends in the ductwork design to prevent pressure build up during the circulation routing. • A thermal bypass should be designed to operator when heat recovery is not advantageous, such as in summertime. • A Thermal wheel matrix can be epoxy coated aluminium or hydroscopic material to remove moisture from the airstream - this would reduce the amount of humidification needed to dry incoming winter air.	• For residential developments, Passivhaus suggests a practical upper limit for total static pressure on each side of the MVHR of 100Pa. This should be the total of the fresh air and supply duct side of the system and also on the extract and exhaust air side of the system [HR.1]. • An air permeability of 5m3/m2/h at 50 Pa is provided as a maximum in Approved Document F for the use of an MVHR system [HR.2]. For optimum performance, this should be below 3m3/m2/h at 50 Pa [HR.3]. • The maximum final pressure drop for each filter type from BS EN13053 are as follows [HR.4]: - G1-G4 = 150 Pa - F5-F7 = 200 Pa - F8-F9 = 300 Pa • Table 2.13 in CIBSE Guide B2 provides typical recovery efficiencies and typical pressure drops for each device [HR.5].	• Overheating control so that when heat recovery is not needed the heat exchanger is stopped modulated or bypassed. • Buildings should be airtight, as infiltration of outside air has a significant impact on the viability of heat recovery • Systems should be designed so that they can be commissioned to suitable ventilation rates so that spaces are not significantly overventilated	• A properly specified and installed MVHR system will recover heat to an efficiency level of more than 90% in the main unit, with a total electricity consumption level of around 0.3W/m3h [HR.2]]. • High grade filters should be specified in the system. A minimum filter grade of F7 for the intake and G4 on the extract is recommended [HR.6]. • Consult Building Regulations Part E for issues regarding sound proofing [HR.7]]. Passivhaus provides special standards for residential applications, this covers [HR.6]: - <35dBA in the installation or plant room - <25dBA in living areas - <30dBA in functional rooms like the kitchen
Ground-Air heat exchanger	• A ground heat exchanger can be buried horizontally in a trench or vertically in a borehole; it will depend on area available, ground conditions and cost. Vertical arrangements are more costly and require a specialist contractor to install, however, they are suitable in applications where land is limited. • The optimum pipe length is a function of pipe diameter and air velocity. Small pipe diameters of between 200 and 300mm are thermally more efficient. Pipes should be buried at a minimum depth of 2m and separated by 1-2m to allow heat dissipation. The optimum air velocity is typically 2m/s [GAHE.1]. • If the earth tube diameter is greater than 1.8 m, consider adding interior devices such as vanes and baffles to encourage air turbulence, thereby increasing heat transfer between the air stream and tube wall surface [GAHE.2]. • The designer should ensure the system provides adequate airflow. Once type of pipe, fittings, elbows, pressure losses and building load requirements are known, air velocities can be calculated using fan laws [GAHE.2]. Consideration: A ground survey should be conducted to ensure adequate spacing is available and any obstructions to laying the pipework have been identified.	• The design of the earth tube heat exchanger system must take into account these parameters in order to produce the temperature difference and heat transfer rate required of the system in a cost effective manner: i.Soil type ii.Soil moisture iii.Soil compaction • Operation of GAHE can be continuous, on a schedule, load dependant, seasonal, or a combination. This operation must be carefully considered as the surrounding soil may gain too much heat from a summer only operation or lose too much heat from a winter operation and be thermally depleted [GAHE.2],	• Systems can be driven by natural stack ventilation, but usually require mechanical ventilation. • Air can be circulated via air handling units, allowing filtering and supplementary heating/cooling. A simple controller can be used to monitor inlet and outlet temperatures, as well as indoor air temperatures [GAHE.1]. • This system can be used in conjunction with other HVAC systems and should not be solely relied upon to provide all heating and cooling loads of a building.	• To ensure a fast removal of the condensate, a continuous gradient of approximately 2-3% is necessary when installing the heat exchanger tube. The draining of the condensate can be done via a condensate collector shaft lying outside the building, or through a condensate drain installed in the building [GAHE.3].
De-humidification	• To minimise surface condensation, the duration and amount of heating should be regulated to maintain the internal surface temperatures above dewpoint. • In naturally ventilated buildings, background ventilation should be provided to dilute excessive levels of pollutants. For higher concentrations of vapour, this should be supplemented by mechanical ventilation or passive-stack ventilation [DEH.1] • Purge ventilation could be used to aid in removal of high concentrations of pollutants and water vapour release, where activities that produce these pollutants is intermittent [DEH.1] • Dehumidifiers should not be employed in continuous use, but they may be used to assist in reduction of water content within the air. Existing & Listed Building Consideration: Assessment of the fabric and building services condition is required to assess risk of moisture build-up. Roof and wall detailing, mortars and pointing would need to be addressed, as would ground levels, rainwater goods and drainage. Adequate ventilation is required to prevent moisture build-up.	• The ideal relative humidity is 40-70%, although it is recommended that it should be below 60% in homes or in any building where it can be controlled by mechanical air conditioning [DEH.2]. • Once excess moisture is removed from the construction phase, the rate at which humidity increase is determined by building activity and the occupants. To prevent excess and sustained humidity, designers should assess the amount of water vapour likely to be generated in the buildings and assess moisture inline with BS 5250:2021 [DEH.1]. • Dehumidification units are more effective where excess moisture is caused by high vapour pressure in well heated buildings, they are less effective at low temperature. Existing & Listed Consideration: Where a building is altered or extended, it should be determined what system(s) were in place to prevent condensation in the original building. These should then be retained and improved, if necessary [DEH.1].	• If a heating system maintains comfort conditions in the whole building at all times, dehumidification requirements are reduced. Residential Consideration: Dehumidification units are not appropriate for domestic buildings when used as a long term solution to moisture control .	• Excessive and sustained levels of moisture within a building can lead to the growth of mould. Mould presents a health hazard, which can cause respiratory allergies and can also cause mental distress and damage to the building (2). Building Management should identify any mould growth on internal surfaces and assess moisture control inline with BS 5250:2021 [DEH.1].

Requirements	Asset Type			Building Type			City of London Document Interlinks (TBC)		Key Stakeholders							
	New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)	City of London Documents and Guidance	Location and Description	Project Management	Mechanical Engineer	Electrical Engineer	Architect	Public Health Engineer	Fire Engineer	Contractor	Building FM / End User
Category / Sub-category							Task Bar	PPG Activities								
Ventilation																
Air Handling/ Mechanical Ventilation Performance	✓	•	•	✓	✓	✓				✓	✓	✓			✓	✓
Extract only fans	✓	✓	✓	✓	✓	✓				✓	✓	✓			✓	✓
Heat recovery	✓	✓	✓	✓	✓	✓	1) City of London Corporation Housing Design Guide Dec 2020 2) Guildhall Specification and tender summary for the mechanical works	1a) P61: The choice of mechanical extract ventilation (MEV) or mechanical ventilation with heat recovery (MVHR) should consider energy efficiency, air quality, maintenance burden, cost and embodied carbon. MEV systems are less suitable in areas of poor air quality due to the lack of filtration of external air. 1b) P85: NHBC Foundation's Guide: Part F 2010 — where to start: an introduction for house builders and designers (NHBC Foundation, 2011) and CIBSE Guide B2 (CIBSE, 2016). For MVHR the rules in NHBC Standards Chapter 8.3 of The Domestic Ventilation Compliance Guide (NBS, 2013) provides guidance on the installation, inspection, testing and commissioning of ventilation systems. 2a) P49: All fans and ancillary equipment to be mounted in accordance with manufacturer recommendations. The EC fans are to be supported on purpose-made fan decks, supplied by the fan manufacturer. All supports and hangers for the EC fans shall be rigid galvanized steel, securely supported to prevent vibrations or movements. All new smoke extract fans should withstand temperatures up to 400°C for up to 2 hours and should be equipped with new speed inverters. The new long case axial (LCA) fan should have a reinforced body and painted with polyester powder finishing coat. The fans should have a modular motor-impeller assembly and the housing should be with motor access door for easy connection. The impeller should be manufactured from cast aluminium with pitch angle. The motor shall be housed in a standard asynchronous squirrel-cage motor with IP-55 protection and Class H insulation certified 400ºC/2h. Manufactured with standard voltages: 230/400V 50Hz in three phase motors up to 3kW and 400V 50Hz for higher powers and 2 speed motors. IE3 efficiency motor from 0,75kW up to 45kW in single speed.		✓	✓	✓			✓	✓
Ground-Air heat exchanger	•	•	•	•	•	•				✓		✓			✓	✓
De-humidification	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓		✓	✓

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ELECTRIC POWER

Overview

Electric power (measured in Watts) is the rate at which electrical energy is transferred by an electrical circuit.

Increasing energy efficiency and reducing energy demand is essential to lowering GHG emissions. Electrical power is generated by the conversion of a source of energy such as fossil fuel, nuclear, wind or solar power. This power is provided through grid connection to distribute energy to where it is required. By sourcing more energy from renewable sources, the grid can decarbonise.

Interdependencies

If lighting systems have been improved from fluorescent to LED lamps, there may be an increased heating load for the building as internal gains are reduced. On the other hand, this change in lighting can reduced cooling loads. Power Factor correction is related to the loads and equipment that is installed in the building and will determine how viable and successful this opportunity would be. Finally electric vehicles will impact on the potential power demand for the building alongside introduction of solar PV. Power Factor Correction Equipment.

Power Factor Correction Equipment

Power factor is the ratio of energy a device is capable of transmitting to the output versus the total amount of energy it takes from the input power source. Power factor correction is an approach that can be used to increase the power factor of a power supply.

Power Factor is a unit-less number used in alternating current circuits. It can be used for many appliances, from a single piece of equipment (like a motor) to all the electrical consumption of a building. The number is determined by the ratio between true power and apparent power, shown by the formula Power Factor = kW/ kVA.

Having a power factor of one correlates to 100% of the electricity flowing through the distribution system being used. For a pure resistive load, the value of power factor is one. However, when the load becomes more inductive or capacitive, the power factor of the circuit decreases. Power Factor Correction technology can be applied at a load level or at a building main incoming supply level.

Electric Vehicles

All vehicles sold in the UK are required to be zero emission by 2040. This requires an increase in low emission vehicles such as Electric Vehicles (EV's) or hydrogen vehicles to be produced and sold. Hydrogen vehicles and charging infrastructure is still being developed, however electric vehicles and charging infrastructure have reached market maturity.

Vehicle charging is anticipated to take place at home, on the streets, and at destination sites. An EV charge point is required to charge electric vehicles. Charging points must be capable of providing a reasonable power output for each parking space. Charges within a commercial office building can be slower than sites such as retail destinations as the user is likely to be on-site for longer. At a retail destination the length of stay is likely to be shorter, and therefore a faster, more powerful charger is required. Each charger must be compatible with all vehicles which may require access to it and should comply with connection standards.

Lighting and Controls

Energy efficiency plays an essential role in achieving net zero and installing light-emitting diode (LED) lighting is one of the quickest and simplest measures to reduce energy consumption. LED lighting provides a more accurate colour rendering, a uniform illuminance output, reduced maintenance requirements and a longer rated lumen output than older forms of lighting. LEDs and other lamp types can be controlled by a range of methods, of which the most efficient are automated controls linked to a management system that can 'dim out' based on external daylight levels and occupation of the lit zone.

TECHNOLOGY GUIDE - PERFORMANCE STANDARDS

Requirements	Performance Requirements	Measurement Standards / Test Conditions	Asset Type			Building Type		
			New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)
Category / Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoLC Standard							
Electrical Power								
Power Correction Unit Performance Threshold and Requirement	There is no performance standard specifically for the power factor technology and devices of facilities and equipment connected to the grid, however the objective of power factor equipment is to move the performance as close to 1 as possible. Technology solutions should be assessed based on this criteria with the assumption that it will in or out to maintain the power factor better than a pre-set limit and should achieve a threshold of 0.95	BS EN 61439-1: Capacitors with a rating less than 500 V are prone to premature failure when used with low-voltage distribution systems containing harmonics generating loads. [IL10] BS EN 60831-1: Cover shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V [PF1] BS EN 60529: Specification for degrees of protection provided by enclosures for electrical equipment. [PF2] Power Factor Correction IEE Wiring Matters (2006) [PF3]	✓	•	•		✓	✓
EV Charging **Threshold and Requirement**	All points will support a charging rate of 3.6kVA. Some should be able to support 7kVA and where appropriate 22kVA/3 phase. On larger installations consider providing very fast charging e.g. Mode 4/DC. BREEAM requirements: Provide electric recharging stations of a minimum of 3kW for at least 10% of the total car parking capacity for the development.	Building Regulations Approved Document Part S. [EV1]	✓	•	•	✓	✓	✓
Internal lighting and controls Performance Threshold and Requirement	Threshold Performance is set out in Building Regulations Part L 1 for Domestic Buildings New or existing residential, each internal light fitting should have lamps with a minimum luminous efficacy of 75 light source lumens per circuit-watt. Should have local controls to allow for the separate control of lighting in each space or zone. Where installed in a new or existing residential, fixed external lighting should have both of the following controls. a. Automatic controls which switch luminaires off in response to daylight. b. If luminous efficacy is 75 light source lumens per circuit-watt or less, automatic controls which switch luminaires off after the area lit becomes unoccupied. If luminous efficacy is greater than 75 light source lumens per circuit-watt, manual control is acceptable. Threshold Performance is set out in Building Regulations Part L 2 for Non-domestic Buildings a. If it is general lighting, either: i. have an average luminaire efficacy of 95 luminaire lumens per circuit-watt ii. the Lighting Energy Numeric Indicator (LENI) method, following Appendix B in the Approved Document. b. If it is display lighting, any of the following: i. have an average light source efficacy of 80 light source lumens per circuit-watt ii. have a rated power usage no greater than 0.3W/m2 in each space iii. the LENI method, following Appendix B. c. For high excitation purity light sources, an average light source efficacy of 65 light source lumens per circuit-watt.	Building Regulations Part L 1 for Domestic Buildings [IL1] Building Regulations Part L 2 for Non-Domestic Buildings [IL2] SLL Lighting Handbook: Provides lighting requirements, including lux levels, colour rendering, colour temperature, glare and efficiency requirements [IL3] IES LM-80 Approved Method [IL4] IEC 62386: DALI-2 Lighting control system requirements [IL5] The Ecodesign for Energy-Related Products and Energy Information (Lighting Products) Regulations 2021 2021 No. 1095. [IL6]	✓	✓	•	✓	✓	✓
Internal Lighting Performance Requirements	Performance Specification for all Buildings Colour: CCT 3500K-6500K Efficacy: 160 lumens/watt Design life: Office Areas: L80, B20 @ >= 50,000 hours , 25°C ambient. Warehouse/industrial Areas: L80, B20 @>= 50,000 hours, 25°C ambient Power Factor: 0.9 min Flicker factor: < 15% Dimming range: 1-100% of measured output	SLL Lighting Handbook: Provides lighting requirements, including lux levels, colour rendering, colour temperature, glare and efficiency requirements [IL3] IES LM-80 Approved Method [IL4] IEC 62386: DALI-2 Lighting control system requirements [IL5] The Ecodesign for Energy-Related Products and Energy Information (Lighting Products) Regulations 2021 2021 No. 1095. [IL6]						
External lighting and controls Performance Threshold and Requirement	There is no specific performance threshold for this sub-category. Performance Standard 140 lumens/Watt (Meet BREEAM International New Construction requirement No.2 of ENE 03 External Lighting) [EL1] Have minimum Colour Rendering Index of CRI>70 or better. [EL2] Have maximum acceptable Chromaticity Tolerance of 5 or less SDMC from initial LED source.[EL3] L80 (100,000 hrs) B20 at -10 °C to +25°C as minimum.[EL3] Colour Temperature of 2700K-6500K. [EL3]	Light and Darkness in the City - A lighting vision for the City of London: Recommended improvements to the City's light quality through considering intensity, colour temperature, colour rendering, glare and scale. [EL3] BRE: BREEAM International New Construction: Requirement for 140 lumens/Watt to meet the Ene 03 credit (60lm/watt). [EL1] IES LM-80 Approved Method [EL4] TM-30-15: Colour rendering guide [EL2] Housing Design Guide 2020: Lighting requirements for steps and ramps - 30lux, 0.4 uniformity. [EL5]	✓	✓	•	✓	✓	✓

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TECHNOLOGY GUIDE - TECHNOLOGY STANDARDS

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Requirements	Technical standards - For references, please refer to the 'Appendix' tab				Asset Type: New build	Asset Type: Refurb	Asset Type: Listed	Building Type: Residential	Building Type: Commercial	Building Type: Public (e.g. Schools)	City of London Document Interlinks (TBC): City of London Documents and Guidance	City of London Document Interlinks (TBC): Location and Description	Key Stakeholders: Project Management	Mechanical Engineer	Electrical Engineer	Architect	Public Health Engineer	Fire Engineer	Contractor	Building FM / End User
Category / Sub-category	Further guidance on design considerations and how the technology category or sub-category should be installed to deliver the performance standard targets										Task Bar	PPG Activities								
Electric Power	Key Design and Operation Considerations		Compatibility / Future proofing	Environmental Impact																
Power Correction Unit	• Power Correction Units are most often installed as a free-standing or wall-mounted enclosure. They can also be installed as part of the main switchboard. • Where there is limited space in a switch room, consider a nearby separate enclosure, ensuring heat can be dissipated adequately. • Ensure a sufficient ingress protection rating is selected for the equipment. BS EN 60529 is a specification for degrees of protection provided by enclosures for electrical equipment. The IP rating specified should be provided by the manufacturer.	• Power factor correction is in operation 24/7 and should be serviced in line with manufacturer documentation or a minimum of annually. • Care must be taken in applying power factor correction to low-voltage distribution systems with harmonic generating (non-linear) loads. If the current distortion exceeds 25% or the amount of non-linear load exceeds 15%, detuned power factor correction should be considered. • Some capacitors with a rating of less than 500V are prone to premature failure. General Consideration: When selecting power factor correction equipment for a low-voltage distribution system which contains harmonic generating loads, check the equipment's suitability for this purpose with the equipment manufacturer.	• Any power factor correction plant must be sized to anticipate any growth in load and current. Power factor correction can be specified as either individual capacitors on specific loads or banks of fixed capacitors at the main incomer.	• Correcting power factor reduces reactive power and therefore overall energy consumption is less. Reducing reactive power can also provide increased electrical capacity within upgrading the existing distribution system.	✓	✓	✓		✓	✓	NA	NA		✓	✓				✓	✓
EV charging – Part S requirements only	• The number of charging points should equal the number of dwellings contained within the building. Spaces without EV charging must have cable routes installed where a residential building has more than 10 associated spaces, or more associated parking spaces than dwellings. a. The number of electric vehicle charge points that must be installed is the maximum number of points that is possible to install at an average cost of £3600 or less. b.If the requirement for the number of associated parking spaces which have access to electric vehicle charge points in that Schedule cannot be met because of the £3600 cap, cable routes for the charge points must be installed in the associated parking spaces that would have been charge points had it not been for the £3600 cap. c.If parking for the residential building is partly in a covered car park, the EV charging points shall first be applied to the non-covered spaces. If this does not fulfil the required number of EV charging points, then EV caballing is required in the number of spaces in the covered car park which, when combined with the non-covered spaces, equals the number of dwellings with associated spaces, or all spaces if the total number of spaces is more than 10. d.If all the parking spaces are covered and there are less than 10 spaces, then cable routes need to be provided in the number of associated spaces which corresponds to the number of dwellings. If there are more than 10 spaces, caballing needs to be provided for all spaces. [EV1] Residential Consideration: All residential car parking spaces must provide infrastructure for electric or Ultra-Low Emission vehicles. At least 20 per cent of spaces should have active charging facilities. All operational office parking must provide infrastructure for electric or other Ultra-Low Emission vehicles, including active charging points for all taxi spaces [EV4].	• Standard chargers Rated at 7kW AC, each with two type 2 connectors for simultaneous charging. These are typically compatible with all PiVs. [EV2] • Rapid chargers Units capable of delivering a maximum of 50kW DC via CCS and CHAdeMO connectors and optionally up to 43kW AC via a Type 2 connector.[EV2]	• Consider site electrical capacity and any potential requirements for upgrades either at an energy distributor level or local consumer unit. • Prepare immediate plans for phased installation of 26 rapid chargers and 65 standard chargers, meeting the forecasts under the low scenario for the City of London. [EV2] • The Corporation should make plans to install at least 65 standard chargers (7kW+), each with two connectors by 2025 (130 x 7kW sockets). These should be capable of charging two vehicles simultaneously. The analysis indicates that 15 of these could be dedicated to electric motorcycles by 2025. • Where it is essential to locate electric vehicle charging infrastructure on street, charge points will be installed in the carriageway rather than on the pavement. [EV3] • Encourage onward net zero travel by co-locating e-bikes and other shared mobility facilities with e-bike/ecargo bikes/PiV charge-points. [EV3]	• The carbon emissions from electric vehicles are dependent on the source of electricity. However, electric vehicles are far more efficient in fuel use/CO2 output than combustion engines. • An EU study based on expected performance in 2020 found that an electric car using electricity generated solely by an oil-fired power station would use only two-thirds of the energy of a petrol car travelling the same distance. [EV3]	✓	✓	✓	✓	✓	✓	NA	NA		✓	✓	✓			✓	✓
Internal Lighting and controls	• All new lighting shall be LED and the installation shall be designed to optimise the internal environment and appearance, whilst minimising energy consumption and maintenance activities. • The lighting solutions proposed shall meet the general recommendations of the relevant CIBSE Lighting Guides, especially Code for Lighting, LG7 [IL7], The Government Workplace Design Guide [IL8] and any other statutory guides for the areas concerned. • All proposed luminaires shall be of LED type, energy efficient and shall comply with the energy usage requirements of the Building Regulations Part L. • All LED luminaires as minimum shall meet following criteria [IL3]: -In full compliance with the requirements set out in the EMC Directive and be CE marked. -Suitable for operation on an electrical supply of 230V ± 10%, 50Hz, single phase -LM80 Tested -Have minimum Colour Rendering Index of CRI>80 or better -Have maximum acceptable Chromaticity Tolerance of 3 or less SDMC from initial LED source -L80 (50,000 hrs) B20 -Manufacturer warranty of 5 years • General lighting and display lighting should be metered by one of the following methods: - Dedicated lighting circuits with a kWh meter for each circuit. - Local power meter coupled to or integrated in the lighting controllers of a lighting management system. - A lighting management system that can both: i. calculate the consumed energy ii. make this information available to a building management system.	• High efficiency, low energy control gear shall be provided in order to satisfy the low energy requirements. The LED drivers will conform to the following performance requirements [IL3]: - LED Driver currents shall be between 240 mA and 1400 mA - LED Drivers shall have a minimum lifespan of 100,000 hours plus for warehouse areas. - LED Drivers shall have a minimum lifespan of 60,000 hours plus for office areas. - LED Drivers shall incorporate Constant Light Output. - LED Drivers shall be fully dimmable and incorporate 1-10 volt (for retrofits only) and/or DALI 2 interface control. [IL5] - LED Drivers shall be fully compatible with CMS/BMS systems. - LED Drivers warranty to be 10 years from the date of installation. **Controls** • Each luminaire shall be connected to a dedicated plug-in type ceiling connection unit "Marshalling Box" via a heat resistant flexible cord of maximum length of 5m. • Automatic lighting control system shall be afforded via a combination of presence or absence detection utilising standard passive infrared (PIR) or microwave occupancy (presence/absence) detectors with run-on timers and manual override switches where required. • When no movement has been detected within the space for a set period (typically 15mins) the lighting will default to off status within appropriate use of zone types. • Controls shall be selected based on the planned usage of the spaces including occupancy patterns, duration of occupancy, and the availability of natural light. • In addition to achieving average light levels, the lighting design shall also consider glare, uniformity, colour rendering, ceiling and wall illumination etc. in accordance with the recommendations made by CIBSE to ensure that good quality lighting is provided.	• Lighting control can be required to achieve adequate flexibility for the variety of tasks performed. Lighting design shall consider ease of maintenance and reconfiguration subject to space considerations and change of space usage.	• The LED luminaires shall be selected by considering the circular economy principles. Hence, the following principles shall be incorporated by the LED Supplier: - Reduce – Supply the most energy efficient fittings required to meet the correct illuminance levels. Therefore, an excess of LED fittings will not be supplied and installed. - Repair/Reuse - Repair faulty LED fittings if it's possible to reduce waste. - Recycle - When the LED fittings reach the end of their operating life they should be recycled to minimise waste. • The LED Supplier shall provide EPDs for all LED fittings. The EPBDs shall be produced according to EN 15804:2012+A2 'Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products' [IL9]. The EPBDs shall provide information on sustainability indicators, but not limited to, as per the below: - Carbon footprint of LED fitting - Energy usage of LED fitting - Impact to air pollution - Life-Cycle Assessment (LCA) of the proposed LED fitting. The LCA shall provide information of the LED fitting's lifetime environmental impacts.	✓	✓	✓	✓	✓	✓	1) CoLC Housing Design Guide 2020	4.1 Technology 4.2 Lighting Standards (48)		✓	✓	✓			✓	✓
External Lighting and Controls	• It is recommended that the current lighting standards are amended to align with the adoption of an updated transport strategy [EL6] and account for the following: - Improvements in the quality of light delivered by new source technologies. - Improvements in the flexibility of lighting delivered by new control technologies. - The needs of character and ambience - Requirements of the City of London Public Realm team - Requirements of the City of London Police - Requirements of the City of London Accessibility Group - Changes in best practice • LEDs use Ra 90, but Ra 80 may be used in historical areas to lower colour rendering. • LED Criteria [EL7]: - IP: External IP65 - Luminaire Warranty Period: 10 years (general lighting), 5 Years (Emergency lighting) - Have minimum Colour Rendering Index of CRI>70 or better. -Have maximum acceptable Chromaticity Tolerance of 5 or less SDMC from initial LED source. - L80 (100,000 hrs) B20 at -10 °C to +25°C as minimum. - Colour Temperature of 2700K-6500K. - All luminaires shall have integral DALI-2 control gear.	• The LED drivers will conform to the following performance requirements [EL7]. - LED Driver currents shall be between 240 mA and 1400 mA - LED Drivers shall have a minimum lifespan of 100,000 hours plus for warehouse areas. - LED Drivers shall have a minimum lifespan of 60,000 hours plus for office areas. - LED Drivers shall incorporate Constant Light Output. - LED Drivers shall be fully dimmable and incorporate 1-10 volt (for retrofits only) and/or DALI 2 interface control. - LED Drivers shall be fully compatible with CMS/BMS systems. - LED Drivers warranty to be 10 years from the date of installation. • Controls shall be selected based on the planned usage of the spaces including occupancy patterns, duration of occupancy, and the availability of natural light.	• Lighting control can be required to achieve adequate flexibility for the variety of tasks performed.	• High efficiency, low energy control gear shall be provided in order to satisfy the low energy requirements. • The LED luminaires shall be selected by considering the circular economy principles. Hence, the following principles shall be incorporated by the LED Supplier: - Reduce – Supply the most energy efficient fittings required to meet the correct illuminance levels. Therefore, an excess of LED fittings will not be supplied and installed. - Repair/Reuse - Repair faulty LED fittings if it's possible to reduce waste. - Recycle - When the LED fittings reach the end of their operating life they should be recycled to minimise waste. • The LED Supplier shall provide EPDs for all LED fittings. The EPBDs shall be produced according to EN 15804:2012+A2 'Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products' [EL8]. The EPBDs shall provide information on sustainability indicators, but not limited to, as per the below: - Carbon footprint of LED fitting - Energy usage of LED fitting - Impact to air pollution - Life-Cycle Assessment (LCA) of the proposed LED fitting. The LCA shall provide information of the LED fitting's lifetime environmental impacts. • In coastal areas up to 5km from the coast, the external LED luminaires shall be manufactured with corrosion resistance materials.	✓	✓	✓	✓	✓	✓	1) CoLC Housing Design Guide 2020 2) Light and Darkness in the City - A lighting vision for the City of London	1) 6.18 Homes: Lighting 2) 4.1 Technology 4.2 Lighting Standards (48)		✓	✓	✓			✓	✓

CONTROLS

Overview

Control and monitoring of a buildings electrical equipment such as ventilation, lighting, energy, fire systems, and security systems can be archived through management platforms. This allows flexibility and remote control of a building's temperature and lighting, to tailor it to the use requirements of the building through programming to reflect occupant schedules. Metering can be used to monitor energy use and report on that consumption.

Interdependencies

Controls have interdependences across all the building services - heating, cooling, lighting and ventilation, to provide information on optimise performance and support decision.

Building Management Systems (BMS)

The Building Management System (BMS) or with additional functionality the Building and Energy Management System (BEMS) is defined as a network of graphical user interface and controllers, with the ability to exchange information with each component of the system to coordinate control. A BMS enables the remote management of Heating, Ventilation and Air conditioning (HVAC) and therefore controls the environmental conditions (temperature, ventilation rate and/or air quality) in individual zones (rooms or areas) within a building. A BMS can be programmed to maintain environmental conditions within pre-set limits in a manner that reflects occupation schedules, occupation status and/or level of activity in the zone, whilst also taking account of internal environmental conditions, and the specific operating requirements of the zone. A BMS can help manage energy demand whilst achieving comfort for users, tenants and residents of buildings. As data is also consolidated within a single system, a BMS can improve reporting and decision making, supporting better building performance and reductions in energy use and GHG emissions.

Metering

Metering systems are products that are specifically designed to measure energy consumption, record, and distribute metered energy data, and analyse and report on energy consumption. They can be termed as sub metering systems which are capable of measuring the consumption at a local level and can be permanent aM&T (Automatic Monitoring & Targeting), or fitted as a temporary measure to assess energy usage in different locations through portable energy monitoring equipment. Metering, including half hourly metering can provide useful information to understand how energy is being used by the building and by the energy consuming plant. This information can help optimise the building, improve energy efficiency and drive energy and cost and carbon reductions.

TECHNOLOGY GUIDE - PERFORMANCE STANDARDS

Requirements	Performance Requirements	Measurement Standards / Test Conditions	Asset Type			Building Type		
			New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)
Category / Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoLC Standard							
Controls								
BMS Performance Threshold and Requirements	Building Regulations Part L: • For heating systems, controls shall be wired to fully switch off the heating appliance and pumps when no demand. • Domestic control systems for heating systems shall be installed in accordance with BS 5864. Ductwork to BS 5422. Building Regulations Part F: • Manual Control, where provided, should be within reasonable reach of the occupants. • Ventilation should be controllable either manually or automatically. • Controls with fans providing intermittent spaces with no window openings shall continue to operate the fan at least 15 minutes after the room is vacated. Energy Technologies List: • Control the to automatically control the individual environmental conditions in one or more zones within a building based on activity status and occupancy levels. • Set with at least 2 of the following operating modes: - normal/comfort mode - economy standby when unoccupied - off mode is switched off or operated at minimum level for fabric frost and equipment protection. Allows users to switch the zone manually to economy or off modes without disabling automatic zone controls.	Building Regulations: Approved Document L1 2021 [CHW.5] Building Regulations: Approved Document L2 2021 [CHW.6] Building Regulations: Approved Document F 2021 [HR.2] Cybersecurity – The system shall comply with the IEC 62443 series of standards d [BMS.4] From CoLC BMS Standardisation Specification: Network Controllers shall be tested and certified by the BACnet Testing Laboratory (BTL). [BMS.13] Energy Technologies List Accuracy of sensors: Conform to BS EN 15500-1:2017. [BMS.5] Controls capable of functioning in an EN 15232 Class A System. [BMS.6] Conform with the requirements of The Electromagnetic Compatibility Regulations 2016 or have an appropriate Conformity Assessment mark. [BMS.7]	✓	•	•	•	✓	✓
Metering Performance Threshold and Requirements	Threshold Performance: Building Regulations Part L: • The Building Regulations part L require energy meters to be provided to allow the use of fuel and power consumption to be monitored, and enable at least 90% of the estimated annua energy consumption of each fuel to be assigned to the various end-use categories (heating, lighting etc.) with separate monitoring of any renewable systems. • Buildings with a total floor area greater than 1,000m² are also required to have automatic meter reading and data collection facilities. • For heating systems, controls shall be wired to fully switch off the heating appliance and pumps when no demand. • Domestic control systems for heating systems shall be installed in accordance to BS 5864. Ductwork to BS 5422. Building Regulations Part F: • Manual Control, where provided, should be within reasonable reach of the occupants. • Ventilation should be controllable either by manual or automatic. • Controls with fans providing intermittent spaces with no window openings shall continue the fan to operate at least 15 minutes after the room is vacated. Additional Performance Standard Energy Technologies List • Shall be capable of: automatically capturing, retrieving, and storing energy metering data of electrical, gas and heat use electronically. Software should enable energy use by means of visualising energy performance data. • Apply separate submetering for specialist systems: Oil fuel flow, compressed air, and steam systems. • Minimum storage of data: half hourly. With data transferred to a data store on a scheduled basis. Data to be retained for a minimum of 2 years. • Software to be capable of identifying failure, missing data, issue with collection of data. Data should be cable of being collated and exportable in a standard format (ASCII or CSV format). Portable meters shall use Total Harmonic Distortion to measure energy usage and power quality, including logging of voltage dips and transients.	Building Regulations: Approved Document L1 2021 [CHW.5] Building Regulations: Approved Document L2 2021 [CHW.6] Building Regulations: Approved Document F 2021 [HR.2] Electricity meters shall meet the accuracy requirements of one of the following: • BS EN62053-21:2003, "Electricity metering equipment (ac) – Particular requirements - Part 21: Static meters for active energy (classes 1 and 2)". [BMS.8] • BS 8431:2010, "Electrical static metering for secondary or sub-metering. Specification" (BSI, ISBN 0 580 451178). Classes 1 or 2. [BMS.9] Gas meters shall meet the accuracy requirements of one of the following standards: • BS EN12261:2002, Gas Meters - Turbine gas meters. [BMS.10] • BS EN12480:2015, Gas Meters - Rotary displacement gas meters. [BMS.11] • BS EN1359:1999, Gas Meters - Diaphragm gas meter. [BMS.12]	✓	•	•	•	✓	✓

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TECHNOLOGY GUIDE - TECHNOLOGY STANDARDS

Requirements	Technical standards - For references, please refer to the 'Appendix' tab			
Category / Sub-category	Further guidance on design considerations and how the technology category or sub-category should be installed to deliver the performance standard targets			
Controls	**Key Design and Operation Considerations**		**Compatibility / Future Proofing**	**Material / Environmental Requirements**
BMS	It is recommended that: • The main BEMS (BACnet backbone) panel is located within the dedicated plant room of each development. Power to the BEMS panel shall be supplied off the Landlord's main LV switchboard. • There are outstations at each floor via a vertical fibre optic backbone within the riser(s) • Operator Stations and controllers are provided with uninterruptable power supplies (UPS) such that in the event of mains failure the equipment supported shall not power down and reboot. • The control panel is accessed from the front, and be built to all relevant British Standards. • The installation electricians plug the control panel gland plates to maintain the panel's IP rating. In accordance with the most recent edition of the IEE Regulations, all doors, mounting plates, and gland plates are earth bonded. • BMS monitoring and "panel healthy" lamps are required for all ELV power supplies. • LSF cable will be used for all internal wiring. Control wiring not exceed 0.75 mm².The current IEE regulations require power cables to be rated for the full load current. • To colour-code all cables: 3 Phase: Neutral: Brown, black, and grey. Control Wiring in Blue: White 24V AC, Grey OV AC ELV DC. [BMS.1]	• Adopt automatic control concepts that are recommended in BSRIA Application Guide AG 7/98 Library of System Control Strategies, or CIBSE Guide H Building Control Systems. • Be capable of control of the Heating, Domestic Hot Water, Ventilation Systems, and Chilled Water Systems, provide Status/mimic alarm monitoring of fire alarm/fire protection, control, manage and monitor the heating, ventilation and air conditioning building services within Landlords common areas, communal areas and energy centre, provide a central head-end computer within each building with facility for full access for both monitoring and control. • Critical alarms are to be set up to typically signal the following criteria, Boiler Lock out, VT and CT Pump Start Failure, Gas Valve Tripped, AHU Start Failure, Fire Circuit Tripped, Advisory alarms, AHU Filter dirty, Change of state etc. [BMS.1] • Recommended set points to be agreed with CoLC. From CoLC BMS Standardisation Specification: • All components of the system – workstations, servers, application controllers, unitary controllers, etc. shall communicate using IP/Ethernet, BACnet/BACnet Secure protocol, or Modbus protocol. • The BMS shall natively support commonly used open protocols such as BACnet (IP and MS/TP), Modbus (IP and RS485), and Web Services (SOAP, Rest, and others). It shall be possible to combine these protocols in suitable controllers to enable efficiency in integrating multiple systems and field network types. • The system shall support Modbus TCP and RTU protocols natively, and not require the use of gateways.	It is recommended that the BMS is Open Protocol which includes: • Each controller or controller location to be provided with spare hardware capacity for future additions of at least 20% of each type of point on the backplate, and incoming terminal connections. Universal inputs may be counted as either a spare digital or analogue point. • Select plant that is "packaged" with its own controls so that it is compatible and "tried and tested". • Consideration for future projects to use controls system using TCP/IP network over a simple 20mA current loop connecting field controllers. • Pneumatic control systems are not to be installed. From CoLC BMS Standardisation Specification: • Shall be approved by City of London for standardisation of the existing and future Building and Energy Management Systems. • The field bus shall support the use of wireless communications. •Workstation(s), Control Panel(s) and Controller(s) of modular design will provide distributed processing capability and allow future expansion of both input/output points and processing/control functions of up to 20%. • In line with the CoLC Heat Stress Interventions, the systems shall enable better visibility of live conditions in occupiable spaces, allowing users to select places to work and stay within buildings. • Smart heating controls must include: - Multi zone heating - External temperature sensing - geo-location controls / control via mobile devices - Occupancy control	• 1 BREEAM Credit is available for WAT02 [BMS.2], where the design must provide monitoring for water meters. Each usage point shall be connected to an appropriate utility monitoring and management system (BMS), for monitoring water consumption or a system that enables connection to a future BMS. The meters must have a pulsed output.
Metering	It is recommended that: • Metering system show all measuring system sensors and equipment clearly on the relevant system's schematic diagram. • Where local, portable or submetering are fitted, these are tamper-proof or sited away from common accessible areas to prevent tampering. • Incoming services are to be arranged to permit permanent a M&T and temporary portable sensors to be clamped onto either a pipe or cables to measure consumption using transducers. [BMS.1] • CoCL uses Team Signa as a centralised system for energy and water monitoring. Project managers and specifiers should ensure that this system is taken account of and included where appropriate as part of energy and water metering and reporting	• City of London Corporation Housing Design Guide Dec 2020 outlines that for residential units, occupants are able to review their heat and electricity consumption. If a communal heating system is proposed, an in home energy display device should be installed and clearly communicate heating bills, historic consumption, and contact.	• Be Open Protocol with storage accessible for analysis with standard office software (as .txt, .csv or ascii format). Installation of metering to permit future enrolment and certification of Nabers UK To be compatible with the approved, by City of London for standardisation of the existing and future Building and Energy Management Systems. • Developments should connect to existing heat networks wherever feasible. This would require metering of Energy by use of Heat Metering, as per the London Plan 2021.	• Two credits are available through Energy 02 Energy Monitoring Credits: [BMS.2], where: - One credit for providing sub-metering to major energy consuming systems. Energy metering systems are installed, that enable at least 90% of the estimated annual energy consumption of each fuel to be assigned to the various end-use categories of energy consuming systems (see Methodology). The energy consuming systems in buildings with a total useful floor area greater than 1,000m² are metered using an appropriate energy monitoring and management system. The systems in smaller buildings are metered either with an energy monitoring and management system, or with separate accessible energy sub-meters with pulsed or other open protocol communication outputs, to enable future connection to an energy monitoring and management system (see Relevant definitions). - The energy consuming end uses are identifiable to the building users, for example through labelling or data outputs. • An additional credit for submetering of high energy load and tenancy areas for an accessible energy monitoring and management system or separate accessible energy sub-meters with pulsed or other open protocol communication outputs to enable future connection to an energy monitoring and management system are provided, covering a significant majority of the energy supply to tenanted areas or, in the case of single occupancy buildings, relevant function areas or departments within the building/unit. Sub-stational systems include boiler systems in excess of 50kW or cooling systems in excess of 20kW, comprising of one or more plant feeding a common system. • NABERS UK provides further guidance for metering installation requirements [BMS.3]: - Installation of a M&T to enable the Post-Occupancy Evaluation and carried out with the same intent; to understand and close the performance gap. This is also a requirement for 2 credits for Energy 01. - Installation of a M&T water meters to enable post occupancy credits for Water Consumption and Water Monitoring (Wat 01 & Wat 02). - Water, Energy and Gas metering fitted to permit a Nabers UK Energy for Offices and Nabers Design for Performance to be undertaken and benchmarked with a rating from one to six starts to be assessed.

	Asset Type			Building Type			City of London Document Interlinks (TBC)		Key Stakeholders							
	New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)	City of London Documents and Guidance	Location and Description	Project Management	Mechanical Engineer	Electrical Engineer	Architect	Public Health Engineer	Fire Engineer	Contractor	Building FM / End User
							Task Bar	PPG Activities								
BMS	✓	✓	✓	•	✓	✓	1) CoLC BEMS Standardisation Specification 2) Climate Action Strategy 2020-2027] 3) City of London Corporation Housing Design Guide Dec 2020	1) CoLC Standards to be adopted to ensure modern design components are used, common philosophy is adopted across all assets and are compatible for future distributed processing capability across multiple assets 2) In line with the CoLC Climate Action Strategy 2020-2027, the systems shall maximise the use of renewable, aim for BREEAM Excellent Rating. 3) Further guidance on designing domestic controls can be found in the following: The Domestic Building Services Compliance Guide (NBS, 2013) and the Domestic Ventilation Compliance Guide (NBS, 2011) (and for communal systems, the Non-Domestic Building Services Compliance Guide (NBS, 2013)) set out minimum recommended control requirements for different systems. Guidance on design of control systems is given in the British Controls Industry Association's Controls for End Users —A guide for good design and implementation (BCIA, 2007). All contractors to use torque screwdrivers calibrated when installing or working on CoLC projects.		✓	✓		•	✓	✓	✓
Metering	✓	✓	✓	•	✓	✓	City of London Corporation Housing Design Guide Dec 2020	For residential units, occupants should be able to review their heat and electricity consumption. If a communal heating system is proposed, an in home energy display device shall be installed. This should clearly communicate heating bills, historic consumption, and contact. Further guidance on designing domestic controls can be found in the following: The Domestic Building Services Compliance Guide (NBS, 2013) and the Domestic Ventilation Compliance Guide (NBS, 2011) (and for communal systems, the Non-Domestic Building Services Compliance Guide (NBS, 2013)) set out minimum recommended control requirements for different systems. Guidance on design of control systems is given in the British Controls Industry Association's Controls for End Users —A guide for good design and implementation (BCIA, 2007). All contractors to use torque screwdrivers calibrated when installing or working on CoLC projects. Smart heating controls must include: - Multi zone heating - External temperature sensing - geo-location controls / control via mobile devices		✓	✓		•		✓	✓

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RENEWABLES

Overview

The UK's energy system is currently dominated by the use of fossil fuels and will need to change dramatically if we are to achieve net zero emissions. Decarbonising the energy system over the coming decades means replacing fossil fuels with 'clean' energy technologies such as renewables. Renewable energy is energy that is collected from resources that are naturally renewed, such as sunlight, wind, water movement, and geothermal heat. Solar thermal is covered in the Domestic Hot Water Section. Wind energy is not included in this section - whilst this is a viable technology at large scale, it has not yet been shown to be viable in the urban environment.

Interdependencies

Solar Hot Water needs to be specified with centralised hot water generation and sized for the hot water demand. Solar PV and battery storage need to be optimised to the building's electricity consumption. For roof top renewables technologies, consideration should be made for their installation when roof improvements/ relevant maintenance activities are being undertaken.

Solar Photovoltaics (PV) and Battery Storage

Photovoltaics (often shortened as 'PV') gets its name from the process of converting light (photons) to electricity ('voltage'). PV cells are made of multiple layers of semiconductor material, with one positive charged and negatively charged. When light enters the cell, some of the photons from the light are absorbed by the semiconductor, freeing electrons from the cell's negative layer to flow through an external circuit and back into the positive layer. This flow of electrons produces electric current. To increase their utility, dozens of individual PV cells are interconnected together in a sealed, weatherproof package called a module. These modules can build up flexibility of PV arrays which can be located on buildings such as the roof or facade or ground mounted.

PV power is generated as Direct Current (DC) and converted to Alternating Current (AC) for use in buildings and the grid by an invertor.

Battery storage can be specified alongside solar PV to maximise the use of energy generated by a PV on site, or optimise the export to grid at time where a higher sale price can be realised. Lithium-ion batteries are by far the most popular battery storage option today and control more than 90% of the global grid battery storage market for both vehicles and stationary uses. However, this market is evolving quickly with flow batteries and solid-state batteries increasing in market share.

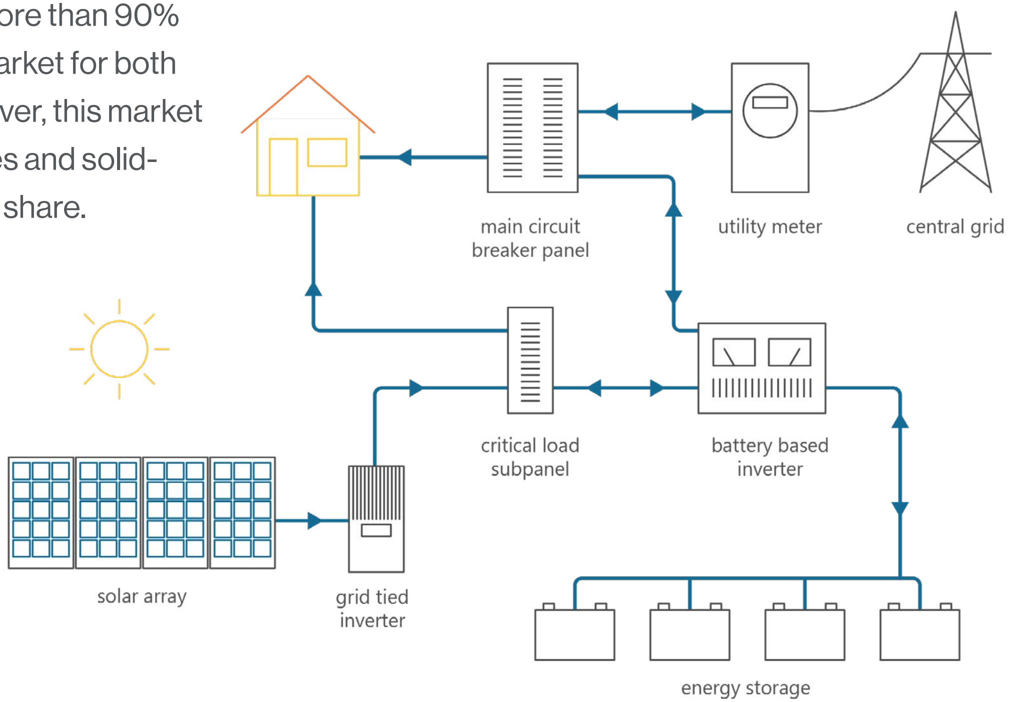

Figure 29 Example schematic of an Ground-Air Heat Exchanger

COMPONENTS

Overview

The components section covers major pieces of equipment in HVAC systems

Interdependencies

Fans should be sized accordingly with the ventilation rates required across the building. Where heating or cooling is provided by an air distribution system, the fan should be sized accordingly with the heat load delivered. Refrigerant selection will be based on heating and cooling loads required to serve the building.

Where hot water is provided by the main heat source of the heating system, the heat source is to be adequately sized to provide hot water at 60°C at peak demand. Key interdependencies for refrigerants are the heating and cooling plant that they are used in. For water quality this will also impact on the heating, cooling, domestic hot water services and other systems where water quality could impact the performance of the service.

Pumps

A pump is a mechanical device used to force a fluid (a liquid or a gas) to move forward inside a pipeline or hose. They are also used to produce pressure by the creation of a suction (partial vacuum), which causes the fluid to rise to a higher altitude.

Fans

Fans can be found in ventilation, heating and cooling (HVAC) systems within the fixed building services and can use up to 40% of all electricity of these systems.

Fans are designed to move the required airflow through a system, overcoming the total pressure loss. The characteristics of a fan can be obtained from manufacturers, and these would be based on standard testing methods measuring the performance of a fan, including volume flow rate and pressure over a range of conditions.

There are a number of measures to optimise the use fans including the inclusion of variable speed drives on the motors which matches to the motor speed with demand and leads to energy, cost and carbon savings.

Generally, there are 3 main types of fans:

- **Axial** – the gas flows straight through the fan along the axis of rotation. Axial fans are generally used for high airflows and not high pressures.
- **Radial** – the gas is drawn in an axial direction and leaves the impeller of the fan at right angles to the axis of rotation
- **Crossflow** – the air moves across the diameter of the impeller. Crossflow fans are generally used in split-systems.

Refrigerants

Refrigerants are a working fluid used for their physical properties which enables them to transfer heat from one area and remove it to another. Devices that use refrigerants to perform this function are used for cooling such as chillers, fridges, freezers, and also plant that provides heating such as heat pumps. Refrigerants are used in the vapour compression cycle. During this cycle the refrigerant is forced to change phase from liquid to gas and vice versa and during these phase changes the refrigerant will pick up or release heat. There are many types of refrigerants with different physical properties depending on the temperature requirements of the application.

Greenhouse gases like carbon dioxide and emissions from some refrigerants are contributors to global warming. This Global Warming Potential (GWP) of refrigerants is measured against carbon dioxide which has a GWP of 1. Some refrigerants also can have an impact on the ozone layer. This is described by a refrigerant's Ozone Depleting Potential (ODP) value, which refers to the relative harmfulness of a substance to the ozone layer (on a scale of 1-10). A further measure called Total Equivalent Warming Impact (TEWI) refers to the indicates the amount of greenhouse gases generated by a refrigeration plant in kilograms (kg) of carbon dioxide – but includes both the direct GWP impacts and the indirect impact of power consumption used by the equipment.

Water Quality

The term 'water quality' refers to the chemical, physical and biological composition of water in relation to the use that it is intended for. In the UK, water is generally supplied to consumers using a pump and pipe system, which is managed by regional water companies.

Water is typically drawn from rainwater in reservoirs, rivers or from groundwater and then pumped to water treatment works. At this stage the purity of water is ensured and tested. Chlorine may be added at this stage to kill any pathogens. The treated water is then stored and sent to the user via a distribution network. This section outlines measures to ensure water quality is monitored and maintained in buildings.

TECHNOLOGY GUIDE - PERFORMANCE STANDARDS

Requirements	Performance Requirements	Measurement Standards / Test Conditions	Asset Type			Building Type		
			New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)
Category / Sub-category	Performance standards and specifications from industry standards, regulations and guidance to set the CoLC Standard							
Renewables								
Roof-Top Solar PV Performance Threshold and Requirements	There are no specific performance requirements in standards for integrated solar PV systems. Key elements to consider for key components when specifying and some recommended threshold levels are below: Installing solar PV modules in the industrial "Bloomberg Tier 1 List PV Modules Use panels with the following requirements: • Module Efficiency: Not less than 20% • Degradation: rated power at Standard Test Condition (STC), the PV modules shall have a power warranty of minimum of 80% at STC after 25 years and 90% after 10 years • Panel product warranty: PV modules manufacturers would normally provide a product warranty of 25 years Specifying the unitary capacity of the PV panels (for instance, request a rated power at STC >300Wp with no negative tolerance allowed) will need to be agreed between client and installers (it would be highly dependent on the roof available area, dimensions or shape). - For the Inverters, some requirements towards the following key aspects (Efficiency and Lifetime) might be worth considering, but we would recommend to be agreed between client and installers > Efficiency:>98% > Expected inverter replacement: > year 12 of operation (due to drop in efficiency) > Total Harmonic distortion:Less than 3%	BS EN 15316-4-3:2017 Energy performance of buildings — Method for calculation of system energy requirements and system efficiencies [PV 1] Bloomberg Tier 1 List PV Modules Methodology : https://data.bloomberglp.com/professional/sites/24/BNEF-PV-Module-Tier-1-List-Methodology.pdf Example, most updated list (Nov. 2022) https://www.renvu.com/Tier-1-Solar-Panels-List-2022 [PV 4]	✓	✓	•	✓	✓	✓
Battery Storage Performance Performance Threshold and Requirements	There are no specific thresholds or performance requirements for Energy Storage Systems as this is a relatively new technology. Key considerations when evaluating this technology in the future will be discharge time, maximum cycles or lifetime, energy density and overall efficiency	IEC 62933-Electrical energy storage (EES) systems [PV 3]	✓	✓	•	✓	✓	✓
Components								
Pump Performance Performance Threshold and Requirements	Circulators/pumps should have class A energy efficiency rating as per EU legislation and pump motor with minimum IE4 (Super Premium Efficiency) with respect to IEC 60034-30-1. For motors which drive the fan system, the efficiency should adhere to Schedule 16, Ecodesign requirements for electric motors and variable speed drives. These provide minimum efficiencies (ηn) for IE3, and IE4 motors at different frequencies and rated power. Pumps have Eco-design regulations that are required to be met as a minimum. Commission Regulation (EU) No 547/2012 Annex III provides minimum efficiency index (MEI) and its corresponding C-value depending on the pump type and speed.	BS EN ISO 12100:2010, General principles for design. Risk assessment and risk reduction. [GN.3] BS EN ISO 13857: 2019, Safety of Machinery. Safety distances to prevent hazard zones being reached by upper and lower limbs. [CP1] BS EN ISO 13854: 2019, Safety of Machinery. Minimum gaps to avoid crushing of parts of the human body. [CP2] BS EN ISO 809: Establishes safety requirements relating to the construction, assembly, erection, operation and servicing of rotodynamic, rotary positive displacement and reciprocating displacement pumps and pump units.CP3]	✓	✓	•	✓	✓	✓
Fans Performance Performance Threshold and Requirements	Specific fan powers (SFP) in air distribution systems in new buildings (existing buildings are provided in brackets) should be no more than: • Central balanced mechanical ventilation system with heating and cooling 2.0 (2.6) • Central balanced mechanical ventilation system with heating only 1.9 (2.2) • All other central balanced mechanical ventilation systems 1.5 (2.0) • Zonal supply system where fan is remote from zone, such as ceiling void or roof-mounted units 1.1 (1.4) • Zonal extract system where fan is remote from zone 0.5 (0.5) • Zonal balanced supply and extract ventilation units, such as ceiling void or roof units 2.3 (2.3) • Local balanced supply and extract ventilation system, such as wall/ roof units 2.0 (2.0) • Local supply or extract ventilation units, such as window/wall/roof units (e.g. toilet extract) 0.3 (0.4) • Other local ventilation supply or extract units 0.5 (0.5) • Fan assisted terminal variable air volume (VAV) unit 0.5 (0.5) • Fan coil unit (rating weighted average) 0.4 (0.4) • Kitchen extract, fan remote from zone with grease filter 1.0 (1.0) For motors which drive the fan system, the efficiency should adhere to Schedule 16, Ecodesign requirements for electric motors and variable speed drives. These provide minimum efficiencies (ηn) for IE3, and IE4 motors at different frequencies and rated power. Fans have Eco-design regulations that are required to be met as a minimum. Commission Regulation (EU) No 327/2011 provides a calculation methodology along with target efficiency for certain fan types. The fan overall efficiency ηe calculated according to the appropriate method in Section 3 of Annex II must be equal to or greater than the target value ηtarget set by the efficiency grade to meet the minimum energy efficiency requirements (mentioned above).	Specific fan power is a function of the system resistance that the fan has to overcome to provide the required flow rate. BS EN 13779 Table A8 provides guidance on system pressure drop. [CP4] Approved Document F needs to be followed to comply to ventilation requirements to maintain indoor air quality in residential and buildings other than residential. [HR.2]	✓	✓	•	✓	✓	✓
Refrigerants Performance Performance Threshold	Threshold Performance - Global Warning Potential (GWP) - Single split air conditioners with a refrigerant charge below 3kg = <750 GWP - Stationary refrigeration equipment = From 2020 a ban on all refrigerants with GWP >2,500 and from 2022 GWP limit of 150 on multipack centralized refrigeration systems for commercial use with a capacity of 40 kW or more. Ozone Depleting Potential (ODP) Follow F-Gas Regulations Total Equivalent Warming Impact (TEWI) There are no regulations on limiting the TEWI value, as this will vary largely on factors such as: life of the system and system running time, which may limit the application of a refrigeration system.	Toxicity and Flammability classification: International Standard ISO 817 classify the toxicity of refrigerant [REF.5] Where the building uses refrigerants, in existing or new installed systems and plant: • all systems must comply with the requirements of EN 378:2016 and EN 378-2:2016	✓	•	•	✓	✓	✓
Refrigerants Performance Performance Threshold	Global Warming Potential For new buildings (and where feasible all buildings) any refrigerants used should have a global warming potential (GWP)≤10.	BREEAM New Construction (2018) [REF.4]	✓	•	•	✓	✓	✓
Water quality Performance Threshold and Requirements	Prescribed concentrations and values of microbiological and chemical parameters are set out, along with their measurement points and frequencies within the Water Supply (Water Quality) Regulations 2018 directive and national requirements. Of particular importance are data points measured at consumers taps as the point of compliance. The Heat Networks Code of Practice (CP1 2020) defines requirements for the water quality within district heating networks.	The Water Supply (Water Quality) Regulations 2018 [WQ.7] The Heat Networks Code of Practice (CP1 2020) [HP.17]	✓	•	•	✓	✓	✓

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TECHNOLOGY GUIDE - TECHNOLOGY STANDARDS

Requirements	Technical standards - For references, please refer to the 'Appendix' tab				New build	Refurb	Listed	Residential	Commercial	Public (e.g. Schools)	City of London Documents and Guidance	Location and Description	Project Management	Mechanical Engineer	Electrical Engineer	Architect	Public Health Engineer	Fire Engineer	Contractor	Building FM / End User
					Asset Type			Building Type			City of London Document Interlinks (TBC)		Key Stakeholders							
Category / Sub-category	Further guidance on design considerations and how the technology category or sub-category should be installed to deliver the performance standard targets										Task Bar	PPG Activities								
Renewables	**Key Design and Operation Considerations**		**Compatibility / Future proofing**	**Environmental Impact**																
Roof Mounted Solar PV	• Determine manufacturer and module type early in the design to ensure the final PV array is designed to suit the mounting options specified. • For the installation of a solar PV system on a buildings, several important aspects will need to be considered: - Refurbishment - roof structure: The rooftop structure will have to be assessed towards an structural survey, to confirm roof structure and supporting building will withstand the added loads that the PV panels and roof mounting structure will impose. - the PV array sizing - roof mounted system will need to use the available roof space, keeping a min of 1m to the roof eves and allow pass way to get access to the panels for maintenance (subject to the maintenance strategy and requirements). - Connection to grid: ENA Engineering Recommendations G99, G98 and G100 will need to be followed to comply and apply for a grid connection application to the DNO networks. - Shading produced by surrounding structures, buildings or trees will have to be minimized. It is advised to avoid permanent shading. Using micro-inverters might be considered to manage variable shading impact on the PV panels. - The solar PV array generation will need to be aligned with building energy demand, ideally utilizing 100% of the generated energy. • Solar PV key plant considerations: - when installing rooftop PV system, roof orientation and tilt as key considerations. - Roofs due south are recommended, with south-west and south-east still acceptable - Flat roofs would make recommendable to install PV panels on ballasted structures with titled panels or console systems	• The standard "IET Code of Practice for Grid Connected Solar Photovoltaic Systems - 1st Edition" provides guidance on the different aspects: - Section 4: System Performance - Section 6: Protection against lightning and overvoltage - Section 7: Inverter sizing, selection, location etc - Section 9: Grid connection / DNO approval - Section 11: Mechanical and civil design and installation - Section 13: Battery systems, applications and installation. • For the selection of equipment for PV arrays, UOC MAX shall be considered as nominal voltage. UOC MAX shall be determined in accordance Regulation 712.433.101.1. • 712.512.1.2 For the selection of equipment for PV arrays, ISC MAX shall be considered as design current. • ISC MAX shall be determined in accordance with Regulation 712.433.101.1. • 712.512.101 If blocking diodes are used, their reverse voltage shall be rated for 2UOC MAX of the PV string and their rated current shall be not less than 1.1 ISC MAX. The blocking diodes shall be connected in series with the PV strings. • 712.512.102 Enclosures for electrical equipment installed outdoors shall have a degree of protection not less than IP44 in accordance with BS EN 60529 and a degree of protection against external mechanical impact not less than IK07 in accordance with BS EN 62262. • 712.512.2.1 As specified by the manufacturer, the PV modules shall be installed in such a way that there is adequate heat dissipation under conditions of maximum solar radiation for the site. • Solar PV panels can be mounted on different rooftop types and at ground level. Solar panels perform well if facing anywhere between south-east and south-west, with preferable option facing south at an angle of 20 to 50 degrees. A PV array that faces due east or west will give about 20% less energy than one facing due south. • Site should ideally be free of shade, particularly between spring and autumn. Permanent shading could produce technical issues on shaded panels and should be avoided.	• Ensure an array is not installed where the building is located in a flood risk zone. • As solar energy is not a consistent energy source all year round, solar PV systems tend to be used in conjunction with other technologies. This includes, but is not limited to, conventional battery storage and grid connection support. • PV rooftop arrays to be eligible to become a small-scale generator within the Smart Export Guarantee (SEG) scheme. Electricity suppliers (SEG Licensees) have to pay small-scale generators (SEG Generators) for low-carbon electricity which they export back to the National Grid, • Charge regulators are required when the system contains storage batteries. This is usually where the system is not connected to the grid, and energy is stored during daylight for use during the hours of darkness. • A comprehensive metering system should be considered, especially if the system is rated above 20kW.	• Embodied carbon of the plant: The solar PV installation would enclose the embodied carbon within the manufacturing process of all its component parts. • Visual impact and Glint and Glare assessment: depending on the existence of nearby dwellings, it might be required to undertake "Glint and Glare" studies to analyse the impact on receptors and mitigate any issues • Standard "BS EN 50625-2-4:2017 - Part 2-4: Treatment requirements for photovoltaic panels" provides guidance to the treatment of photovoltaic panels until end-of-waste status is fulfilled, or photovoltaic panel fractions are recycled, recovered or disposed. • BREEAM credits are available where renewable or low emission energy source meet a percentage of the total building energy demand, the figures used for calculations of the percentage carbon reduction provided by LZC technology are based on the output from approved energy modelling software.	✓	✓	•	✓	✓	✓	NA	NA		✓	✓	✓			✓	✓
Battery Storage	• The applications of battery energy storage systems differ according to their purposes. The applications of EES systems are classified into three classes: a) class A applications: short duration/power intensive applications (with a duty cycle of less than 1 h); b) class B applications: long duration/energy intensive applications (with a duty cycle of more than 1 h), and c) class C applications: back-up applications. • A battery storage system co-located to a solar PV rooftop system will need to be assessed on a case-by-case basis depending on the application given to the battery storage system. • It might be beneficial and advisable: - Depending on the percentage of generated energy which is being consumed to cover the building demand - Depending on the benefit to increase the amount of solar energy being consumed by the building demand. Hence reducing energy export to the grid and reducing energy costs • The sizing of a potential battery storage system will be guided by: - the site demand vs solar PV generation analysis - a trade-off of costs (added CapEX versus the financial benefit of reducing consumption from the grid) • The standard IET CoP for Electrical Energy Storage Systems; 2020 2nd edition [BT.2] provides guidance on: - the specification and sizing for an EES for renewable time shifting (maximising self-use) which is the most probable application with a solar PV system in CoLC buildings - the specification and sizing for an EES for grid services (page 64) or back-up and island-mode system (page 60), which are less probable in an application of CoLC buildings	• The standard IET CoP for Electrical Energy Storage Systems; 2020 2nd edition [BT.2] will provide guidance on the different aspects: - Section 4: Electrical Energy Storage Systems (EESS) operating states and applications. - Section 5: Batteries (common storage devices, battery characteristics, charge profiles and battery warranties) - Section 7: EESS safety and planning considerations - Section 8: Specification of an EESS (system specification and sizing) - Section 9: Design of an EESS - Section 10: Network connection and DNO approval - Section 12: EESS Inspection and Testing - Section 14: EESS operation and maintenance • The standard "IET Code of Practice for Grid Connected Solar Photovoltaic Systems - 1st Edition" will provide guidance on battery systems and solar PV systems: - Section 13: Battery systems, applications and installation. • A risk assessment should be made to assess the need for surge protective devices. To protect the a.c. system, surge protective devices should be fitted at the main incoming supply to the premises.	• When combining a battery with a PV system, battery manufacturers should be consulted to assist with selection. Several manufacturers offer battery selection software that can assist in making a choice. • There are several suitable battery types that are compatible with solar PV, including some that are specifically manufactured for use in PV systems.	• Part 4-1 Guidance on environmental issues - General specification (PD IEC/TS 62933 -4-1:2017 Standard) [BT.3] describes environmental issues associated with EES systems, and presents guidelines to address the environmental impacts to and from EES systems including the impacts to humans due to chronic exposure associated with the mentioned environmental impacts. - Part 4-1, section 5 identifies environmental issues in EES systems - Part 4-1, section 6 provides environmental guidelines of EES systems, with guidelines for: i.issues from the EES system to the environment, ii.issues from the environment to the EES system and iii.issues from the EES system to humans with a chronic impact. - Part 4-2: Assessment of the environmental impact of battery failure in an electrochemical based storage system (BS EN IEC 62933-4-2 EES Systems Standard) [BT.4] defines the requirements and structure for the evaluation and reporting of the impact on the environment, from a failure of the electrochemical core of the battery-based energy storage system (BESS) due to internal and exogenous causes.	✓	✓	•	✓	✓	✓	NA	NA		✓	✓	✓			✓	✓
Components	**Key Design and Operation Considerations**		**Compatibility / Future Proofing**	**Material / Environmental Requirements**																
Pumps	• Where pumps are installed in Internal Plant Rooms these should be fitted with isolation valves, strainer before, pump failure alarms linked to the controller/BMS. • Pumps for variable flow applications, selecting a variable speed drive should be based on application. In applications that require flow or pressure control, particularly in systems with high friction loss, the most energy-efficient option for control is an electronic VSD, commonly referred to as a variable frequency drive (VFD) or inverters. A properly selected VSD can save up to 40% compared to standard on/off systems. • For redundancy, a common approach is a duty/standby-by configuration, where there is 1 pump doing 100% of the load, and one pump in standby in case of failure [PUM.1] (or a twin pump which can tolerate one pump failure). An alternative to this is to use three pumps and size each for 50% of maximum flow, where one pump is on standby in case of breakdown or regular maintenance [PUM.1]. For large volume water systems, using a great number of pumps has the following benefits [PUM.2]: a. for systems with wide-flow variation, the control system can ensure pumps operate at their peak efficiency b. higher levels of redundancy c. smaller pumps, non-return valves and pump isolating valves are easier to maintain and repair. • The pump motor starters/circuit breakers and controls should be enclosed within an electrical control panel. The front of the panel should include the mains isolator switch [PUM.2]. • An inverter should be selected to reduce energy consumption. A properly selected inverted can save up to 40% compared to standard on/off • Commission Regulation (EU) No 547/2012 Annex III provides design requirements for eco-design aspects of a pumping system. • Pumps for Variable Flow applications to be selected in line with best practice guidance to ensure controllable and operable at minimum and maximum fan speeds, avoiding flat region of a pump curve. The manufacturer shall provide confirmation that the minimum turndown requested is possible. Commercial Consideration: For factories, commercial and research establishments with high water usage, where loss of water supply will have major cost implications. Design a strong redundancy scheme to prevent downtime. General Consideration: As a rule, the maximum hydraulic output required in commercial buildings is rarely so large as to need more than a total of six pumps [PUM.2].	• For Open Look domestic water systems, UK water authorities are obliged to supply water at a minimum 70kPa (0.7 bar) at the point where the communication pipe joins the consumer supply pipe [PUM.3] For low-rise buildings (apartment blocks up to six floors) and light commercial applications, a simple variable speed pump set can be used. • Water pumps used on a closed loop circuit and the motor is rated at more than 750W should be fitted with or controlled by an appropriate variable speed controller on any variable volume system. • As an alternative to a duty-standby pump arrangement, is to use three pumps and size each for 50% maximum flow – the premise being that, should any one pump go out of service, 100% redundancy is still assured. • Low velocity systems result in lower system resistances, smaller fans, less noise and efficient designs. Pumps shall be sized based on system pressure drops with velocities as per CIBSE B (typically between 100-250 Pa/m for pipes <65mmDIA)	• 'Intelligent' controls are allowing optimised control and data collection. These systems ensure the optimum operation of pump systems in terms of resilience, efficiency and reduce maintenance frequency [PUM.1]. Consultation with manufacturers and control specialist recommended. • For better system performance and lower energy consumed by the pump, the designer should consider closed loop heating and cooling systems with larger temperature differences between flow and return to reduce flowrates. The use of a variable temperature flow systems are generally preferred, and opportunities to replace constant flow systems should be considered. [PUM.4]. • For improved energy efficiency, ensure a frequent wear and maintenance check is carried out. Wear can produce losses up to 25%. Retrofit Consideration: If a pump has been oversized, consider trimming or replacing the impeller as a cost-saving measure. Trimming should be limited to 75% of the pumps maximum diameter.	• Mechanical seal failures in pumps cause sometimes dangerous and harmful chemicals and other pollutants to leak that can cause serious harm to humans, plant and equipment, the environment and can even contribute to the greenhouse effect. To avoid this, seal less pumps are recommended to be used. • Pump vibration can be harmful to the pump itself, causing wear and tear to fixings, and generate excessive noise to surrounding areas. Sound and vibration isolation is required for all fans - these can be the following: - vibration isolation bell mounts. - buffers and stops to protect adjacent parts. - concrete plinths with antivibration mounts. • The specific type to be selected for specific weight, direction of forces, and movement required.	✓	✓	✓	✓	✓	✓	NA	NA			✓		✓		✓	✓
Fans	• European Union Directive 2009/125/EC established a framework for the setting of eco-design requirements for energy related products [FAN.1]. EU Regulations (EU) No. 327/2011 is the implementing directive for 2009/125/EC about eco-design of requirements for fans driven by motors with an electric input power between 125W and 500kW [FAN.2]. • Ventilation: Approved Document F needs to be followed to comply to ventilation requirements to maintain indoor air quality in both dwellings and buildings other than dwellings [FAN.3]. • The efficiency of a fan varies greatly across its operating range, while it is possible to design fans for 'high efficiency', it is also vitally important to ensure that the selection of the fan is correct and operating at its highest efficiency. • Specific fan power should be calculated in accordance with BS EN 16798-3 at the full design load. For fan coil units, use BS 8850 [FAN.4]. • Fans used for general air distribution that are rated at more than 1100W should be fitted with variable speed drives [FAN.4]. • Fans for variable flow applications, selecting a variable speed drive (inverter) should be based on application. In applications that require flow or pressure control, particularly in systems with high friction loss, the most energy-efficient option for control is an electronic VSD, commonly referred to as a variable frequency drive (VFD). The VFD losses are typically 2-5%. • A belt drive should be not be less than 90% efficient, if designed properly. • Fans in Variable Air Volume applications to be selected in line with best practice guidance to ensure controllable and operable at minimum and maximum fan speeds, avoiding flat region of a fan curve. The manufacturer shall provide confirmation that the minimum turndown requested is possible.	• The performance of the fan must be tested in accordance with BS 5801:2017. Fan performance data is usually specified in the form of characteristic curves or diagrams. These are standard characteristics determined on standard test rigs according to ISO 5801 [FAN.5]. • For ducted systems that are served by fans with a design flow rate greater than 1m3 /s, ductwork leakage tests should be carried out. Tests should follow the procedures in the Building and Engineering Services Association (BESA) documents DW/143 and DW/144 [FAN.4]. • BS 5801 provides a correlation between the total pressure increase and the drawn in airflow [FAN.5]. • In outputs above 200W, these are typically AC induction motors where the rotational speed is dependent on supply frequency and internal constructions and having efficiencies varying from 60-90%, over the range to 75kW. • BS 8233 is a standard governing acoustic control for a host of activities and HVAC elements within buildings e.g. Fan coil units, unit heaters and coolers [FAN.6]. • Low velocity systems result in lower system resistances, smaller fans, less noise and efficient designs. • Fans shall be sized based on system pressure drops with velocities as per CIBSE B (typically main ducts at no more than 6m/s, branches at no more than 4m/s, and final runs no more than 2m/s in spaces that are NR35).	• A system of fans can be arranged in a system in two ways: i. Series: two or more fans can be connected so that the flow passes through each fan in turn. This leads to a constant flow through each fan, but the system pressure will increase with each passing fan. Series operation can be used as a method of controlling the flow through a system by shutting down fans as appropriate, but the resistance to flow of those fans not being driven should be allowed for in the calculations and reference should be made to the fan manufacturers. ii. Parallel: Where two or more fans each receive air from, and deliver air into a common system, they are said to be operating in parallel. Fans operated in parallel should be of the same type, size and speed, otherwise undesirable performance complications may result. It is strongly advised that the advice of the fan manufacturer be sought when considering the use of fans in parallel. Future consideration for ECM (Electronically commutated motors) for fans in HVAC applications. These fans have the ability to vary the voltage and fan speed to match the ventilation demanded exactly, thereby reducing the energy consumption of fans. These are relatively new technologies and therefore currently expensive, however, prices are becoming competitive with larger quantities produced each year. ECM provides benefits over variable speed drives (VCD) by less noise, less heat generated and better controllability.	• For fans which are in noise sensitive areas, such as offices and bedrooms, filters are available to dampen the noise levels, these filters can be chosen based on the sound pressure levels produced by the fan system. •Fan manufacturers provide sound ratings in various ways such as average sound pressure level in a free field at a distance of 3m from the impeller from the fan inlet or discharge, or average sound pressure level in free field at a distance of 1 metre from the fan inlet or discharge. • Noise generated by the fans can transmit up and downstream of the air path, and cause noise to surrounding areas. Systems shall be located in areas where noise is not unwanted (to avoid bedroom, laboratory, classrooms, etc.). All fans above the NR (Noise Rating) requirement for the spaces shall be fitted with ductwork attenuators, the fans mounted on plinths with antivibration mounts or suspended with antivibration mounts, and attenuation kit around the fans as recommended from the manufacturer. • Fans suitable for potentially explosive applications such as gas or dust shall adopt ATEX Rated Fans that meet the requirements of the ATEX 2014/34/EU	✓	✓	✓	✓	✓	✓	NA	NA			✓				✓	✓
Refrigerant	• Where CO_2 is used as a refrigerant, it can be used without a recovery system, provided that the system installation requirements of BS EN 378 [REF.1] and the Institute of Refrigeration publication Safety code of practice for refrigerating systems utilising carbon dioxide refrigerant are met [REF.2]. • Likewise, ammonia can be used as a refrigerant without the need for a recovery system, provided system installation requirements of BS EN 378 [REF.1] and the Institute of Refrigeration Ammonia Refrigeration Systems Code of Practice are met [REF.3]. • Refrigerants in package room conditioning units, variable refrigerant volume/flow systems, hermetically sealed systems, air conditioning and heat pump systems shall be as stated in the technical schedules and shall have the lowest Global Warming Potential able to be offered by the manufacturer for the equipment in question. Leak Detection: •Consult BREEAM New Construction (2018) Credit POL 01 for guidance on how to achieve BREEAM credits through leak detection. This credit requires monitoring of the refrigerant pressure and the operating conditions to address the problem of natural fluctuation [REF.4]. An additional credit relating to refrigerant leak detection requires that: i. The building has no refrigerants, or ii. Systems using refrigerants are contained in a moderately airtight enclosure (or a mechanically ventilated plant room), and a refrigerant leak detection system is installed covering high-risk parts of the plant, or iii. An automatic permanent refrigerant leak detection system is specified, which is not based on the principle of detecting or measuring the concentration of refrigerant in air.	•The desirable characteristics of 'ideal' refrigerants are considered to be as follows: i.Normal boiling point below 0°C. ii.Non-flammable. iii.Non-toxic. iv.Easily detectable in case of leakage. v.Stable under operating conditions. vi.Easy to recycle after use. vii.Relatively large area for heat evaporation. viii.Relatively inexpensive to produce. ix.Low environmental impacts in case of accidental venting. x.Low gas flow rate per unit of cooling at compressor. • Where systems are being recharged with different refrigerants, these have to be checked and approved by the manufacturer to verify these have been tested and are safe for usage.	• Under UK and EU legislation, a ban came into force on 1 January 2020 that will ban refrigerants with a global warming potential (GWP) greater than 2500 being used to service or refill your refrigeration or freezer system. Existing F-Gas Registers will need to be amended to take into account the GWP of the refrigerant. • 5-49 CO2 equivalent (tonnes) - leak check annually • 50-499 CO2 equivalent (tonnes) - leak check every 6 months • 500+ CO2 equivalent (tonnes) - leak check 3 monthly • Usage of newer cooling system configurations shall be considered to reduce the amount of refrigeration required. For example, see Hybrid VRF guidance which use approximately 75% less refrigerant than standard VRF systems.	•Toxicity and Flammability classification: International Standard ISO 817 classify the toxicity of refrigerant into 2 categories of Class A (lower toxicity) and Class B (higher toxicity), and the flammability of refrigerants into 4 categories as follows [REF.5]: 1.Class 1 (no flame propagation) 2.Class 2L (Lower flammability) 3.Class 2 (Flammable) 4.Class 3 (Higher flammability).	✓	✓	✓	✓	✓	✓	CoLC Broad Street Place Mechanical Specification	Section M100400: Provides compliance requirements for refrigerants			✓		✓	✓	✓	✓
Water Quality	Ensuring adequate water quality levels within district heating networks, or within in-building system connected to communal heating networks, is a key priority to ensure operational performance and equipment longevity. BS EN 806 provides specifications for installations inside buildings conveying water for human consumption and BS 5422 outlines methodologies for specifying thermal insulating materials for pipes, tanks, vessels, ductwork and equipment operating within the temperature range -40°C to +700°C. - Backflow prevention devices are to recommend to be provided to all branch fittings -The cold-water distribution pipework is to be run in independent risers and horizontal distribution routes, where possible, to ensure heat gain from other services is kept to a minimum -The discharge pipework from the cold-water booster set is recommended to be fitted with an electromagnetic water conditioner and UV water treatment to protect the hot and cold-water systems and inhibit hard scale formation -The complete installation of the works shall include pressure testing, flushing and cleaning, chlorination and commissioning •Due to the hardness of water within the Greater London area a water softener(s) and or carbon/ceramic filters should be considered for installation to reduce levels of calcium and hardwater deposits on plant, such as water heaters, kettles, pipework ancillary components. Depending on the volume of water required to be treated a centralised water softener may be applicable or alternatively several smaller units serving individual plant or floors. This could reduce the need for filtered water taps within tenant demises.	• Domestic hot water is to be generated at 60°C to minimise the risk of legionella bacteria outbreaks in line with local guidance. • Dead legs are recommended to be reduced to a minimum and that temperature maintaining tape be installed to within 3m of a hot water outlet to outlet to alleviate the risk of legionella. • All pipework is to be insulated to protect against condensation and heat gain, to assist in avoiding the cold-water supply temperature rising above 20°C to reduce the risk of legionella within the system District Heating Where a building is to be directly hydraulically connected to a heat network, it is imperative that the heat network water quality adheres to the following standards. This is achieved via dedicated water treatment (chemical dosing, or otherwise) and filtration plant, typically installed at the network energy centre. Water quality should be tested regularly to identify deficiencies. • BSRIA BG 50/2013: Water treatment of Closed Heating and Cooling System • BSRIA BG 29/2020: Pre-Commission Cleaning of Pipework Systems • VDI 2035 Part 1: Prevention of damage in water heating installations. Scale formation in domestic hot water supply installations and water heating installations • VDI 2035 Part 1: Prevention of damage in water heating installations. Water-side corrosion • Water quality assessment in UK district heating systems (Greaves, 2019) • Water Treatment and Corrosion Prevention: Recommendations (Danish District Heating Association, 2015) Where a building is not directly hydraulically connected (i.e. separation achieved via a plate heat exchanger, or otherwise), an equivalent water treatment/filtration system should also be installed on the secondary (building side) hydraulic system to ensure compliance with the CP1 2020 guidance. Where retrofitting an existing building to a heat network (whether direct or indirect connection), specific consideration should be given to the existing water treatment regime in the building to ensure that the introduction of new water treatment regimes would not compromise the condition of the existing in-building (secondary or tertiary) system.	• No plant, equipment or installation should be in installed in a way that it cannot be routinely and regularly maintained in a safe and practical manner. • Maintenance requirements for all water installations are to be established and recorded within the building logbook. • AMR water and heat meters shall considered as part of the installation to allow for any future recharging or reporting functions	• Disposal of industrial or process water, including chlorinated water bust be authorised by the Environmental Regulator of the local water/sewage company. • Energy is lost from a variety of applications from increased calcium and hardwater deposits on plant, such as water heaters, kettles, pipework ancillary components. Reducing hardwater minimises scale deposits and improves all plant using water.	✓	✓	✓	✓	✓	✓	NA	NA		✓	✓	✓			✓	✓

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BEST AVAILABLE TECHNOLOGY ASSESSMENT GUIDANCE

The Best Available Technology (BAT) process has been developed to ensure that evidence is provided that the most appropriate technology has been chosen for the CoLC project. This approach will be similar for all Technology Categories where options are available. It is recommended the BAT assessment is undertaken for all projects for each Technology Category or an explanation is provided why it would not be appropriate.

See the BAT as a process TAB in the spreadsheet found ➲**here.**

The Best Available Technology (BAT)

The following section provides a summary of the activities that should be followed to provide evidence that the Best Available Technology (BAT) has been chosen for the CoLC project. This approach will be similar for all Technology Categories where options are available. It is recommended the BAT assessment is undertaken for all projects for each Technology Category or an explanation is provided why it would not be appropriate.

Topics		Strategic definition, preparation and brief	Concept design	Developed design	Technical design	Construction	Handover and close out	In Use
	Gateway 1	Gateway 2	Gateway 3	Gateway 4	Gateway 4	Gateway 5	Gateway 6	None
	RIBA 0	RIBA 1	RIBA 2	RIBA 3	RIBA 4	RIBA 5	RIBA 6	RIBA 7
BAT Guidance	Project Preparation 1. A subject matter expert should be identified early in the design stage to undertake the relevant assessment. The ten technology categories are fabric, heating, future heating, domestic hot water, cooling, ventilation, renewables, electric power, controls and components 2. Confirmation of the overall project requirements including the energy and carbon targets (including net zero) targets should be undertaken.	Technology Long List and Short List Selection: Evidence of optioneering process of potential technologies and initial decision tree assessment based on building type and project. 1. Long List Selection: Develop a long-list of suitable technologies (sub-categories) that may be suitable for the project. Identify interdependencies with other technology categories. Any clearly unsuitable technologies should be removed from the Long List. Ensure that interaction and interplay between other technical 'Categories' is considered at this stage and fed back into long list options. 2. Short List Selection: An initial review of the short list of technologies should then be developed using a technology decision tree assessment based on information in LETI Climate Emergency Design guidance and CIBSE TM53 Refurbishment for non-domestic buildings. Ensure that interaction and interplay between other technical 'Categories' is considered at this stage and fed back options asessment.	BAT Assessment This should be a feasibility assessment of the Short List of technologies to provide the evidence to demonstrate the most suitable technology has been chosen. The feasibility assessments needs to compare technologies on the following three elements: 1. Technology Assessment: (a) Review the technology maturity and compatibility to deliver the design and delivery requirements including, space, utility requirements, planning and interdependencies with other building services and fabric. (b) Technology is future-proofed with respect to GHG mitigation and resilience to climate risk 2. Carbon Emissions: (a) Minimise operational carbon emissions (based CIBSE TM54 Evaluating Operational Energy Performance at the Design Stage, or similar), (b) Assessment and comparison of technologies that minimise whole life carbon emissions 3. Project Costs (a) Comparison of operational energy costs of different technologies and whole life costs where appropriate The results of the BAT assessment should provided in a report outlining the chosen technology based on these three parameters with a focus on delivering a net zero building.	Monitoring and Performance Approach / Review BAT 1. Review and update the BAT Assessment 2. Monitoring and Performance approach: During the design stage an approach including monitoring period and data requirements should be developed for key technologies such as heating, cooling, domestic hot water, ventilation and renewables to ensure that the technology is performing as the design intention and Performance Standards. Roles and responsibilities for collecting this data and reporting performance should also be developed alongside actions if the technology is not performing as the design intention.	Information Requirements: 1. During the Detailed Design and Construction Phase evidence should be gathered from suppliers to confirm that the technology meets the Performance Standards and the requirements of the BAT assessment.	Information Requirements: 1. During the Detailed Design and Construction Phase evidence should be gathered from suppliers to confirm that the technology meets the Performance Standards and the requirements of the BAT assessment.	Information Requirements: 1. During the Detailed Design and Construction Phase evidence should be gathered from suppliers to confirm that the technology meets the Performance Standards and the requirements of the BAT assessment.	Monitoring and Reporting 1. Based on the monitoring approach developed at the Design Stage, undertake regular monitoring and collection of operational energy data to confirm BAT and the Performance Standards outlined in this Net Zero Technology Guide have been met. This should be undertaken for at least 3 year's after contract completion.

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Introduction

This section identifies the sources of industry good practice which were used to develop the Technical and Performance requirement tables.

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SHW.5	Department for Business, Energy and Industrial Strategy. (2019). Energy Technology Criteria List. London.
SHW.6	British Standards Institution. BS EN 12975: 2022. Solar collectors. General requirements. London.
SHW.7	British Standards Institution. BS EN 12976-1: 2021. Thermal solar systems and components - factory made systems. General requirements. London.
SHW.8	BS EN ISO 9806:2017 Solar energy - solar thermal collectors - test methods (ISO 9806:2017)

Cooling	
C.1	Department for Levelling Up, Housing & Communities, (2022). Approved Document L, Conservation of fuel and power, Volume 2: Buildings other than dwellings.
C.2	Standard, British, (2018). BS EN 14511-2: 2018. Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors Test conditions. British Standards.
C.3	Ministry of Defence. Ministry of Defence JSP 850.
C.4	BREEAM. (2018). BREEAM New Construction 2018 (UK). BREEAM.
C.5	Directive 2009/125/EC of the European Parliament and of the Council, (2009).
C.6	Directive 2014/30/EU of the European Parliament and of the Council, (2014).
C.7	BSRIA, (2011). Rule of Thumb: BSRIA, 2011. BG 9 / 2011.
C.8	European Standards, (2020). BS EN 378-3:2016+A1:2020 Refrigerating systems and heat pumps. Safety and environmental requirements Installation site and personal protection.
C.9	CIBSE, (2016). "Guide B," London.
C.10	BRE Trust, (2009). Energy Management in the Built Environment - Review of Best Practice. BRE Trust.
C.11	BCO Guide to Specification, (2009). Cooling Section.
C.12	Department for Levelling Up, Housing & Communities, (2022). Approved Document O, Building regulation in England setting standards for overheating in new residential buildings.
C.13	SFG20: Software.
C.14	CIBSE, (2014). Guide M Maintenance engineering and management, London.
C.15	Microgeneration Certification Scheme, (2018). MCS 007: Product Certification Scheme Requirements – Heat Pumps.
C.16	BRE Trust (2013). BREEAM, "Pol 01 - Impact of Refrigerants," BREEAM, 2013. [Online]. Available: https://kb.breeam.com/wp-content/plugins/breeamkb-pdf/pdf/?c=266. [Accessed 02 08 2022].
C.17	CIBSE, (2016). Guide C, London.
C.18	CIBSE, (2015). Guide A: Environmental Design, London.
C.19	BSRIA. (2010). BSRIA, 2010. BG 1/2010.
C.20	Standard, British. (2018). BS EN 14511-2: 2018. Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors Test conditions. British Standards.
C.21	BSRIA: BSRIA, (2011). BG41 / 2011.
C. 22	BS EN 1264-4: 2021. Water based surface embedded heating and cooling systems Installation.
C.23	BS 4485-2: Water cooling towers. (1988). Methods for performance testing.
C.24	Notification of Cooling Towers and Evaporative Condensers Regulations 1992 (SI 1992/2225).
C.25	BSRIA, (2011). Rule of Thumb. BSRIA, 2011. BG 9 / 2011.
C.26	BSRIA, (2009). Model Commissioning. BSRIA, 2009. BG 8 / 2009.
C.27	Health and Safety Executive. (2013). HSG274. Part 1 Legionnaires' disease: The control of Legionella bacteria.
C.28	CIBSE, (2013). TM13 Minimising the risk of Legionnaires disease.
C.29	Health and Safety Executive. (2013). Legionnaires' disease. The control of legionella bacteria in water systems.
C.30	CIBSE, (2009). Guide H: Building Control Systems, London.
C. 31	The European Commission, (2012). Commission Regulation (EU) No 206/2012, Official Journal of the European Union.
C. 32	BEIS. (2021). Energy Technology Criteria List. BEIS.
C. 33	Building Regulations. Approved Document Part L. 2021.
C. 34	BSI. BS 1566-1:2002+A1: 2011. Copper indirect cylinders for domestic purposes - Open vented copper cylinders. Requirements and test methods. BSI Knowledge, 2002.
C. 35	European Standards. BS EN 60379: 2004. Methods for measuring the performance of electric storage water-heaters for household purposes.
C. 36	BS EN 14705:2005
C. 37	Heat exchangers. Method of measurement and evaluation of thermal performances of wet cooling towers
C. 38	Eurovent 9/12 (2016). Performance Efficiency Standard for Evaporative Cooling Equipment.

Ventilation	
General	
V.1	BS EN 13779:2007 Ventilation for non-residential buildings - Performance requirements for ventilation and room-conditioning systems (incorporating corrigendum May 2014) (Withdrawn)
V.2	BS EN 15232:2012 Energy performance of buildings - Impact of building automation, controls and building management
Air Handling/ Mechanical Ventilation	
AHU.1	British Standards Institute, (2017). BS EN 16798-3: 2017. Energy performance of buildings - ventilation for buildings.
AHU.2	British Standards Institute, (2019). BS EN 13053: 2019. Ventilation for buildings. Air handling units. Rating and performance for units, components and sections.
AHU.3	British Standards Institute, (2007). BS EN 1886: 2007. Ventilation for buildings - Air handling units - Mechanical Performance.
AHU.4	British Standards Institute, (2011). BS EN 15780: 2011. Ventilation for buildings - Ductwork - Cleanliness of ventilation systems.
AHU.5	BSRIA, (2011). Rule of Thumb: Guidelines for building services (5th Edition).
AHU.6	Department for Levelling Up, Housing & Communities, (2022). Approved Document L, Conservation of fuel and power, Volume 1: Dwellings.
AHU.7	HM Government, (2013). Non-Domestic Building Services Compliance Guide.
AHU.8	CIBSE, (2013). TM13 Minimising the risk of Legionnaires disease,
AHU.9	Health and Safety Executive, (2013). Legionnaires' disease. The control of legionella bacteria in water systems.
AHU.10	Institute of Air Quality Management, (2021). Indoor Air Quality Guidance: Assessment, Monitoring, Modelling and Mitigation: Version 1.
Extract Only Fans	
EOF.1	CIBSE, (2016). Guide B2: Ventilation and Ductwork, London.
EOF.2	Department for Levelling Up, Housing and Communities and Ministry of Housing, Communities & Local Government. (2022). Combustion appliances and fuel storage systems: Approved Document J.
EOF.3	BSRIA. (2013). BG 43/2013 Flexible ductwork: a guide to specification, procurement, installation and maintenance.
EOF.4	Department for Levelling Up, Housing and Communities and Ministry of Housing, Communities & Local Government. (2022). Ventilation: Approved Document F.
EOF.5	BSRIA. (2009). The Illustrated Guide to Ventilation.

EOF.6	CIBSE. (2005). AM10: Natural ventilation in non-domestic buildings. London : CIBSE Publications.
EOF.7	NHBC. 8.3 Mechanical ventilation with heat recovery: 8.3.5 Design Considerations, 2022 [Online]. Available: https://nhbc-standards.co.uk/8-services/8-3-mechanical-ventilation-with-heat-recovery/8-3-5-design-considerations/
EOF.8	Ministry of Housing, Communities & Local Government. (2015). Approved Document E: resistance to the passage of sound.
EOF.9	Passivhaus Trust. (2018). Good Practice Guide - MVHR for single dwelling.
Heat Recovery	
HR.1	Passivhaus Trust. (2018) Good Practice Guide - MVHR for single dwelling.
HR.2	Department for Levelling Up, Housing and Communities and Ministry of Housing, Communities & Local Government. (2022) Ventilation: Approved Document F.
HR.3	Module 141: MVHR for energy-efficient ventilation and summer cooling. CIBSE Journal. s.l. : CIBSE, 2019, Vol. 141.
HR.4	British Standard Institute. BS EN 13053:2019 Ventilation for buildings - air handling units - rating and performance for units, components and sections.
HR.5	CIBSE, (2016) Guide B2: Ventilation and Ductwork," London.
HR.6	EcoFlow Ventilation Ltd. (2014). How does MVHR comply with building regulations UK?. [Online]. Available: http://www.ecoflowventilation.co.uk/mvhr-comply-building-regulations-uk/
HR.7	Ministry of Housing, Communities & Local Government. (2015) Approved Document E: resistance to the passage of sound.
HR.8	BS EN 308:1997 Heat exchangers - test procedures for establishing the performance of air to air and flue gases heat recovery devices (Withdrawn)
HR.9	BS EN 13053:2006 Ventilation for buildings - Air handling units - Ratings and performance for units, components and sections (+A1:2011)
Ground-Air Heat Exchanger	
GAHE.1	Design Buildings. (2021). Earth to air heat exchangers. Design Buildings. [Online] Sep 02, 2021. [Cited: Nov 11, 2022.] https://www.designingbuildings.co.uk/wiki/Earth_to_air_heat_exchangers.
GAHE.2	CanmetENERGY. (2021). Earth to Air Thermal Exchanger (EATEX).
GAHE.3	REHAU. Ground-Air Heat Exchanger FAQs. REHAU. [Online] 2022. [Cited: November 14, 2022.] https://www.rehau.com/uk-en/frequently-asked-questions-earth-tubes#:~:text=What%20is%20a%20Ground%2Dair,constant%208%2D12%C2%B0C..

Dehumidification	
DEH.1	British Standards Institute, (2021). BS 5250: 2021. Management of moisture in buildings – Code of practice.
DEH.2	CIBSE, (2020). TM40 - Health and wellbeing in building services. CIBSE.
DEH.3	BS EN 810:1997 Dehumidifiers with electrically driven compressors - Rating tests, marking, operational requirements and technical data sheet
Electric Power	
Power factor correction	
PF.1	BS EN 60831-1:2014 Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V. General - Performance, testing and rating - Safety requirements - Guide for installation and operation (incorporating corrigendum May 2014)
PF.2	BS EN 60529:1992+A2:2013
PF.3	Degrees of protection provided by enclosures (IP Code)
EV Charging	
EV.1	Department for Levelling Up, Housing and Communities. (2021). Infrastructure for charging electric vehicles: Approved Document S.
EV.2	Energy Saving Trust (2020). Electric Vehicle Infrastructure Forecasts 2025. Energy Saving Trust.
EV.3	City of London Corporation. (2019). City Streets, Transport for a changing Square Mile.
EV.4	Mayor of London. (2021). The London Plan.
Internal lighting and controls	
IL.1	Department for Levelling Up, Housing & Communities, (2022). Approved Document L, Conservation of fuel and power, Volume 1: Dwellings.
IL.2	Department for Levelling Up, Housing & Communities, (2022). Approved Document L, Conservation of fuel and power, Volume 2: Non-Dwellings.
IL.3	CIBSE, (2018). SLL Lighting Handbook.
IL.4	Illuminating Engineering Society, (2019). IES LM-80 Approved Method: Measuring Luminous flux and colour maintenance of LED packages, arrays and modules. IES.
IL.5	International Electrotechnical Commission, (2019). Digital Addressable Lighting Interface (DALI).
IL.6	The Ecodesign for Energy-Related Products and Energy Information (Lighting Products) Regulations 2021, No. 1095.

IL.7	British Standards Institute, (2021). BS 5250: 2021. Management of moisture in buildings – Code of practice.
IL.8	CIBSE, (2020). TM40 - Health and wellbeing in building services. CIBSE.
IL.9	BS EN 810:1997 Dehumidifiers with electrically driven compressors - Rating tests, marking, operational requirements and technical data sheet
IL.10	BS EN IEC 61439-1:2021 Low-voltage switchgear and controlgear assemblies General rules
External lighting and controls	
EL.1	BRE, (2016). BREEAM International New Construction. 2016.
EL.2	Illumination Engineering Society, (2015). TM-30-15. 2015.
EL.3	City of London Corporation, (2018). Light and Darkness in the City - A lighting vision for the City of London.
EL.4	Illuminating Engineering Society, (2019). IES LM-80 Approved Method: Measuring Luminous flux and colour maintenance of LED packages, arrays and modules. IES.
EL.5	City of London Corporation, (2020). Housing Design Guide.
EL.6	City of London Corporation, (2019). City Streets, Transport for a changing Square Mile.
EL.7	CIBSE, (2018). SLL Lighting Handbook.
EL.8	British Standards Institution, (2019). BS EN 15804: 2012+A2: 2019: Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products.
Controls	
BMS	
BMS.1	Department for Business, Energy and Industrial Strategy. (2019). Energy Technology Criteria List. London.
BMS.2	BREEAM. (2018). BREEAM New Construction 2018 (UK). BREEAM.
BMS.3	Nabers
BMS.4	ISA/IEC 62443 Series of Standards
BMS.5	BS EN 15500-1:2017 Energy performance of buildings - control for heating, ventilating, and air conditioning applications. Electronic individual zone control equipment - modules M3-5, M4-5, M5-5
BMS.6	BS EN 15232 Energy performance of buildings: impact of building automation, controls and building management

BMS.7	The Electromagnetic Compatibility Regulations 2016
BMS.8	BS EN 62053-21:2003 Electricity metering equipment (a.c) - particular requirements. Static meters for active energy (classes 1 and 2) (+A1:2017) (Incorporating corrigenda February 2004 and July 2018) (Withdrawn)
BMS.9	BS 8431:2010 Electrical static meters for secondary metering and sub-metering. Specification
BMS.10	BS EN 12261:2002 Gas meters - Turbine gas meters (incorporating corrigendum No.1 and amendment No.1) (Withdrawn)
BMS.11	BS EN 12480:2015 Gas meters - rotary displacement gas meters
BMS.12	BS EN 1359:1999 Gas meters. Diaphragm gas meters (+ AMD 16457) (Withdrawn)
BMS.13	City of London (2022), Building Energy Management System Standardisation Specification, Version 1.4
Renewables	
Solar PV	
PV.1	EN 15316-4-3: 2017. Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-3: Heat generation systems, thermal solar and photovoltaic systems.
PV.2	IEC, (2017). Electrical energy storage (EES) systems - Part 2-1: Unit parameters and testing methods - General specification.
PV.3	The Ecodesign for Energy-Related Products and Energy Information (Lighting Products) Regulations 2021 No. 1095.
PV.4	BloombergNEF (2020). BloombergNEF PV Module Tier 1 List Methodology.
Battery Storage	
BT.1	IEC 62933 (2018) -Electrical energy storage (EES) systems
BT.2	IET CoP for Electrical Energy Storage Systems; 2020 2nd edition
BT.3	PD IEC/TS 62933-4-1:2017 Electrical energy storage (EES) systems Guidance on environmental issues. General specification
BT.4	(BS EN IEC 62933-4-2 EES Systems Standard)

Components	
General	
CP.1	ISO 13857:2019 Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs
CP.2	BS EN ISO 13854:2019, 'Safety of machinery. Minimum gaps to avoid crushing of parts of the human body.'
CP.3	BS EN ISO 809: Establishes safety requirements relating to the construction, assembly, erection, operation and servicing of rotodynamic, rotary positive displacement and reciprocating displacement pumps and pump units.
CP.4	BS EN 13779:2007 Ventilation for non-residential buildings - Performance requirements for ventilation and room-conditioning systems (incorporating corrigendum May 2014) (Withdrawn)
Pumps	
PUM.1	Module 145: Resilient and efficient parallel pump systems with controlled redundancy. CIBSE journal. London, CIBSE, 2019.
PUM.2	CIBSE. Guide G: Public health and plumbing engineering. CIBSE, 2014.
PUM.3	OfWat. The guaranteed standards scheme (GSS): summary of standards and conditions. 2017.
PUM.4	BSRIA, (2002). Key Skills Variable Temperature Flow Systems.
Fans	
FAN.1	European Commission. (2009). Directive 2009/125/EC of the European Parliament and of the Council.
FAN.2	European Commission. (2011). Directive 327/2011 of the European Parliament and of the Council.
FAN.3	Department for Levelling Up, Housing and Communities and Ministry of Housing, Communities & Local Government. (2022). Ventilation: Approved Document F.
FAN.4	Department for Levelling Up, Housing & Communities, (2022). Approved Document L, Conservation of fuel and power, Volume 1: Dwellings.
FAN.5	British Standards Institution. (2017). BS EN ISO 5801: 2017 Edition, Fans - Performance testing using standardized airways.
FAN.6	British Standards Institution. (2014). BS EN ISO 8233, Guidance on sound insulation and noise reduction for buildings.

Refrigerant	
REF.1	European Standards, (2020). BS EN 378-3:2016+A1:2020 Refrigerating systems and heat pumps. Safety and environmental requirements Installation site and personal protection.
REF.2	Institute of Refrigeration. (2013). Safety code of practice for refrigerating systems utilising carbon dioxide refrigerant. Carshalton.
REF.3	Institute of Refrigeration. (2013). Safety code of practice - ammonia refrigerant. Carshalton.
REF.4	BRE Trust, (2013). BREEAM, Pol 01 - Impact of Refrigerants. [Online]. Available: https://kb.breeam.com/wp-content/plugins/breeamkb-pdf/pdf/?c=266. [Accessed 02 08 2022].
REF.5	International Organization for Standardization. (2014). ISO 817:2014 - Refrigerants — Designation and safety classification.
Water Quality	
WQ.1	BS EN 806 (2012) Specifications for installations inside buildings conveying water for human consumption
WQ.2	BSRIA BG 50/2013: Water treatment of Closed Heating and Cooling System
WQ.3	BSRIA BG 29/2020: Pre-Commission Cleaning of Pipework Systems
WQ.4	DI 2035 Part 1: Prevention of damage in water heating installations. Scale formation in domestic hot water supply installations and water heating installations
WQ.5	Water quality assessment in UK district heating systems (Greaves, 2019)
WQ.6	Water Treatment and Corrosion Prevention: Recommendations (Danish District Heating Association, 2015)
WQ.7	The Water Supply (Water Quality) Regulations 2018

GLOSSARY

- Advisory Professional (AP) – a role demonstrating specialist skills in sustainability and environmental design combined with a high level of competence in the assessment process.
- Air Handling Unit (AHU) – Air handling units' condition and distribute air within a building. They take fresh ambient air from outside, clean it, heat it or cool it
- Ambient Temperature Loop district heating scheme (ATL)
- Air Source Heat Pump (ASHP) – a type of heat pump that can absorb heat from outside a structure and release it inside using the same vapor-compression refrigeration process and much the same equipment as air conditioners but used in the opposite direction
- Best Available Technology (BAT) - Guidance in the Technology Guide on actions and studies to be undertaken across the RIBA stages to provide evidence the best available technology is chosen, evidence is provided on its implementation and monitoring is undertaken
- Branch Controller Boxes – Controller within a VRF system which intelligently transfers energy around the system, drawing on energy from the heat source / outdoor units. It directs energy as requested by the individual indoor units
- Building and Energy Management System (BEMS) – is a computer-based system designed to help to monitor, control, measure, and optimize energy consumption needs of a building
- Building Information Modelling (BIM) – a process for creating and managing digital information throughout the lifetime of a building
- Building Management SysteQm (BMS) – a computer-based system installed in buildings to manage and monitor equipment such as air-conditioning, heating, ventilation, lighting, power systems, security devices, IoT sensors, energy, and gas meters
- Building Performance Evaluation (BPE) – an evaluation of the performance of different components and aspects of a building, including building fabric building services and controls strategies energy, fuel and water use handover and commissioning processes occupant satisfaction occupant comfort
- Building Regulations Approved Documents – reports compiled by Government to provide guidance for how each 'Part' of the Building Regulations can be complied with when undertaking building work (including plumbing, electrics, extensions, etc.).
- Building Regulations UK Part L (BRUKL) – a UK building regulation issued by the Secretary of State which lays down specific measures for the conservation of fuel and power. Part L aims to make buildings as energy efficient as possible and therefore efficient electric lighting is required in most buildings.
- Building Research Establishment Environmental Assessment Method (BREEAM) – an assessment undertaken by independent licensed assessors using scientifically-based sustainability metrics and indices which cover a range of environmental issues
- CE Marking – certifies the manufacturer or importer affirms the good's conformity with European health, safety, and environmental protection standards.

- Chartered Institute of Building Services Engineers Guides (CIBSE) – an international professional engineering that represents building services engineers
- Chilled Water Systems (CHW) – cooling systems that circulate chilled water throughout a building for cooling and dehumidifying a building's air
- Climate Adaptation – the process of adjusting to current or expected effects of climate change
- Coefficient of Performance (COP) – a ratio of useful heating or cooling provided to work (energy) required a heat pump, refrigerator or air conditioning system
- Combined Heat and Power (CHP) – the simultaneous generation of heat and power in a single process and provides one of the most cost-effective methods for reducing carbon emissions
- Combined Heat and Power Quality Assurance (CHPQA) – the Government initiative that provides a practical approach to assessing all types and sizes of CHP schemes in the UK.
- Compulsory Purchase Order (CPO) – a legal function in the United Kingdom and Ireland that allows certain bodies to obtain land or property without the consent of the owner.
- Computational Fluid Dynamic (CFD) – a branch of fluid mechanics that uses numerical analysis and data structures to analyse and solve problems that involve fluid flows.
- Control of Substances Hazardous to Health Regulations (COSHH) – statutory instrument which states general requirements imposed on employers to protect employees and others from the hazards of substances used at work by risk assessment, control of exposure, health surveillance and incident planning.
- Cooling Technology Institute (CTI) –
- Department for Environment, Food and Rural Affairs (DEFRA) – a department responsible for environmental protection, food production and standards, agriculture, fisheries, and rural communities in the United Kingdom.
- Domestic Hot Water (DHW) – the heated potable water that feeds taps, showers, baths, or the kitchen hot taps
- Direct Effect Life CO_2 equivalent emissions (DELC) (air cool chillers Future Proofing)
- DX Units – are complete systems, which are not reliant on other sets of equipment like cooling towers and condenser water pumps
- Electric Vehicle (EV) – a vehicle that uses one or more electric motors for driving
- Electricity at Work Regulations – guidelines to prevent death or personal injury to any person from electrical causes in connection with work activities
- Electromagnetic Compatibility (EMC) – is the ability of electrical equipment and systems to function acceptably in their electromagnetic environment, by limiting the unintentional generation, propagation and reception of electromagnetic energy which may cause unwanted effects
- Electronically Commutated Motors (ECM) – is a synchronous motor using a direct current electric power supply. It uses an electronic controller to switch DC currents to the motor windings producing magnetic fields which effectively rotate in space and which the permanent magnet rotor follows

- Energy Performance Certificate (EPC) – a rating scheme to summarise the energy efficiency of buildings. The building is given a rating between A (Very efficient) - G (Inefficient).
- Energy Use Intensity (EUI) – a measure of the energy inefficiency of an economy. It is calculated as units of energy per unit of GDP.
- Environmental Impact Assessment (EIA) – a report which estimates the effects of a proposed development or construction project. It provides a technical evaluation that are intended to contribute to more objective decision making.
- Fan Terminal Units (FTU) – a type of terminal unit that uses a fan to provide air movement.
- Variable Air Volume (VAV) – is a type of heating, ventilating, and/or air-conditioning system. The system varies the airflow at a constant or varying temperature.
- Fan Coil Unit (FCU) – often connected to ductwork and a thermostat to regulate the temperature of one or more spaces as well as assisting the main air handling unit for each space if used with chillers.
- Ground Air Heat Exchanger (GAHE) – offer an innovative method of heating and cooling a building and are often used on zero carbon/ Passivhaus buildings. Ventilation air is drawn through underground pups which pre-heats the air.
- Gateway
- Global Warming Potential (GWP) – is the heat absorbed by any greenhouse gas in the atmosphere, as a multiple of the heat that would be absorbed by the same mass of carbon dioxide (CO_2).
- Gross Internal Area (GIA) – the area of a building measured to the internal face of the perimeter walls at each floor level.
- Ground Source Heat Pump (GSHP) - a heating/ cooling system for buildings that uses a type of heat pump to transfer heat to or from the ground
- Health and Safety at Work Act – defines the fundamental structure and authority for the encouragement, regulation and enforcement of workplace health, safety and welfare within the United Kingdom.
- Heat Pumps – a device that can heat a building by transferring thermal energy from the outside using the refrigeration cycle.
- Heating, Ventilation and Air Conditioning (HVAC) – is the use of various technologies to control the temperature, humidity, and purity of the air in an enclosed space
- High Efficiency Particulate Air (HEPA) – a type of pleated mechanical air filter
- Home Quality Mark (HQM) – a national standard for new homes, which uses a simple 5-star rating to provide impartial information from independent experts on a new home's design, construction quality and running costs.
- Hydrochlorofluorocarbons (HCFCs) – are man-made organic compounds that contain fluorine and hydrogen atoms and are the most common type of organofluoride compounds.
- Indoor Air Quality (IAQ) – the air quality within and around buildings and structures.
- International Organization for Standardisation (ISO) – an international standard composed of representatives from the national standards organizations of member countries.

- IWI (Internal solid wall insulation Tech Standard).
- Land Use and Ecology (LE) – is one of nine categories and accounts for 10% of the total credits in BREEAM assessments.
- Leadership in Energy and Environmental Design (LEED) – a green building certification program. It includes a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes, and neighbourhoods, which aims to help building owners and operators be environmentally responsible and use resources efficiently.
- Legionella bacteria – a genus of pathogenic gram-negative bacteria that includes the species L. pneumophila, causing legionellosis; including a pneumonia-type illness called Legionnaires' disease and a mild flu-like illness called Pontiac fever.
- Life-Cycle Assessment (LCA) – a methodology for assessing environmental impacts associated with all the stages of the life cycle of a commercial product, process, or service.
- London Energy Transformation Initiative (LETI) – a network of over 1,000 built environment professionals working together to put London on the path to a zero-carbon future.
- Low Temperature Hot Water Heating (LTHW) –
- Management of Health and Safety at Work Regulations 1999 – the regulation which places a duty on employers to assess and manage risks to their employees and others arising from work activities
- Mechanical Ventilation with Heat Recovery (MVHR) – a whole house ventilation system that both supplies and extracts air throughout a property.
- Monitoring Certification Scheme (MCERTS) –
- National Australian Build Environment Rating System (NABERS) – is an initiative by the government of Australia to measure and compare the environmental performance of Australian buildings and tenancies
- Net Zero – achieving a balance between the carbon emitted into the atmosphere, and the carbon removed from it.
- Occupational Safety and Health Administration (OSHA) – to assure safe and healthy working conditions for employees by setting and enforcing standards and by providing training, outreach, education, and assistance
- Ozone Depleting Potential (ODP) – is the relative amount of degradation a chemical compound can cause to the ozone layer
- Particulate Matter (PM10) – a microscopic particles of solid or liquid matter suspended in the air with a diameter of 10 micrometers (μm) or less.
- Particulate Matter (PM2.5) – a microscopic particles of solid or liquid matter suspended in the air with a diameter of 2.5 micrometers (μm) or less.
- Passivhaus – is a voluntary standard for energy efficiency in a building, which reduces the building's ecological footprint.
- Performance Standard – Provides guidance on the minimum threshold performance and higher performance requirements recommended for technologies contained in the Technology Guide to support the deliver of net zero projects.

- Photovoltaics (PV) – the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect.
- Point of Use Heaters (POU)
- Post Occupancy Evaluation (POE)¬¬ – is the process of obtaining feedback on a building's performance in use
- Polyvinyl chloride (PVC) – a tough chemically resistant synthetic resin used for a wide variety of products
- Royal Institute of British Architects (RIBA) ¬– is a professional body for architects in the United Kingdom.
- Royal Institute of Chartered Surveyors (RICS) – a global professional body for surveyors. It works at a cross-governmental level. It aims to promote and enforce the highest international standards in the valuation, management and development of land, real estate, construction, and infrastructure.
- Seasonal Energy Efficiency Ratio (SEER) – is a rating of a unit which identifies the cooling output during a typical cooling-season divided by the total electric energy input during the same period
- SIP (roof insulation Tech Standard)
- Solar Assisted Heat Pumps (SAHP) – a machine that represents the integration of a heat pump and thermal solar panels in a single integrated system.
- Specific Fan Powers (SFP) – parameter that quantifies the energy-efficiency of fan air movement systems. It is a measure of the electric power that is needed to drive a fan (or collection of fans), relative to the amount of air that is circulated through the fan
- Suitably Qualified Ecologist (SQE) – are ecologist who are full members of the Chartered Institute of Ecology and Environmental Management.
- Technology Guide - The Technology Guide is divided into ten main Technology Categories Each sub-category is divided into a Performance Standard and a Technical Standard.
- Technology Standard – The Technical Standards provide guidance on the application of the technology or component within the project
- The Construction, Design and Management Regulations 2007 – key piece of health and safety legislation affecting construction and engineering projects and property development.
- Total Equivalent Warming Impact (TEWI) – a measure of the combined global warming impacts of the refrigerant losses to the atmosphere and the CO 2 emissions from fossil fuels to generate power to run the refrigeration and air-conditioning systems.
- Total Volatile Solids (TVOC) – materials that are completely volatilized from water at higher temperature
- UK Green Building Council (UKGBC) – a United Kingdom membership organisation, which aims to 'radically transform' the way that the built environment in the UK is planned, designed, constructed, maintained, and operated.
- US Green Building Council (USGBC) – a private, membership-based non-profit organization that promotes sustainability in building design, construction, and operation

- Variable Frequency Drive (VFD) – a type of motor drive used in electro-mechanical drive systems to control AC motor speed and torque by varying motor input frequency and, depending on topology, to control associated voltage or current variation
- Volatile Organic Solvents (VOCs) – are organic chemicals that have a high evaporation rate at room temperature
- Variable Refrigerant Flow (VRF) - also known as variable refrigerant volume (VRV), uses refrigerant as the cooling and heating medium. This refrigerant is conditioned by one or more condensing units (which may be outdoors or indoors, water or air cooled), and is circulated within the building to multiple indoor units
- WELL Building Standard (WELL) – aims to encourage the creation of spaces that enhance health and well-being
- World Health Organisation (WHO)– is a specialized agency of the United Nations responsible for international public health.

// Building Blocks for Net Zero

Appendix 2 - References

DESIGN ZERO DESIGN STANDARD REFERENCES

Introduction

This glossary presents the sources of industry good practice which were used to develop the process, project and information requirement tables. The sources are presented by Design Guide sub-categories. Each sub-category also lists the CoLC documents which were reviewed to ensure alignment and prevent contradiction.

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Minimising Carbon

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Light Pollution:

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2. CIRCULAR ECONOMY

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- UKGBC (2022). Insights on how circular economy principles can impact carbon and value.
- https://www.london.gov.uk/sites/default/files/design_for_a_circular_economy_primer_ggbd_web2.pdf

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Modern Methods of Construction

- Mayor of London. Homes for Londoners: Affordable Homes Programme 2021-2026. Further readings: MMC categories and definition framework. https://www.london.gov.uk/programmes-strategies/housing-and-land/homes-londoners-affordable-homes-programmes/homes-londoners-affordable-homes-programme-2021-2026#:~:text=About%20the%20programme&text=This%20funding%20is%20expected%20to,new%20affordable%20-homes%20in%20London. (Accessed: 30 Nov 2022)

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- City of London Corporation (2022). Climate Action Strategy: NZ3 – Capital Projects (Design Standards), Version 2.1.

WELL Type Requirements

- The WELL Building Standard™ version 2 (Q3 2022).

6. POE

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Embodied Carbon

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Local Air Quality

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WELL Type Requirements

- Listed above in the WELL type requirements subcategory.

Introduction

This section presents a summary of the asset classes the Design and Technology Guides apply to and the symbols used in the tables.

ASSET CLASSES & SYMBOLS

Symbols

√ - Applicable: to this asset, class, type, value, stakeholder

● - Circumstantial: further analysis and/or surveying required to determine applicability

BLANK - Not applicable: to this asset, type, value, stakeholder

Residential

- Designed to meet the function of a long-term self-contained home even though there may be some provision of communal facilities which can be used on a voluntary basis
- Classified under Building regulations Part L1a (i.e. required to complete SAP assessments)
- Homes for sale, social housing or homes for rent (PRS and Built to Rent), some student and retirement/sheltered accommodation where the units are comparable to a normal self-contained flat/home

NOTE:

- The term ‘multi-residential’ is used in the context of buildings that contain rooms for residential purposes alongside communal facilities for catering, leisure, care, etc. These residential rooms would normally not have the full, self-contained functions of a home. This is more specialist residential care homes, student halls of residence, and other more communal accommodation. The scheme can cater for a small number of self-contained dwellings where these form part of a larger multi-residential development (e.g. on-site warden homes etc.).

- Provided for transient / non-permanent occupants
- Provide suitable accommodation for occupants requiring support from carers, wardens or similar
- Include shared living spaces
- Be classified under Building regulations Part L2a (i.e. required to complete SBEM assessments, but can account for some SAP assessed spaces where associated with the project)
- Rooms rather than self-contained flats or homes

Commercial

Office

- General office buildings
- Offices with research and development areas (i.e. category 1 laboratories only)

Industrial

- Industrial unit – warehouse storage or distribution
- Industrial unit – process, manufacturing or vehicle servicing

Retail

- Shop or shopping centre
- Retail park or warehouse
- ‘Over the counter’ service provider, e.g. financial, estate and employment agencies and betting offices
- Showroom
- Restaurant, café and drinking establishment
- Hot food takeaway

Public (non-housing)

Education

- Preschool
- Schools and sixth form colleges
- Further education or vocational colleges
- Higher education institutions

Healthcare

- Teaching or specialist hospitals
- General acute hospitals
- Community and mental health hospitals
- GP surgeries
- Health centres and clinics

Prison

- High security prison
- Standard secured prison
- Young offender institution and juvenile prisons
- Local prison
- Holding centre

Law Court

- Law courts
- Crown and criminal courts
- County courts
- Magistrates’ courts
- Civil justice centres
- Family courts
- Youth courts
- Combined courts

Also included within the public categorisation are:

Residential Institution (short term stay)

- Hotel, hostel, boarding and guest house
- Secure training centre
- Residential training centre

Non-residential Institution

- Art gallery, museum
- Library
- Day centre, hall, civic or community centre
- Place of worship

Assembly and Leisure

- Cinema
- Theatre, music or concert hall
- Exhibition or conference hall
- Indoor or outdoor sports, fitness and recreation centre (with or without pool)

Other

- Transportation hub (coach or bus station and above ground rail station)
- Research and development (category 2 or 3 laboratories - non-higher education)
- Crèche
- Fire stations
- Visitor centres

FURTHER READING

RIBA

- The RIBA Plan of Work is the definitive model for the design and construction process of buildings

- http://xn--https-ix3b//riba-prd-assets.azureedge.net/-/media/Files/Resources/2020RIBAPlanofWorkoverviewpdf-(1).
- https://riba-prd-assets.azureedge.net/-/media/GatherContent/Business-Benchmarking/Additional-Documents/2020RIBAPlanofWorktemplatepdf.pdf?rev=6f995f6f39d2414daf50889b00a7ecb4

UKGBC

- The UK Green Building Council (UKGBC) is a charity organisation launched by the Construction and Property industry in 2007. They offer clarity, cohesion and leadership across the built sector towards a sustainable build environment.
- The UKGBC share knowledge and best practice and advocate progressive policy and have produced the Net Zero Whole Life Carbon Roadmap for the Built Environment.
- Welcome to UKGBC | UK Green Building Council
- Net Zero Whole Life Carbon Roadmap for the Built Environment - UKGBC - UK Green Building Council

LETI

- Originally the 'London Energy Transformation Initiative' LETI was established to support the transition of London's built environment to meet net zero carbon. It has now gown and become the Low Energy Transformation Initiative commonly known as LETI to reflect the interest in all IK zero carbon policy and regulation.
- In 2020 LETI published the Climate Emergency Design Guide which outlines the requirements for new buildings to ensure climate change targets are met.
- Climate Emergency Design Guide | LETI
- Home | LETI

RICS Whole Life Carbon Assessment

- The RICS (Royal Institute of Chartered Surveyors) have developed a comprehensive set of guidance for Whole Life Carbon Assessments for the Built Environment.
- The Guidance mandates a whole life approach to reducing carbon and sets of specific mandatory principles and supporting guidance for the interpretation and implementation of EN 15978 methodology.
- EN15978 is an assessment of environmental performance of buildings.
- The Whole Life Carbon objectives include providing a consistent whole life carbon assessment implementation plan and reporting structure for built projects, and promoting the reliability of whole life carbon assessments by acting as a solid reference in the industry.
- Whole Life Carbon Assessment for the Built Environment, 1st edition (rics.org)

SUSTAINABILITY ACCREDITATIONS AND REFERENCES

Please note the terms outlined below are used across topic categories and are not used solely within Operational or Construction etc.

BREEAM

- Building Research Establishment Environmental Assessment Method (BREEAM)
- https://bregroup.com/products/breeam/
- BREEAM is the world's leading science-based suite of validation and certification systems for sustainable built environment.
- Since 1990, BREEAM's third-party certified standards have helped improve asset performance at every stage, from design through construction, to use and refurbishment. Millions of buildings across the world are registered to work towards BREEAM's holistic approach to achieve ESG, health, and net zero goals. It is owned by BRE – a profit-for-purpose organisation with over 100 years of building science and research background.
- BREEAM Advisory Professional (AP)
- https://www.breeam.com/wp-content/uploads/sites/3/2018/06/GD121_BREEAM_Professionals_Guide_Briefing_Paper_v.0.0.pdf
- The BREEAM AP can be called on and provide 'scheme-related' expertise to design teams, specifiers, constructors and other key stakeholders. This will inform decision-making and therefore identify opportunities to maximise performance and work towards a targeted rating in the most cost-effective, timely and solutions orientated way.
- An AP can work for a construction organisation frequently undertaking BREEAM-related work. Moreover, the BREEAM AP can be the same person as the BREEAM Assessor. This allows flexibility and versatility of their role.
- Cost efficiencies are expected where the appointed licensed assessor also acts as the BREEAM AP for a project.
- In either case, an efficient AP will coordinate with the BREEAM Assessor to ensure an efficient and smooth assessment process, aiming to maximise the performance of the assessed project.

An individual with a high level of general knowledge of the scheme(s) principles, requirements and processes. They also have the skills and experience needed to inform, guide and facilitate project teams throughout the BREEAM process. APs assist project teams in their individual and collective decision-making and evidence preparation throughout a project with a view to optimise performance, assessment management and efficiency.

- In doing so the AP can support project teams in obtaining maximum value and cost-effective performance from the use of BREEAM throughout the project life, whilst managing risks and staying on course to achieve the target rating.

- Additional BREEAM requirements associated with specific credits and categories can be found within the Topic categories Sections

LEED

- The Leadership in Energy and Environmental Design commonly referred to as LEED Is a Green Building Certification program used globally. It was developed by the USGBC and includes a rating system for the design, construction, operational and maintenance of green buildings.
- LEED uses a similar requirements system to BREEAM, with credits being broken down into topics surrounding Energy, Waste, Materials, Health and Wellbeing etc. LEEDs thresholds are based on percentages whilst BREEAM uses quantitative standards.
- LEED is considered to be simpler in its approach however BREEM is the more popular accreditation method chosen in the UK.
- Home | LEED Lookbook (usgbc.org)
- LEED certification for new buildings | U.S. Green Building Council (usgbc.org)

WELL

- The WELL building standard differs from LEED or BREEAM due to being predominantly health focused, however aspects of sustainability, environmental management and carbon reduction do align with health benefits.
- WELL is a performance based system for measuring, certifying and monitoring features of the build environment that impact human health and well-being through air, water ,nourishment, light ,fitness comfort and mind.
- WELL Certification | WELL Standard (wellcertified.com)

Passivhaus

- Passivhaus is an international standard for reducing the ecological footprint of a building by building them to be ultra-low in energy consumption.
- Passivhaus adopts a whole-building approach with clear, measured targets, focusing on high quality construction, certified through an exacting quality assurance process.
- To achieve Passivhaus Standard in the UK typically involves ;
- Accurate design modelling using the Passive House Planning Package (PHPP) very high levels of insulation extremely high performance windows with insulated frames airtight building fabric 'thermal bridge free' construction a mechanical ventilation system with highly efficient heat recovery
- https://passivehouse.com/

SKA Rating Self-Assessment

- SKA rating is an environmental assessment method, benchmark and standard for non-domestic fit-outs, led and owned by the Royal Institute of Chartered Surveyors (RICS).
- Projects use the SKA rating method to carry out an informal self-assessment of the environmental performance of their fit-out as well as;
- Commission a quality-assured assessment and certificate from an RICS accredited SKA assessor
- Obtain clear guidance on good practice in fit-out and how to implement it.
- Benchmark the performance of fit-outs against each other and the rest of the industry.
- There are three rating thresholds that can be achieved : Bronze, Silver and Gold reaches by achieving 25,50 and 75% respectively.

NABERS UK

- Nabers UK is a simple and reliable system for rating the energy efficiency of office buildings across England, Wales, Scotland and Northern Ireland.
- Nabers offers two products, UK Design for performance and Nabers UK – Energy for Offices.
- Nabers Energy measures the efficiency of an office building and rates its performance by comparing the energy consumption of a building against a set of benchmarks.
- Nabers Design for Performance is a process whereby a developer of owner commits to design, build and commission a new office development or major refurbishment to achieve a specific Nabers rating.
- Star Ratings range from one to six for building efficiency across Energy, Water, Waste, and Indoor Environment.

Home Quality Mark (HQM)

- The Home Quality Mark helps house builders to demonstrate the high quality of their homes and to differentiate them in the marketplace.
- HQM was developed by BRE and is based on years of building standards experience.
- HQM provide a rating out of 5 stars across 3 indicators, Cost, Wellbeing and Footprint which is ranked on a five-point scale. Additional minimum requirements need to be met.

BRUKL

- BRUKL (Building Regulations United Kingdom Part L) calculations are used to predict energy efficiency of new construction. If you are constructing a new non domestic building in the UK you will need to have BUKL calculations complete by an accredited energy assessor in order to obtain an EPC on completion of your property.
- BRUKL Reports are also known an SBEM calculation reports (Simplified Building Energy Model).

BBP

- The Better Buildings Partnership (BBP) brings together a number of the largest commercial and public property owners in London in one collaborative organisation. All members are working together to improve the sustainability of London's existing commercial building stock and accelerate the reduction in CO_2 emissions from these buildings.
- Better Metering Toolkit sets out the metering options currently available for commercial buildings, considers the costs and benefits and provides advice on how metering data can be used to make energy, cost and CO_2 reductions

Carbon Buzz

- Carbon Buzz is a RIBA and CIBSE platform in which users are able to analyse and compare data entered for their buildings at each project stage through energy and carbon graphs known as Energy Bars. The user is then able to track, review and compare energy records as a form of data monitoring.

CIBSE

- CIBSE is the Chartered Institute of Building Services Engineers. They provide guidance documents for a range of building aspects including TM54; Evaluating Operational Energy use at the design stage (2022) which provides a methodology to calculate energy performance including spreadsheet and dynamic simulation modelling.

RICS New Rules of Measurement (NRM)

- The RICS New Rules of Measurement provides a standard set of measurement rules and essential guidance for the cost management of construction projects and maintenance works. The three volumes of the NRM include;

  a. NRM 1: Order of cost estimating and cost planning for capital building works

  b. NRM 2: Detailed measurement of for building works

  c. NRM 3: Order of cost estimating and cost planning for building maintenance works

- The NRM form the basis on the Circular Economy Statement, outlining the application stage in the Bill of Materials Building Layers and their life span

Circular Economy Statement (CE)

- Circular economy is an economic model of production and consumption that involved sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible, in order to minimise the effects on climate change, biodiversity loss, waste and pollution.
- A CE statement (CES) is a detailed appraisal of the potential material that can be reused from an existing project side ,some of the contents include a description of the development, method statement , circular economy aspirations and statement, and detailed circular economy statement.

- Circular Economy Statement Guidance | GLA (london.gov.uk)

Environment Act 2021

- The Environment Act 2021 is a government bill that makes provision about targets, plans and policies for improving the natural environment; for statements and reports about environmental protection; for the Office for Environmental Protection; about waste and resource efficiency; about air quality; for the recall of products that fail to meet environmental standards; about water; about nature and biodiversity; for conservation covenants; about the regulation of chemicals; and for connected purposes.

Mitigation Hierarchy

- A mitigation hierarchy is a widely used tool that guides users towards limiting as far as possible the negative impacts on biodiversity from development projects. It emphasises best-practice of avoiding and minimising any negative impacts, and then restoring site no longer used by a project before finally considering offsetting residual impacts.

CSBI (Cross Sector Biodiversity Initiative) provide a comprehensive mitigation hierarchy guide to implement effectively: Mitigation Hierarchy Guide – CSBI

Sustainability Statements

- A Sustainability Statement is a report showing how a developer will address local objectives concerning environment and sustainability. It covers all aspects of the environmental impact of a planned development alongside targets surrounding CO_2 emissions and Renewable energy and more. Energy efficiency is the use of less energy to operate the same equipment and / or preform the same task to produce the same result. Energy efficiency measures include double glazing, cavity wall insulation of energy efficient lighting. Minimise pollution is limiting the amount and toxicity of hazardous substances though all stages of product or building life.

Heat Island Effect

- The heat island effect is a term used to describe higher air and structure temperatures in an urban setting. It is a common environmental problem occurring in metropolitan areas in which the air temperature is significantly higher, leading to a smoggy climate.

Climate Change Adaptation Strategy

- A Climate Change Adaptation Strategy is a strategy developed by the design team and other relevant stakeholders for a specific project or programme of works, that involves recommendations and solutions to adjusting to the current or expected effects of climate change. This includes protection against flooding, sea level rise, heatwaves and increase of high-risk weather events.

Post Occupancy Evaluation (POE)

- Post Occupancy Evaluation.
- POE is also known as Building Performance Evaluation (BPE).
- The POE is used to improve the building operation, occupants' comfort and other areas based on its outcomes. Therefore, the POE provides suggestions on potential improvements, including, but not limited to the following:
  a. Re-commissioning activities.
  b. Measures that maintain or improve end users' comfort and productivity.
  c. Health and safety.
- A POE can also be used as part of the stakeholder consultation at the briefing stage for a new construction or the refurbishment of an existing one, in cases where the building occupants are the same. This can be achieved through the use of a questionnaire or workshops to highlight lessons from the old or existing building that could be taken into account in the design of the new project.

Whole Life Carbon Assessments

The City of London is embedding circular economy principles into their capital projects and reducing carbon intensity by using lifecycle carbon and cost assessment techniques and design specifications, identified as an action to support the targets and achievement of net zero. The CoLC requires stakeholders to undertake WLC Assessments using the CoLC Assessment checklist. Together with the WLC methodology, the WLC Assessments will support the CoLC to ensure all future capital projects (refurbishments and new build) meet the highest commercially viable standards for sustainable and low carbon design.

The CoLC also commissioned works to undertake a Whole Life Cycle Carbon (WLCC) assessment exercise on six chosen projects, and to estimate the carbon and cost impact of suggested optimisation measures which would reduce the WLC emissions. The six projects selected include new build and refurbishments, offices, a café and schools:

- Finsbury Gardens Pavilion
- 15-17 Eldon Street
- 1st-5th/6 Broad Street Place
- Brewery Road
- CoL Junior School
- COLPAI- CoL Primary Academy and Islington

For each project, the WLC was calculated, including optioneering providing e.g. alternative material choices to help reduce the WLC carbon emissions. The optimisation measures were then costed, and a menu of the measures was created based on the cost of the optimisation in £/kgCO2e saving. The lower the cost in £/kgCO2e, the bigger the carbon saving for a lower financial cost of investment. The recommended measures were tailored to each project and tabulated in a results report. These measures have also been reviewed and incorporated into the Standard as part of the Project Requirements.

Climate Impact Modelling

In support of the CAS, there was a requirement for Impact Modelling for CPG and IPG Assets on temperature and pluvial / fluvial flooding. This was split into two phases:

- Phase 1: Modelling to identify assets with heightened risk and the need for enhanced resilience and mitigation measures.
- Phase 2: Modelling the impact of specific resilience and mitigation measures on key assets, providing insight into the scope and specifications of the interventions to be adopted.

The purpose therefore was to:

- Identify the risks associated with Resilience posed throughout the Square Mile (and other CoL building assets located throughout London) for residential and non-residential properties which fall under the remit of CoLC.
- Identify a set of proposed interventions and any constraints to the implementation of intervention measures for the CoLC physical assets. These proposed interventions and constraints for the CoLCs physical assets informed this sub-category as well as the Flood Resilience sub-category, and fed into the future proofing recommendations for the Technology Guide including Fabric and Cooling – please see Appendix 1. A full report of the findings is made available outside this Standard.

The work comprised building a Digital Twin of The Square Mile, using powerful data GIS tools to provide impactful and easy to interpret visualisations of the climate impacts and the effect of proposed interventions. The model was built, using Tygron software -Tygron EN Geo design Platform | Water and climate adaption. The outputs to support reporting were produced for the 'Top 100 CoLC Assets' and provided in GIS format for use by CoLC.

The results of the Tygron modelling exercise were overlayed onto the GIS dashboard to visually present at-risk areas of flooding and high temperature within the Square Mile. This interactive tool is available to the users of this Standard for identifying buildings of interest and identifying the risks identified through modelling. The tool also shows potential interventions identified to mitigate the risk. It will allow planners and asset managers to prioritise implementation of interventions, dependant on the asset's risk rating and help make informed decisions on funding allocation. It will also allow for protection of the asset, inside and out and building on learnings from past projects. The intervention measures are split between heat stress and flooding, and categorised for new assets and retrofits along with risks, benefits and timeframes detailed. Being digital, the tool will allow periodic updates to the asset list and location data as it evolves. This model will be hosted on Arcadis Arc GIS which CoLC staff have access licenses for.

Refer to Buildings Resilience Plan. ➲**Climate Impact Modelling Tool**

// Building Blocks for Net Zero

Appendix 3 - Abbreviations

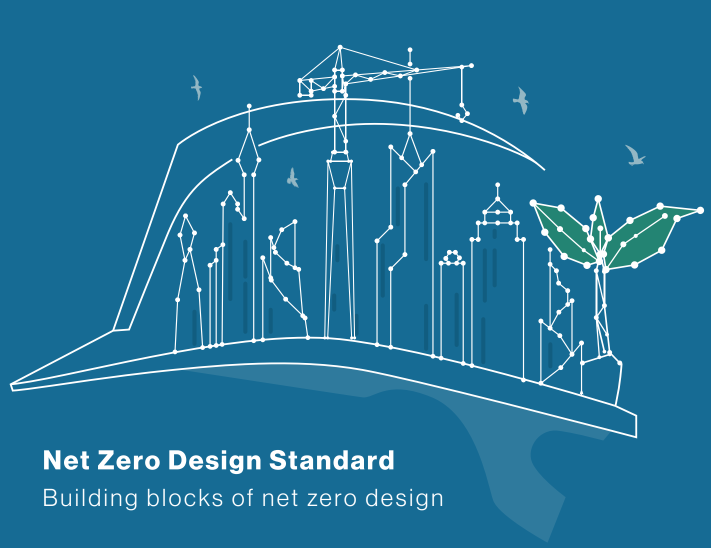
ABBREVIATIONS

AP	Accredited Professional
ASHP	Air Source Heat Pump
ASHRAE	The American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAU	Business as Usual
BBP	Better Buildings Partnership
BEMS	Building Energy Management System
BER	Building Emission Rate
BIM	Building Information Modelling
BMS	Building Management Systems
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
BRUKL	Building Regulations UK Part L
BS	British Standard
BSI EN	British Standards Institute Adopted as a European Standard
CAS	Climate Action Strategy
CCS	Considerate Constructor's Scheme
CDM	Construction Design and Management
CE	Circular Economy
CIBSE	Chartered Institution of Building Services Engineers
CoL	City of London
CoLC	City of London Corporation
CPG	Capital and Planning Group
CPO	Compulsory Purchase Order
DEC	Display Energy Certificate
DEFRA	Department for Environment, Food and Rural Affairs
DELC	Direct Effect Life Cycle
DNO	Distribution Network Operator
DSM	Dynamic Solution Model
DT	Design Team
EPC	Energy Performance Certificate
EPD	Environmental Product Declaration
EQ	Environmental Quality
EUI	Energy Use Intensity
FF&E	Furniture, Fixtures and Equipment

FITWEL	Facility Innovations Toward Wellness Environment Leadership
FM	Facility Manager
GHG	Greenhouse Gas
GIA	Gross Internal Area
GLA	Greater London Authority
GWP	Global Warming Potential
HQM	Home Quality Mark
HSE	Health and Safety Executive
HVAC	Heating, Ventilation and Air Conditioning
IAQ	Indoor Air Quality
IES	The Institution of Environmental Sciences
ILP	Institute of Lighting Professionals
IPG	Investment Property Group
ISO	International Organisation for Standardisation
KPI	Key Performance Indicator
kWh	Kilowatt Hours
LCA	Life Cycle Assessment
LE	Land Use and Ecology
LED	Light-Emitting Diode
LEED	Leadership in Energy and Environmental Design
LETI	London Energy Transformation Initiative
LT	Location and Transportation
LZC	Low and Zero Carbon (Technologies)
MEP	Mechanical, Electrical and Plumbing (Systems or Engineers)
MCERTS	Monitoring Certification Scheme
MERV	Minimum Efficiency Reporting Value
MMC	Modern Methods of Construction
NABERS	National Australian Build Environment Rating System
NCM	National Calculation Methodology
NOx	Nitric Oxide (NO) and Nitrogen Dioxide (NO2)
NPPF	National Planning Policy Framework
NRM	New Rules of Measurement
PM	Project Manager

POE	Post Occupancy Evaluation
ppb	Parts per Billion
ppm	Parts per Million
RAID	Risks, Assumptions, Issues, Dependencies
RFI	Request for Information
RIBA	Royal Institute of British Architects
RICS	Royal Institute of Chartered Surveyors
SBEM	Simplified Buildings Energy Model
SBTi	Science Based Targets initiative
SKA	Skansen Rating
SLR	Sea Level Rise
SME	Subject Matter Experts
SQE	Suitably Qualified Ecologist
SR	Solar Reflectance
SRI	Solar Reflectance Index
SuDS	Sustainable Drainage Systems
TM54	Technical Memorandum 54
TSVOC	Total Semi-Volatile Organic Compound
TVOS	Total Volatile Solids
VOC	Volatile Organic Solvents
VRF	Variable Refrigerant Flow
WC	Water Closet
WELL	WELL Building Standard
WHO	World Health Organisation
WLC	Whole Life Carbon

LIST OF FIGURES



Net Zero Design Standard
Building blocks of net zero design

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