2024

Refurbishing the City – insights into current best practice

CITY OF LONDON
HILSON MORAN

Contents

Acknowledgments

This report has been complied by Hilson Moran in collaboration with the City of London Corporation's Environment Department.

Several stakeholders have contributed information to this report, and we are grateful for their time and efforts in helping with information and compiling the case studies of their commercial office developments.

British Land

Great Portland Estates

Bluebutton Properties UK Limited

Piercy & Co

U&I

Morris and Company

Doone Silver Kerr

Helical

Pilbrow & Partners

Gensler

ORMS

Barr Gazetas

Permodalan Nasional Berhad PNB and LaSalle Investment Management

Bruntwood

Sheppard Robson

Brookfield Office Property Management

Stiff + Trevillion

DSDHA

Ashby Capital and Janson Urban

King's Cross Central Limited Partnership (KCCLP)

Heatherwick Studio & BAM Design

Fletcher Priest Architects

AMP Capital

3XN

Quadrant and Oaktree Capital

Buckley Gray Yeoman

Rolfe Judd Architects

Royal Sun Alliance Insurance

Landsec

KPF

Orion Capital Managers

Foreword – Climate Policy Lead (DRAFT)

At the City of London Corporation, we are passionate about doing our part to tackle the climate emergency. Our Climate Action Strategy commits us to supporting the achievement of net zero for the Square Mile by 2040, ten years ahead of UK Government plans.

Commercial buildings make up 65% of greenhouse gas emissions in the City of London and is a key focus area in our Strategy. As highlighted in our 'Taking Climate Action: Our Progress 2023', the Square Mile's carbon footprint has reduced by 40% between 2017 (our baseline year) and 2020 (the latest available data). While these figures suggest positive progress, we should recognise the decarbonisation of the grid and the COVID pandemic's social restrictions have contributed significantly to this development.

To maintain this positive trajectory, there is an urgent need to increase the pace at which we are refurbishing and retrofit our commercial real estate, not just in the City but across London, the UK and globally. Doing so will enable us to meet our net zero targets whilst simultaneously supporting the Paris Climate Agreement's commitment to limiting global temperature increase to 1.5 degrees Celsius.

As a City Corporation, we are using our influence to shape and accelerate action:

- We have adopted a ground-breaking Planning Advice Note on Carbon Options Guidance which requires developers to carry out a detailed review of the carbon impact of development options before submitting a planning application, including refurbishing existing buildings rather than demolishing and replacing them.
- We are currently consulting on a 'Planning for Sustainability' Supplementary Planning Document to drive forward best practice in sustainable development in the Square Mile.
- Our new City Plan 2040 will take a 'Retrofit First' approach to development to support the ambition for a net-zero Square Mile

I welcome the case studies and recommendations set out in this report as another important contribution to current discussions on the whole lifecycle carbon of our commercial buildings and the role refurbishment can play in improving the energy-efficiency of buildings and reducing embodied carbon. It underlines the need for more reliable and standardised data, examples of leading practice and collective action across the built environment value chain.

Alderman Alison Gowman

City of London Corporation

Executive Summary:

In 2023 the Climate Change Committee (CCC)[1] stated "*Progress remains broadly insufficient to ensure that the buildings sector reaches zero emissions by 2050*" and "*the UK meeting its goals from 2030 onwards is now markedly less than it was in our previous assessment a year ago. A key opportunity to push a faster pace of progress has been missed*".

The built environment sector needs to do more to effectively reduce its emissions and to progress towards the UK's legally binding commitment to reach net zero by 2050. The industry is being judged on its outcomes, in relation to the built embodied 'upfront carbon' as well as in use performance of materials and energy consumption within buildings. It is, therefore, imperative to act now and progress toward the achievement of the net zero target by 2050.

Case studies and insights

This report, 'Refurbishing the City – insight into current best practice', has collected a series of case studies to provide a deep-dive into key aspects of commercial building refurbishment in the City, London and beyond. The case studies show that retrofit and refurbishment schemes can make a key contribution to sustainability goals, both in terms of reducing the use of new resources and their associated impacts, including carbon emissions.

The 18 case studies collected range across different typologies and sizes of buildings as well as time periods. At the time of collecting the data some of the case studies were at an early design stage, where the embodied carbon analysis had not yet been concluded. Nevertheless, these examples still have an important part to play in demonstrating what retrofit measures can be achieved with existing building stock.

The carbon performance of the case studies was also compared to voluntary industry benchmarks. As set out in Table 1 below, 8 of the projects are currently in line with the LETI 2030 metric for upfront carbon. Given several of the projects have had little to no structural intervention, the case studies illustrate how challenging these metrics are to achieve. 10 projects perform in line with RIBA benchmark Challenge 2025, and the remaining 7 fall within RIBA benchmark Challenge 2030. Whilst these metrics are voluntary, the case studies do reflect how current practice compares against emerging industry ambitions.

Table 1: Summary of Carbon Performance data of Case Studies

Total Case Study Projects: **18** Total with A1-A5 (upfront carbon) provided: **15** Total with A1-A5, B1-B5, C1-C4 life cycle embodied carbon provided: **13**	**Metric ($kgCO_{2e}$ /m^2 /GIA)**	**Number achieving LETI / RIBA 'Metric'***
LETI 2020 (Band C) (A1-A5)	600	12
LETI 2030 (Band A) (A1-A5)	350	8
RIBA 2030 Challenge 2025 (A1-A5, B1-B5, C1-C4)	970	10

[1] CCC – The independent body set up to advise and monitor the UK's progress in reducing greenhouse gas emissions

RIBA 2030 Challenge 2030 (A1-A5, B1-B5, C1-C4)	750	7

The information gathered from the portfolio of case studies also provides other key insights and lessons learned. The following provides a summary – further details are set out in section 7:

Data availability: historically, data surrounding both embodied carbon and in use operational energy is scarce. This is correlated to the feedback provided by designers in terms of how the building operates in use, from an energy perspective. Nevertheless, positive change is taking place as policy evolves, and developers seek to report on their actual emissions.

A more comprehensive approach to whole lifecycle carbon assessment: the case studies show that data, evaluation, and transparency is improving over time, and key metrics are now being looked at all stages of development. Improved and consistent data is predominant in more recent projects, indicating that as performance-based parameters become a mandatory requirement, the knowledge, data, and reporting related to carbon is expected to become more accurate and standardised.

Consistency of data is key for evaluation and learning from best practice. Estimations should be developed to reflect an outcome closer to the reality. Initiatives like the Built Environment Carbon Database (BECD)[2] should assist with this data collection and evaluation. The industry requires a national approach, with clear and consistent calculation methodology, scopes, evaluation, and reporting transparency, to address this issue.

The challenges of benchmarking: the data related to building and carbon performance is difficult to compare on a like-to-like basis. This is because design teams have followed varying methodologies and used differing carbon factors across projects. Benchmarking and analysis for carbon impacts has been evolving at a fast pace, making historical comparison challenging. Without a development's wider context and/or good understanding of the calculation methodologies, comparisons are difficult or at times unfeasible.

Schemes, such as the NABERS UK rating for office buildings, and in-use energy reporting requirements under the London Plan are helping with this standardisation, particularly the disclosure of a Display Energy Certificate (DEC) after full occupation for at least 11 months.

Policy and regulatory landscape

A review of international regulation and policy within the built environment (set out in section with further detail in Appendix B) shows a general movement towards reducing

[2] Developed in partnership BRE and other major organisations operating across every part of the construction sector, the Built Environment Carbon Database (BECD) is free-to-access and is designed to become the main source of carbon estimating and benchmarking for the industry.

the whole lifecycle carbon of buildings, with significant innovation and variation across countries and cities.

At a UK level, such requirements are not in place yet. New policy frameworks need to be created, allowing for some regional adaptions, to allow consistent approaches to be adopted. The industry understands the need for change but requires consistency to be able to invest in effective and viables solutions.

In London, policy is developing at pace around operational energy and embodied carbon data, particularly in relation to retrofit first approaches. These are reflected in the London and in the City of London's own policy and guidance framework. It is expected that over the next few years, building in-use reporting will become a regular occurrence and more data will be available to designers due to mandated planning requirements. However, this will only apply for GLA referable schemes and some Boroughs requirements.

Market trends

The case studies compiled in this report show both the complexity in retrofit/ refurbishment as well as the benefits, often resulting in innovative and successful 'products.' Some remarkable architectural and engineering solutions have been developed and implemented. These include aspects of:

- building retention;
- value retention within used material;
- material passporting;
- the integration of low carbon technologies; and
- optimising design for adaptability and flexibility.

These solutions have also resulted in co-benefits beyond carbon savings, such as potentially cheaper costs, less use of intensive resources and potentially shorter programmes. However, there is no golden rule or silver bullet. Refurbishment and retrofit need careful consideration, the availability of good building records, viable business models, high expertise, and good design.

An increased body of evidence demonstrates that refurbishment and retrofit form an important part of achieving low Whole Life Carbon performance as well as 'Circular Economy' goals. These refurbishment schemes are also driving industry transformation by creating green jobs and upskilling workers, as recognised by the Skills for the Sustainable Skyline Taskforce.

Data relating to the business case of the schemes have proved more difficult to collect given commercial considerations. This is an area which needs further work to develop clear and consistent metrics for considering aspects of sustainability in market and investment value. However, these case studies demonstrate the viability of refurbishment schemes which combine economic, social, and environmental benefits within a long-term framework.

From a commercial perspective, there is emerging evidence (e.g. JLL, 2023) that buildings can attract a premium on rents due to its green credentials e.g. buildings with lower EPC or high sustainable certification and potentially lower operational costs. Currently, this is primarily focused on the operation of the building rather than a whole lifecycle carbon perspective.

Recommendations

Overall, this report aims to take insights from real refurbishment projects and summaries several key best practice recommendations. These include:

1. Collect and analyse existing building data.
2. Ensure the business case also accounts for carbon impact.
3. Evaluate risks and opportunities for the site.
4. Establish a clear strategy for decarbonisation, accounting for comparisons of building types and regulation considerations.
5. Use consistent reporting metrics and review against targets (peer reviewed data is recommended)
6. Consider market maturity – i.e. can lower whole life carbon buildings attract a premium if demand rises?
7. If refurbishment / retrofit is not possible and demolition is required, ensure a justification and plan is in place to have rationalized the demolition and maximise reuse potential of existing materials. This should be communicated to the planners.
8. Report on as built upfront carbon performance and operational energy in use.

Further details on each of these aspects is set out in chapter 8.

The case studies and report underline the transformational shift underway within the built environment industry in London and beyond towards the retention, refurbishment and retrofit of buildings. They draw on a series of leading, real-world schemes which have taken ambitious action in terms of decarbonisation, innovation, and value-creation.

They provide further evidence of what can be achieved through the refurbishment of commercial buildings and provide key insights into the challenges and opportunities involved.

Introduction to the document

Purpose of the report

This report is aimed at individuals and actors across the built environment value chain interested in the move towards commercial building refurbishment.

It seeks to capture current policy and practice on commercial building retrofit and draws on a range of real-word case studies with input from across the built environment industry. It highlights some of the innovative approaches to adapting our existing building stock to deliver successful outcomes.

The publication is a contribution to current discussions on the drive towards net zero carbon in our existing building stock. It includes retrofit definitions, key considerations and supporting case studies - outlining a method for approaching retrofit projects and setting out clear definitions to help give clarity to the industry in establishing best practice approaches.

Case Studies: Methodology & Approach

In March 2023, a case study request was initiated and issued by the City of London, supported by Hilson Moran, to several organisations actively working within the retrofit arena.

A case study template form was independently completed by the design team with the available quantitative and qualitative data related to the project brought forward. The data was reviewed with regards to suitability, quality, and quantity.

The selected case studies aim to provide a spectrum of different measures, approaches related to retrofit, redevelopment and retention of building elements across different typologies of buildings that vary in ages and architecture style.

A series of insights have emerged from the case studies which aim to highlight the multitude of drivers that the design team must consider, effective interventions and retrofit/refurbishment methodologies, as well as typical challenges that are worth considering during design stage. All such insights aim to provide key learnings for future projects.

The case studies illustrated are projects that are either in design or construction or have been completed relatively recently (in the last decade) and therefore were not subject to the same level of regulation or reporting standards that is perhaps mandated today.

It is worth noting that more recent developer requirements/ standards, as well as policy and regulation at national and regional scale, have developed considerably in relation to whole life carbon targets, measures, and assessment methodologies.

For this reason, more recent data is more detailed and complete today compared to project assessments that have been conducted in the past. Some case studies collected within this report do not have clearly broken down and available data due to the standards and requirements at the time of completion.

The performance data included in the case studies should not be compared like-to-like as there are several varying factors, contextual conditions, carbon factors and differing methodologies of data calculation. In addition, the data illustrated for each case study has been retrieved by design teams and have not been verified by a third-party or been peer reviewed. This underlines the need for better, more transparent, and standardised

data collection, which is likely to improve over time as both policy and client requirements evolve,

1. Introduction

The Climate Emergency and impact of the built environment

As set out in Figure 1 below, the built environment (buildings and infrastructure, excluding surface transport) is currently responsible for 25% of the UK's total greenhouse gas emissions (177 MtCO2e). This is one of the main sources of emissions resulting from human activities (UKGBC, 2021). It is also an area for which the UK has direct control and therefore has the potential to reduce effectively, in line with its net-zero commitments.

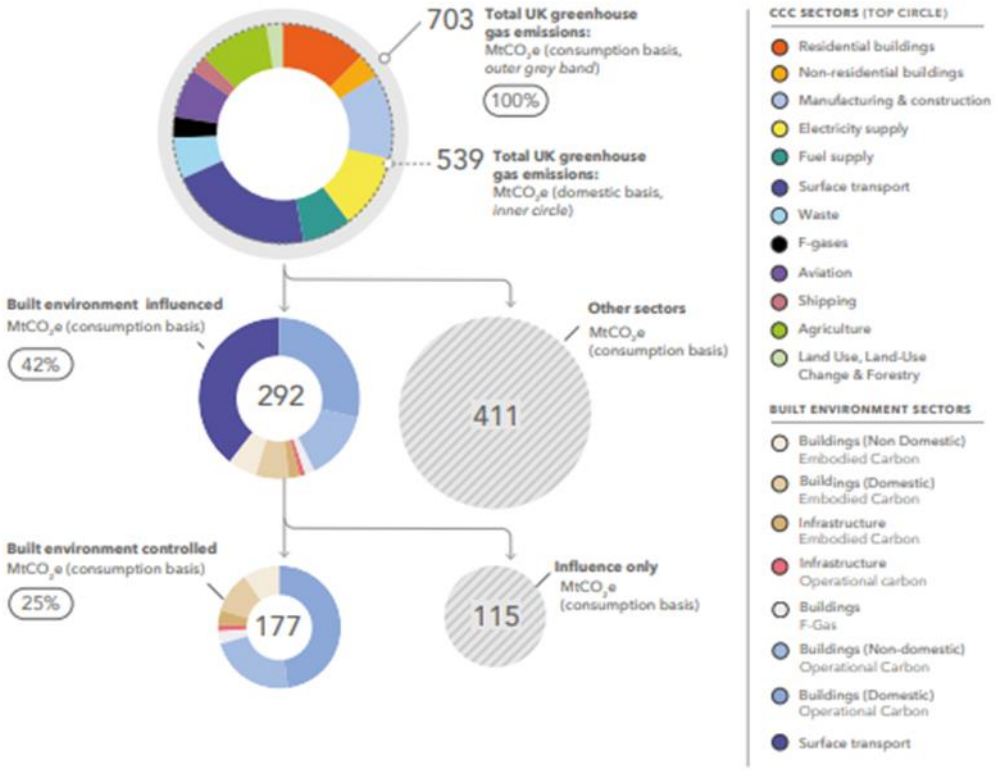


Figure 1: Total UK GHG Emissions (2018 CCC Data) showing proportion of Built Environment emissions.

In London 78% of emissions are generated from buildings (JLL, 2022). Specifically, within the Square Mile 65% emissions arises from all commercial building (GLA, 2020)

UK Policy framework

The UK has mandated a legally binding target to reach net zero by 2050 under the Climate Change Act 2008. At COP26 the Government committed to achieving 68% reductions in carbon emissions by 2030. Therefore, there is an urgent need for decarbonisation strategies and actions for energy and material efficiency improvements in buildings as

well as adopting a circular economy model to the design of the built environment to truly achieve the national carbon reduction targets (EMF, 2021).

Despite this overarching policy there are insufficient policies and guidance on effective energy efficient retrofitting and net zero carbon strategies. As a result, the industry may struggle to reach net zero aspirations. Business as usual (BAU) projections, informed by the existing government policy framework, indicate that the sector will fall well short of 2050 net zero targets. Only a 60% reduction will be achieved compared to 1990 emission levels.

The UK's 2020 Energy white paper confirmed that the future trajectory for the non-residential minimum energy efficiency standards (MEES) will be EPC 'B' by 203010 (EPC 'C' by 2027), creating a clear regulatory driver for commercial building retrofits. However, in November 2023 the Government announced an intention to 'update' these minimum energy efficiency timelines to allow 'sufficient lead in time for landlords and the supply chain'. No further details of the Government's plans are yet available, but it appears that an increase in the minimum energy rating may be delayed.

In 2023 the Climate Change Committee (the independent body set up to advise and monitor the UK's progress in reducing greenhouse gas emissions) stated '*Progress remains broadly insufficient to ensure that the buildings sector reaches zero emissions by 2050'* and that the '*UK meeting its goals from 2030 onwards is now markedly less than it was in our previous assessment a year ago. A key opportunity to push a faster pace of progress has been missed.'*

Market drivers

The demand for sustainable urban development is growing in line with increased market expectations and potentially forthcoming regulations. Net zero and ESG targets have shifted investors' focus to more sustainable real estate properties. Regulation has become more stringent in recent years, with solutions requiring for more energy efficient buildings and electrification of heat and transport.

New buildings coming forward need to be equipped to deliver the energy performance levels required for net zero and should eliminate the need for future retrofitting, which would cause future occupant disruption, cost, and embodied carbon emissions. Opportunities exist in tackling embodied carbon from construction and refurbishment, which accounts for 20% of built environment emissions, as well as improve utilisation of existing building stock and reducing operational carbon by decreasing energy demand (UKGBC, 2021).

The UK has the potential to lead on innovation for net zero and more needs to be done to achieve this in the non-domestic sector. Policy and sector collaboration is key for addressing the UK's commitment for 'net zero by 2050' and Paris Climate Agreement to limiting global temperature increase of 1.5 ^{0}C.

The UK must increase and mobilise efforts, policy and capital towards low embodied carbon structures, greater energy efficiency buildings, retrofitting, enabling infrastructure for the electrification of heat and transport and installation of low carbon and renewable energy technologies.

Towards a Net Zero Built Environment

Over the last couple of decades, Building & Infrastructure emissions have dropped by 30% (against 1990 baseline). Most of the decline has been due to operational emissions and

decarbonisation of the grid as opposed to improvement in energy efficiency or reducing 'embodied' carbon (UKGBC, 2021).

There are big opportunities to help push emissions down further by retrofitting existing buildings to reduce energy demand, reduce embodied carbon emissions (versus new build equivalents) and enable adaption to climate change.

80% of UK's 2050 building stock has already been built (UKGBC, 2021). There is therefore an urgent need to accelerate and focus the priority on decarbonising existing stock (but also to ensure new / updated stock is fit for purpose).

Whilst there are overarching policies on carbon performance there is little policy, especially over the long term, to enable improvements in emissions, both upfront embodied carbon (form the materials used) and in use.

In terms of in-use or operational emissions, grid decarbonisation relies heavily on electrification which will require significant grid upgrades and for buildings to become more energy efficient to maximise their effectiveness.

It is critical that the built environment increases its pace in adapting to the everchanging climatic environment to deliver low carbon and energy efficiency performance.

Retrofitting is necessary to enable millions of properties in the UK to become more resilient and address the risk of flooding and overheating that will be exacerbated by climate change, whilst also maintaining and maximising materials use to a highest value in the 'Circular Economy'.

In addition to focusing on reducing operational emissions, which has been given most attention up until recent years, there is now a recognition for an urgent need to move further and consider the whole lifecycle including embodied carbon. As operational carbon is reduced, embodied carbon will be the largest portion of carbon left unaddressed. A focus on the buildings' embodied is paramount as generally it has the biggest share of carbon across the buildings'/ developments' lifespan. Embodied carbon must be measured and reduced to effectively reach real net zero carbon target (WGBC, 2022).

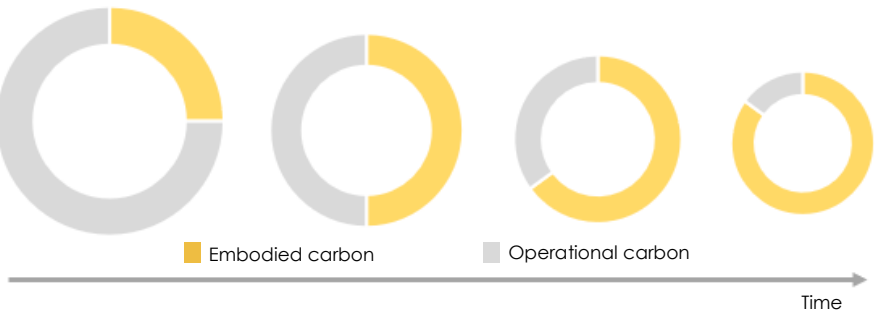


Figure 2: Illustration of growing importance of embodied carbon in time (as operational energy decarbonises)

The Government is yet to publish a consistent plan and guidance to support the built environment to transition towards a net zero future, and the commercial sector is seemingly leading the market to influence change along with local policies.

2. Net Zero Carbon Buildings & Whole Life Carbon

To understand the benefits of retrofit and refurbishment versus new build it is important to understand key terminology. This section aims to define different types of carbon emissions, what a net zero carbon building or development is and how this can be evaluated by a whole life carbon assessment (WLCA).

Introduction

Over the course of a development's lifetime, carbon emissions are emitted during construction, in use, maintenance and decommissioning stages. For simplicity, carbon emissions can be split into two categories (see Figure 3):

1. **Embodied Carbon**, the carbon emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials.

2. **Operational Carbon**, carbon emissions emitted during the operational or in-use phase of a building through consumption of resources, fuel, and electricity.

The combination of both the above (plus the carbon from operational water use), is the Whole Life Carbon of the development.

Generally, most embodied carbon emissions take place at the beginning and end of developments lifespan. These can amount to between 35% and 70% of the whole life carbon emissions from buildings depending on the use class, as illustrated in figure 3 below, and other factors.

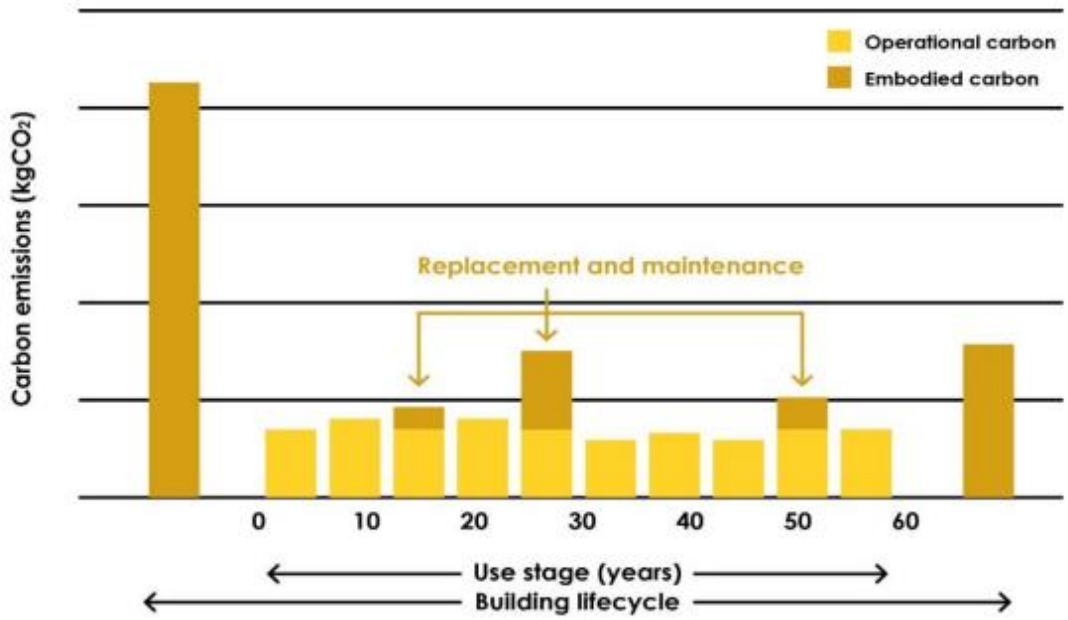


Figure 3: Indicative building lifecycle carbon emissions (operational and embodied) – note replacement phases and timings of them can vary considerably and are challenging to predict, they can in realty mount up over a buildings life time (they will also vary on use type).

In simple terms, embodied carbon emissions in new construction can outweigh operational emissions (especially as the grid decarbonises). Crucially, a major component of this embodied carbon is the upfront carbon associated with the initial construction process and hence reaching the atmosphere at the very outset. For this

reason, retrofit / refurbishment projects which have the potential to retain foundations, superstructure and/or external elements of a building and effectively eliminate the need for intensive new materials, thus reducing the upfront carbon emissions when compared to a new build equivalent. It should be noted that replacement can mount up over a building's lifetime reference period (which is typically cited as 60 years in the UK). In the commercial sector this can be heavily dictated by tenancy length.

Whole Life Carbon Assessment (WLCA)

The embodied carbon emissions generated across a building's lifetime can be estimated by undertaking a whole life cycle assessment. This study provides an overview of the carbon footprint (in $kgCO_2$) associated with each of the building's lifecycle stages. As illustrated in Figure 4, the stages are namely:

- A1-A3: extraction and manufacturing,
- A4 materials transportation,
- A5 construction processes,
- B1-B5 replacement, repair, or maintenance of materials/building elements,
- B6-B7 operational carbon (energy and water consumption),
- C1-C4 end-of-life,
- D use in the next 'life cycle' recycling, reusing or disposal.

A carbon assessment can highlight the most carbon-intensive areas to focus on and help make informed carbon decisions in both design of the building and procurement material.

The scope of WLCA may differ across different Councils in the UK. The City of London Corporation follow the adoption of the London Plan WLCA guidance (Policy SI2) for all major development. Typically, this GLA approach applicable and a requirement of all referable schemes within the Greater London Authority (GLA) and follows the RICS WLCA professional Statement (RICS, 2017) with a few additional features / requirements.

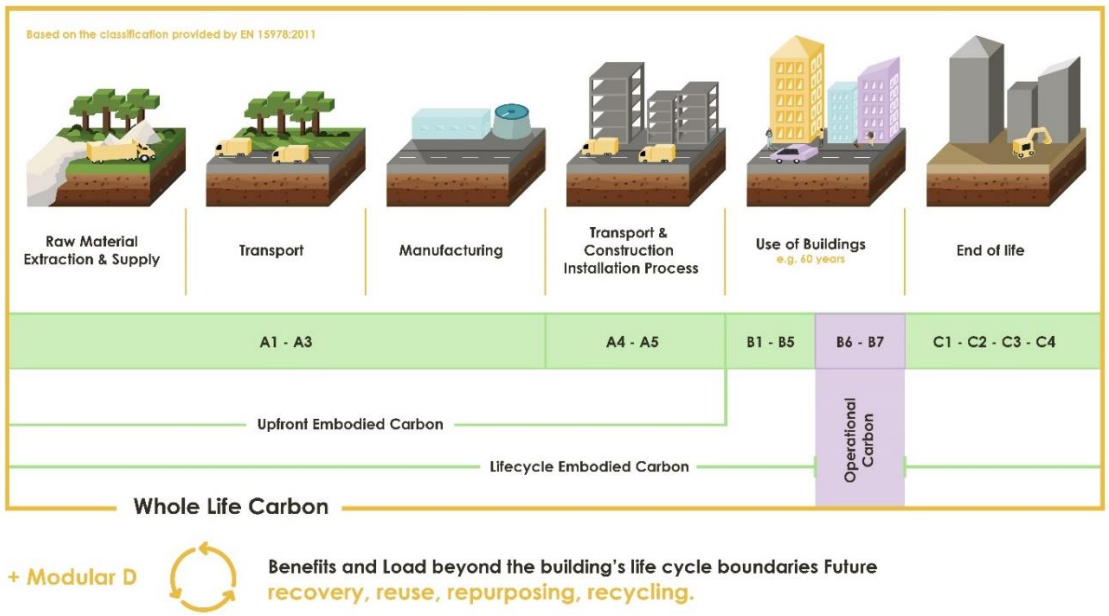


Figure 4: Whole Life Carbon Assessment Stages

Building Regulations Compliant building vs Ultra-low energy building

Embodied carbon occurs at different stages of the lifecycle, and this may differ across different building types, the scope of construction works, longevity and maintenance requirements. The London Energy Transformation Initiative (LETI) conducted a study utilising RICS data to demonstrate the differences of embodied carbon proportions between a new office building that is Building Regulations compliant against an ultra-low energy building. The embodied carbon resulted to be 33-34% against 72% respectively of WLC emissions for a new office building (embodied carbon including maintenance, repair, and replacement of components during the in-use phase).

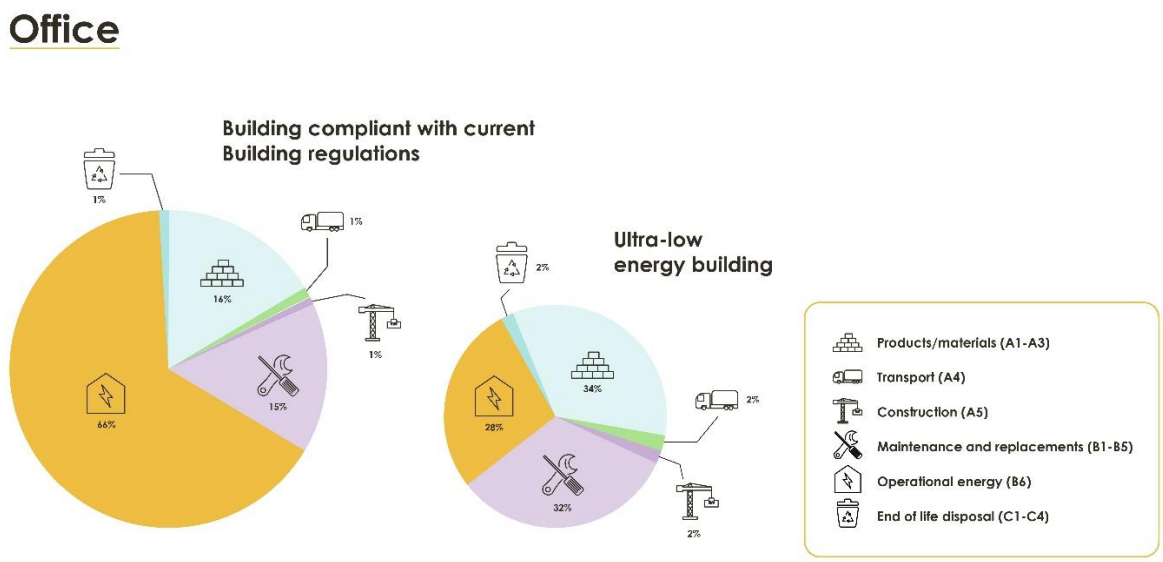
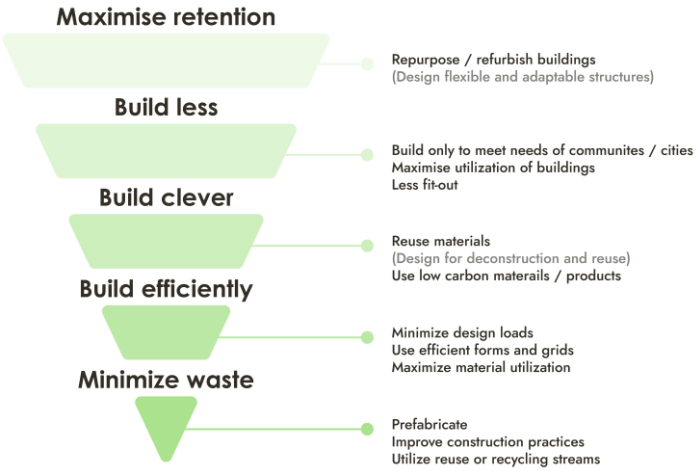


Figure 5: Building Regulations Compliant vs Ultra-low Energy New Office Building , LETI

Approximately half of the raw materials around the globe are utilised for the built environment. Therefore, reducing new build is the most effective way to save on resources and avoid high upfront embodied carbon emissions, despite new build having lower operational emissions. Arguably the most sustainable and less embodied carbon-intensive buildings are the ones which are retained and have their lifespan extended.



Embodied Carbon Reduction

Decarbonising construction and lifecycle processes through the design and procurement of buildings and infrastructure is required for achieving the net zero carbon ambition.

Embodied carbon is not currently part of building regulations in the UK, despite typically accounting for 35-70% of a building's lifetime emissions and up to 85% of a masterplan's total embodied carbon, including the spaces between buildings (i.e. hard surfaces, roads, parking areas) (UKGBC, 2022).

Lower embodied carbon emissions can be achieved by implementing measures such as material use optimisation and waste reduction; increased recycled content; low carbon alternatives to building elements; local sourcing (where lower carbon in production); low emission construction processes; and reducing the need for soil movements and reducing need for hard surfaces in the spaces between buildings. Optimising and reducing level of embodied carbon at masterplan-level should be tackled at early design stages with careful planning.

The use of mass timber construction, cement alternatives and reused steel beams for example are just some of the trends and innovations observed recently in the construction industry where developers are targeting low embodied carbon emissions. The industry is rapidly gathering, improving, and benchmarking data around greenhouse gas emissions from manufacturing, transportation, construction, and maintenance processes.

Embodied carbon emission targets up to Practical Completion (also known as the Product Stage or Upfront Carbon) have been established in industry publications (e.g. by LETI – see Figure 6, and the RIBA) and more recently in planning policy (GLA), to provide some industry direction around what best practice looks like today and how it needs to improve over time to limit global warming.

Figure 6: Example of embodied carbon targets trajectory for residential and non-residential buildings (Source: LETI)

Operational Carbon Reduction

Operational carbon derives primarily from operational (regulated and unregulated) energy use and operational water use. Typically, the aim of designing new build is on lowering the energy demand and consumption of the property.

For refurbishment projects, certain design solutions may not be possible depending on the scope and constraints of a project, the design focus may vary largely depending on specific building characteristics, context, changing (existing or future) operational uses.

Generally, the first rule to follow to reduce carbon emitted from energy consumption, is for passive design and efficiency. For years, the UK Building Regulations have applied standards on building fabric insulation and permeability, heat recovery and the energy efficiency ratings of buildings services.

A fabric first approach following a passive design is typically prioritised to reduce energy demand. This may include optimising orientation and glazing, improving thermal performance and reducing thermal bridging and heat losses. In addition, improving energy efficiency is a good policy solution, not only because of reduced carbon emissions, but it also offers additional benefits such as future resilience, affordability, comfort, energy security and innovation.

The retrofit interventions for commercial buildings vary across a spectrum from light to deep interventions, as illustrated in the figure below. The UKGBC defines these as:

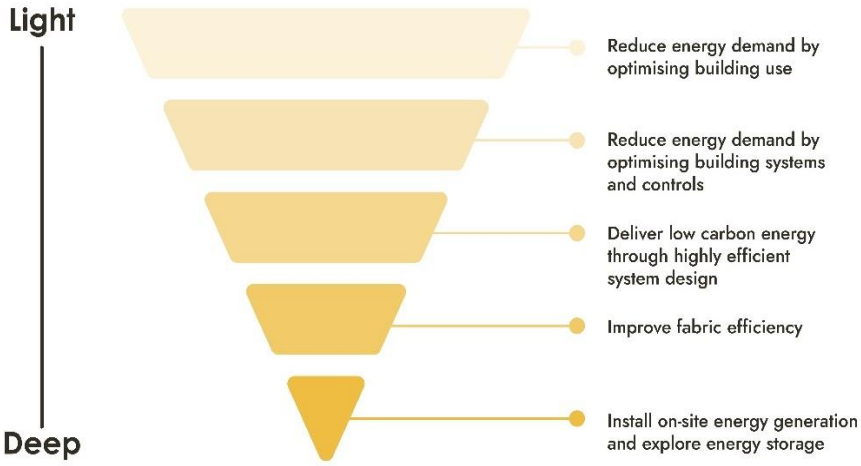


Figure 7: Hierarchy of retrofit interventions for commercial buildings, (adapted from: (UKGBC, 2021)*)*

Light Retrofit:

UKGBC (Delivering Net Zero: Key considerations or commercial retrofit, May 2022) defined light retrofit as having a "*focus on performance optimisation, basic remodelling, replacement, or adaptation of existing building elements which tend to focus on a single aspect or feature (lighting upgrades, optimisation of building controls and operation, etc)*." (UKGBC, 2021) These interventions are commonly effective when stakeholders/ occupiers are engaged and behavioural change is achieved, as this further increases the efficiency and may maintains good performance of the building. Light retrofit measures are consider 'easy wins' as these are less disruptive, less costly and may address in the short-term smaller energy reductions. These may form the basis of an initial retrofit approach ahead of a more in-depth, intrusive retrofit works.

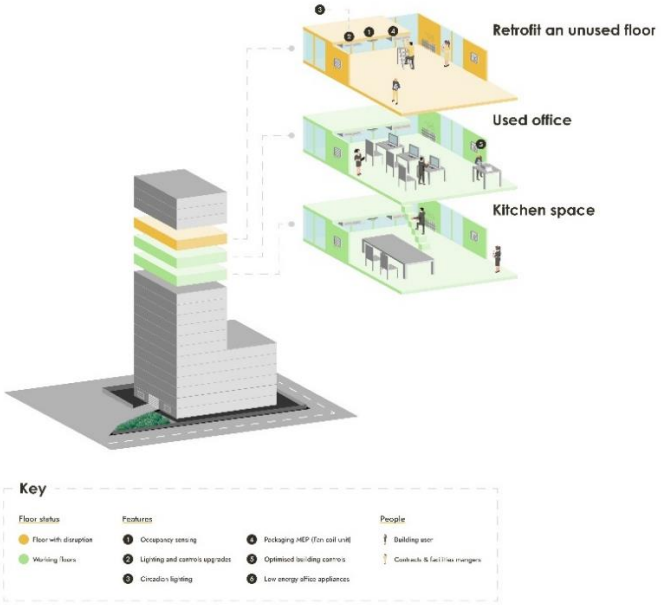


Figure 8: Light Retrofit Measures (adapted from: (UKGBC, 2021)*)*

Deep Retrofit:

UKGBC (Delivering Net Zero: Key considerations or commercial retrofit, May 2022) defined deep retrofit as having a "*focus on significant works of size or scale that result in a fundamental change to the building structure and/or services. This can be represented as a collection of light retrofit enhancements or individually disruptive measures, such as major plant replacement.*" (UKGBC, 2021)

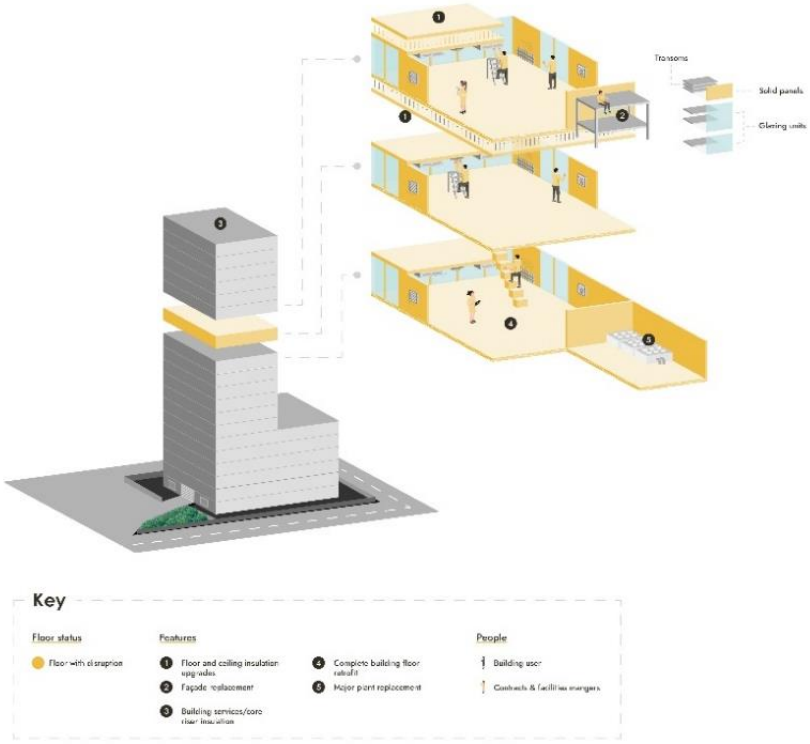


Figure 8: Deep Retrofit Measures (adapted from: (UKGBC, 2021)*)*

3. Current Policy, Regulation and Market Trends

Carbon and Building Retrofit/Redevelopment in Planning Policy

This section highlights some of the key policies focused on sustainable design and construction across a few major countries and cities around the world. Table 1 gives an overview of the key policies related to energy efficiency in buildings, decarbonisation, and carbon neutral buildings. An in-depth policy review can be found in the White Paper "*International Regulatory & Policy Review on Carbon Emissions within the Built Environment*". There is a vast quantity of requirements and polices across various nations. These have been developing at pace over the last few years, however there is also an enormous variation in the approaches taken to reducing carbon. Most policies seem to focus on operational energy, with few looking at the carbon impact of materials. It could be observed that the area of embodied carbon is beginning to become part of policy, due to its known adverse impacts at scale.

Policies are quite varied and use a variety of methods to achieve lower carbon objectives, often factoring in consideration of regional and local issues. Most policies focus on macro decarbonisation strategies with a focus on emissions form energy consumption.

Where specifically mentioned in policy, low carbon refurbishment / retrofit or similar is an encouraged option rather than a mandated one, yet no real metrics are attributed to it.

In addition the EU are looking implement a suite of forthcoming polices, including mandating of Digital Product Passports (under the Proposal for Eco-design for Sustainable Products Regulations) and a declaration of performance such as an Environmental Product Declarations (EPD) as part of the review of the Construction Product Regulations (European Commission, 2022). The White Paper summarises all policies related to energy and carbon falling under the EU remit. The proposed revision of the Energy Performance of Buildings Directive (European Parliment, 2023) is proposing that '*The life-cycle Global Warming Potential (GWP) of new buildings will have to be calculated as of 2030 in accordance with the Level(s) framework, informing on whole life-cycle carbon emissions (2027 for large buildings)*', the methodology is yet to be defined, but broadly will require LCA to EN 15978 and encourages the use of national tools. Should this be implemented, this will accelerate policy making in EU nations by requiring policies and reduction targets of WLC GHGs in member states.

Policy developments are moving at pace because of drivers such as climate change. Polices are currently more weighted to predicted energy emissions, energy in use, and or energy efficiency. Policies in terms of embodied carbon are starting to appear in various forms, and this trend may continue as countries try to transpose their legally binding carbon commitments into policy and aim to achieve their carbon reduction goals. The UK has been a leader for some time in this area, but more recently it appears to be lagging as well as lacking in long term vision.

There are also several building certification standards that include energy and carbon performance and associated metrics. These have not been reviewed as part of this exercise. BREEAM version 6 for instance does not mandate the implementation of the

lowest (or even a lower carbon) carbon options choice, yet the Mat 01 credit makes up approximately 10% of the total scheme score.

As part of the policy outlook, there is clear that short term policy goals will not solve the problem, as it needs longer term thinking, with clearer and consistent action. Policies also need to be quicker to react to fast changing data and approaches for carbon calculations. Without further policy, until the market matures (UK approach appears to be market led) and there is further evidence of higher value for more sustainable buildings, it will be challenging for the UK to achieve carbon emission goals, let alone be a leader on the global stage.

Net Zero Carbon Buildings

At the time of writing of this topic paper, '*a UK Net Zero Carbon Building Standard'* is being drafted in a joint initiative between BBP, BRE, the Carbon Trust, CIBSE, IstructE, LETI, RIBA, RICS, and UKGBC. Whilst significant progress has been made in defining what 'net zero' means for buildings since 2019, there is a demand for a single, consulted, and national methodology. The aim is to produce a standard which enables the industry to robustly prove their built assets are net zero carbon in line with our national climate targets.

The most robust guidance produced to date is the UKGBC 'Net Zero Carbon: A Framework Definition' (April 2019) and its subsequent 'Renewable Energy Procurement and Carbon Offsetting: Guidance for Net Zero Carbon Buildings' (April 2021).

The Net Zero Carbon framework sets out definitions and principles around two approaches of equal importance, namely:

- **Net zero carbon – Construction:**
  "When the amount of carbon emissions associated with a building's product and construction stages up to practical completion is zero or negative, through the use of offsets or the net export of on-site renewable energy."
    - Requires a WLCA to be undertaken (module A) with a strategy to effectively abate embodied carbon emissions arising from product and construction stages, as far as practical. Only secondly should the remaining emissions be offset at practical completion.

- **Net zero carbon – Operational:**
  "When the amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset."
    - Requires the calculation of regulated, operational energy consumption and a strategy to abate operational emissions through reduced energy demand, fabric first approach, energy efficient electric-led heating solutions, and on-site renewable energy generation. Off-site renewable energy can be considered if additionality is demonstrated. The residual emissions that cannot be reduced should be offset via a recognised framework and disclosure.

- **Net zero carbon – Whole life:**
  "When the amount of carbon emissions associated with a building's embodied AND operational impacts over the life of the building, including its disposal, are zero or negative."
    - Requires a WLCA that covers modules A-D with a strategy that reduces both embodied and operational carbon where practically feasible across all lifespan stages. Only as a last resort, should residual emissions be offset.

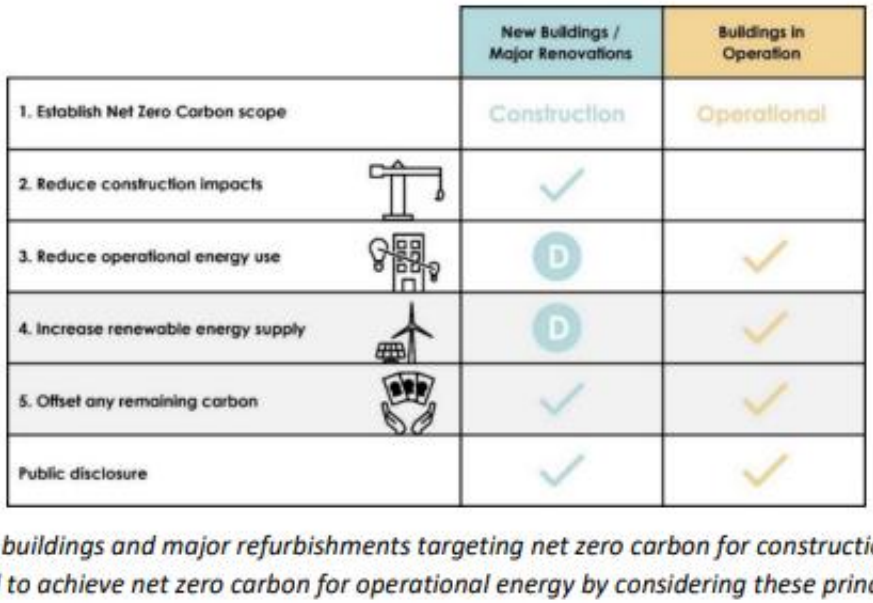


Figure 9: Steps to Achieving a Net Zero Carbon Building, UKGBC 'Net Zero Carbon: Framework Definition' (April 2019)

The framework establishes the steps for reducing emissions, offsetting the remaining carbon and public disclosure. It is worth noting that limitations exist when calculating emissions related to the maintenance, repair, and end-of-life parts of a building's lifecycle.

Note on 'True Zero Carbon': The "net" element in NZC essentially treats CO_2 emissions like a balance. If, you emit 1,000 tonnes of CO_2 from construction activity, for example, you can account for them by buying 1,000 tonnes of high value carbon offsets. Despite the definitions of NZC focusing on offsetting as a last resort, the 'net' element is increasingly viewed as insufficient because the offsets don't replace the emissions generated. The term 'True Zero Carbon' or "Zero Carbon" therefore describes a situation where no carbon emissions are being produced from a product or service.

International Carbon Buildings Policies

Several policies have been reviewed and summarised in Table 1. It is not a comprehensive list but shows the general themes and approaches to reducing carbon in policy and some wider initiatives.

The review in Table 1 has identified that there are different approaches around the globe to the same carbon emissions problem. More policy and legislation is emerging to address this issue at national and local level. The UK appears to be lagging in policy terms compared to other nations and does not appear to have a clear strategy to address carbon reduction in the industry. Most of the action is being undertaken by the voluntary and commercial groups (i.e. LETI, RICS). It is worth noting that there is lack of consistency and standardisation at a global scale. Therefore, the methodologies, scopes and data metrics vary across nations, despite having very similar objectives to reduce carbon emissions.

Table 1: ***Summary of Carbon-related policies at national scale globally (Detailed version of this table available in White Paper 'International Regulatory & Policy Review on Carbon Emissions within the Built Environment')***

Location	Policy Level	Policies Titles	Summary of the Standards / Requirements
United States	**State/national level** ***New York State (NYS)***	• **2020 Energy Conservation Construction Code of New York State (ECCCNYS)** [1] • **NYStretch Energy Code (2020)** [2]	**(1)** Establishing minimum requirements for energy-efficient buildings, encouraging refurbishments and retrofits. **(2)** Available for voluntary adoption by local governments as a more stringent local energy code. It aims to improve the ECCCNYS's efficacy by roughly 10% and is a model for New York jurisdictions to use to meet their energy and climate goals.
	City level guiding visions ***New York City (NYC)***	• **80x50** [1] • **Mayor's NYC Green New Deal** [2] • **NYC Benchmarking Law (Local Law 133 of 2016)** [3] • **The Climate Mobilization Act** [4] • **Executive Order 23: Clean Construction (2022)** [5] • **New York City Energy Conservation Code (NYCECC)** [6]	**(1)** Aiming to achieve at least 80% reduction on GHG emissions by 2050. **(2)** Bringing new legislation and concrete action at the city level for *a nearly 30% additional reduction in emissions by 2030.* **(3)** Mandating owners of large buildings must annually measure their energy & water consumption through benchmarking and standardises this process by requiring utilising Environmental Protection Agency's (EPA) online benchmarking tool, Energy Star Portfolio Manager. **(4)** A package of legislation to reduce greenhouse gas emissions from and improve energy efficiency for certain buildings in NYC. **(5)** Emphasising to reduce embodied carbon of building materials and construction equipment and strategies. Within this scope, it requires the development of guidelines of procurement of low-carbon concrete. **(6)** More stringent than the state level energy conservation code.

Location	Policy Level	Policies Titles	Summary of the Standards / Requirements
	California	• **2022 California Green Building Standards Code (CALGreen), Part 11, Title 24**	**(1)** Inclusion of a reserved mandatory section over the existing voluntary measures, for the deconstruction and reuse of existing structures measuring 50,000 sqft, as well as stricter requirements for Tier 1 (150,000 sqft project aggregate) and Tier 2 (250,000 sqft project aggregate). **(2)** Establishing a minimum requirement for building reuse, including at least 45% of structure and enclosure. **(3)** Requiring mandatory Whole Building Life Cycle Assessment (WBLCA), with the intent of indirectly conserving energy and resources. The WBLCA conducted should achieve at least a 10% improvement in environmental impact for specific building components. **(4)** A prescriptive approach is mandated, specifying the materials that meet specified emission limits, including the specification for concrete.
	External initiatives	• **Environmental Protection Agency (EPA) Energy Star Portfolio Manager (ESPM)** [1]	**(1)** An online and interactive resource management tool that enables the users to benchmark the energy use of any type of building.
Hong Kong Special Administrative Region of the People's Republic of China	**National level**	• **Buildings Energy Efficiency Ordinance (BEEO)** [1] • **Building Energy Code (BEC) and Energy Audit Code (EAC)** [2] • **Energy Saving Plan for Hong Kong's Built Environment 2015~2025+** [3]	**(1)** Promoting building energy efficiency by focusing on building services installation. **(2)** Setting out the technical guidance and details in respect of the minimum energy efficiency requirements governing the building services installations defined in the ordinance. **(3)** Aiming to achieve an energy intensity reduction of 40% by 2025 using 2005 as the base.
	External initiatives	• **The Hong Kong Green Building Council (HKGBC) Benchmarking & Energy Saving Tool (HK BEST)** [1] • **HKGBC ACT-Shop Program** [2] • **HKGBC BEAM Plus scheme (New Buildings & Existing Buildings and Interiors)** [3] • **RCx Retro-commissioning** [4]	**(1)** Promoting better energy performance for commercial and office buildings. Providing a comparison practice and identify potential energy improvement measures. **(2)** Focussing on the enhancement of the energy performance of the existing buildings. **(3)** Offers independent assessment of building sustainability performance. **(4)** The program is developed to timely check the energy performance of an existing building to identify energy saving potentials for operational improvement.
Japan	**National level**	• **Building Energy Efficiency Act (2016)** [1] • **Building Energy Conservation Act (2022)** [2]	**(1)** Introducing regulatory measures for mandatory compliance with energy efficiency standards for large-scale non-residential buildings. **(2)** Mandating all new houses and buildings from 2025 to comply with upgraded energy efficiency standards.
	City level guiding visions *Tokyo*	• **Renewable Energy Installation Standards** [1] • **Tokyo Cap-and-Trade Program (2010)** [2]	**(1)** Require the installation of PVs on buildings of a certain size (or larger) **(2)** Within the city's sustainable building policy, it was developed for existing large facilities.

Location	Policy Level	Policies Titles	Summary of the Standards / Requirements
		• **Carbon Reduction Reporting Program (2010)** [3] • **Green Building Program (2002)** [4]	**(3)** It is required for small and medium facilities. Operational carbon reporting became mandatory in 2014. **(4)** It focusses on the environmental performance of new buildings (reducing energy consumption, using eco-friendly materials).
	External initiatives	• **Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) for Existing Buildings & CASBEE for Renovation** [1]	**(1)** A green building rating system assessing the environmental efficiency of buildings, evaluating materials and equipment that save energy or achieve smaller environmental loads.
The European Union	**European (EU) level**	• **The European Green Deal (2019)** [1] • **2030 Climate Target Plan (2020)** [2] • **A Renovation Wave for Europe (2020)** [3] • **Level(s) framework** [4] • **The European Climate Law (2021)** [5] • **The Fit for 55' Package (2021)** [6] • **The Energy Performance of Buildings Directive (EPBD) (2021)** [7]	**(1)** A package of policy initiatives aiming to set the EU on the path to a green transition, with an ultimate goal of reaching climate neutrality by 2050. **(2)** It was proposed to change the current emissions reduction pathway to reach climate neutrality by 2050. **(3)** Aiming at least doubling the annual energy renovation rate of buildings by 2030 (based on an annual renovation rate of 1% in 2020). **(4)** The framework was developed to be as a guidance on key areas of sustainability and how to measure them. It also promotes the use of Life Cycle Assessment (LCA) and Life Cycle Costing (LCC). **(5)** The framework established for achieving climate neutrality and amending regulations (enacting the targets stated in the Climate Target Plan into law). **(6)** Aiming to modernise existing legislation in line with the EU's 2030 climate target and introduce new policy measures to help bring about the transformative changes. **(7)** The latest revision of the directive sets out how the EU can achieve a zero-emission and fully decarbonised building stock by 2050, by increasing the rate of renovation for the worst-performing buildings in each EU Member State.
	National level	• **RT par élément (Regulation by Building Component) (2007 & 2018 & 2023)** [1] • **RT globale (Global Thermal Regulation) (2008 & 2018 & 2023)** [2] • **RT travaux embarqués (Regulation for embedded works)** [3] • **RE2020** [4] • **Low Energy Consumption Renovation - BBC renovation (2023)** [5] • **E+C- (Positive energy, carbon reduction) Scheme** [6]	**(1)** An existing regulation applies to existing buildings (residential or not) related to the thermal characteristics and energy performance of them. **(2)** An existing regulation applies to existing buildings with a surface area of more than 1,000 m² is subject to major renovation work (residential and tertiary buildings). **(3)** Relating to energy transition, an obligation to implement thermal insulation during major building renovation works, such as façade renovation, roofing, or the transformation of garages or attics into habitable rooms.

Location	Policy Level	Policies Titles	Summary of the Standards / Requirements
France			**(4)** A national regulation for all new building. It is the combination of the energy, the carbon criteria (embodied) in buildings and the summer comfort. Embodied carbon limits given for dwellings, multi-residential buildings, offices, and educational buildings. **(5)** Demanding conventional energy consumption of less than 110 kWhEP/m²/year and induced greenhouse gas emissions of less than 11 $kgCO_{2\ eq}$/m²/year for residential buildings **(6)** A pilot programme prepared by the government for new constructions (residential and tertiary). It is based on a new calculation method and new indicators to assess not only the energy performance but also the environmental performance of buildings. It prefigures the RE 2020.
	City level guiding visions ***Paris***	• **The Ile-de-France Region Territorial Energy Renovation Platform (Plateforme Territoriale de Rénovation Énergétique – PTRE) (2019)** [1] • **The City of Paris Plan Local d'Urbanisme' (PLU)** [2] • **City Of Paris, Paris Climate Action Plan (2018)** [3]	**(1)** Aiming to bring together all the players to encourage the emergence of a market. **(2)** A new local plan promoting more environmentally friendly construction are in the city. Introducing a height limit for new buildings of 37 metres or 12 storeys. **(3)** Aiming to achieve the goal of zero emissions in Paris: halving the energy consumption in Paris and obtaining its energy from 100% renewable sources.
	External initiatives	• **The Paris Climate Agency (APC)** o CoachCopro [1]	**(1)** Aiming to accelerate the massification of energy renovations of residential condominiums on the Parisian territory and implement comprehensive interventions with high environmental value.
The Netherlands	**National level**	• **The Building Decree 2012** [1] • **The Dutch Climate Act (2019)** [2] • **The National Climate Agreement (2019)** [3] • **Energy Performance Standard for Buildings (NEN 7120) (2021)** [4]	**(1)** Containing the technical regulations that represent the minimum requirements (incl. energy efficiency) for all structures it the country, also mandating embodied carbon reporting for new residential and office buildings over 100 m². **(2)** Aiming to 49% reduction in GHG emissions by 2030, compared to 1990 levels, and a 95% reduction by 2050. **(3)** Containing a package of measures and agreements with the sectors on what they will do to help achieve these climate goals. **(4)** Also referred as EPG, setting minimum energy performance for new buildings. Mandatory for all new buildings and for large renovations.
	City level guiding visions ***Amsterdam***	• **The Amsterdam Climate Neutral Roadmap 2050 (2020)** [1] • **The Amsterdam's Circular Strategy 2020-2025** [2]	**(1)** Setting out a long-term vision of the energy transition in Amsterdam, and the actions to be taken in the short term. It aims the city to be climate-neutral by 2030. **(2)** The strategy aims to significantly reduce the use of new raw materials and preserve valuable raw materials.

Location	Policy Level	Policies Titles	Summary of the Standards / Requirements
	External initiatives	• **Dutch Green Building Council (DGBC), The Paris Proof Commitment: Delta Plan for Sustainable Renovation** [1] • **DGBC, The Paris Proof Methodology (2019)** [2] • **The Netherlands Enterprise Agency (RVO), Energy Saving Monitor for the Built Environment (2017)** [3]	**(1)** A nationwide plan aiming for buildings to be extensively energy efficient. **(2)** Introduced as a common sustainable goal for urban buildings to achieve the Paris climate accords by accelerating to carry out major renovations, measuring actual consumption. **(3)** An online tool that enables building owners to explore investment costs, annual savings, payback times and carbon savings for different options to meet the minimum energy performance standard.
Germany	**National level**	• **National Action Plan on Energy Efficiency (NAPE) (2014)** [1] • **The Energy Saving Ordinance (EnEV, 2017)**[2] • **Buildings Energy Act (GEG) (2020)** [3] • **The Assessment System for Sustainable Building (BNB)** [4]	**(1)** Aiming to achieve 20% reduction in primary energy consumption by 2020 compared with 2008 and halve it by 2050. **(2)** Setting minimum requirements for the quality of energy performance in the envelopes and technical installations of new buildings and larger-scale renovations of existing buildings **(3)** Introducing mandatory standards for energy performance of new construction, existing building stock and the use of renewable energy for heating and cooling buildings. **(4)** A novel integral quantitative assessment method for office, administrative, teaching and laboratory buildings completing the guide to sustainable construction. Whole-building LCA is required for new federal building projects as part of a green building rating program specific to government projects.
	City level guiding visions ***Berlin***	• **The Berlin Climate Protection and Energy Transition Act (EWG Bln) (2021)**[1] • **Berlin Energy and Climate Protection Program 2030 (BEK 2030) (2019)** [2] • **diBEK** [3] • **The Berlin ImpulsE Programme** [4]	**(1)** Setting a legal framework for ambitious binding climate protection goals to become climate-neutral by 2045 at the latest with at least 70% by 2030 and at least 90% by 2040 (compared to 1990's levels). **(2)** Presenting an integrated approach to climate change mitigation by defining a range of measures that can contribute the city's decarbonisation. **(3)** The digital monitoring and information system of the BEK 2030. It creates transparency on data and promoting continuous monitoring and evaluation. **(4)** The central information and education platform on energy efficiency. One of the key focus areas of the programme is the mobilisation of energy savings potential in existing buildings.
	External initiatives	• **German Sustainable Building Council (DGNB), Framework for Carbon Neutral Buildings and Sites (2020)** [1] • **Passivhaus Institut,** EnerPHit [2]	**(1)** Presenting a climate action roadmap and a framework for CO_2 reporting with a structured and transparent format. **(2)** The Passive House Certificate for retrofits
	National level	• **The Danish Parliament, The Climate Act (2020)** [1]	**(1)** A legal goal to reduce its CO_2 emissions by 70% by 2030, compared to 1990's levels, and climate neutrality by 2050 at the latest.

Location	Policy Level	Policies Titles	Summary of the Standards / Requirements
Denmark		• **The Danish Building Code 2018 (BR18)** [2] • **The Danish National Strategy for Sustainable Construction (2021)** [3] • **The Danish Government 2020 Green Housing Agreement (2020)** [4]	**(2)** The minimum requirements/regulations for the building construction to ensure they achieve minimum standards in fire, safety & health terms, and energy efficiency; applicable for new construction and renovation works. **(3)** The Government's sectoral action plan for the building and construction sector; it sets out tightening of targets combining both embodied carbon and operational carbon emissions for buildings. **(4)** Supporting the launch of comprehensive refurbishment measures in the council housing sector.
	City level guiding visions ***Copenhagen***	• **The Copenhagen 2025 Climate Plan (2012)**[1]	**(1)** A holistic plan for Copenhagen's decarbonisation journey (carbon neutral by 2025).
	External initiatives	• **Københavns Kommune, Energispring (2020)**	**(1)** It is a partnership between large building owners, administrators, and interest organizations in Copenhagen. The main aim is reducing energy consumption.
UK	**National level**	• **The Climate Change Act 2008, 2050 Target Amendment (2019)** [1] • **Industrial Decarbonisation Strategy (2021)** [2] • **Net Zero Strategy: Build Back Greener (2021)** [3] • **Future Building Standard 2025** *(still emerging)* [4] • **The Department for Levelling Up, Housing and Communities and Ministry of Housing, Communities & Local Government** Approved Document Part L1B&L2B (2021) [5] • **The Department for Business, Energy, and Industrial Strategy (BEIS)** The Non-Domestic Private Rented Property Minimum Standards (2021) [6] • **BSI PAS 2035/2030:2019+A1:2022 (2022)** [7]	**(1)** A legally binding commitment of the UK government to reduce national carbon emissions. With the amendment in 2019, the net UK carbon account for the year 2050 must be lower than the 1990 baseline is increased from 80% to 100%. **(2)** Covering the full range of UK industry sectors, it sets out how the UK can have a thriving industrial sector aligned with the net zero target, without pushing emissions and business abroad. **(3)** It sets out policies and proposals for decarbonising all sectors of the UK economy to meet our net zero target by 2050. It is also the main climate change policy document of the UK. **(4)** Expected to come in to effect from 2025, it aims to deliver energy efficient non-domestic buildings by using low carbon heating. Primary focus is new buildings, but it includes policy regarding works to be undertaken on existing buildings. **(5)** An uplift to the energy efficiency standards for existing and new non-domestic buildings. It came into force in June 2022. **(6)** A future regulatory target for the non-domestic buildings to have a minimum rating of EPC C by 2027 and EPC B by 2030. **(7)** It presents a framework of new and existing standards on how to conduct effective energy retrofits of existing domestic buildings.
	City level guiding visions ***London***	• **The City of London Corporation** Climate Action Strategy 2020-2027 (2020) [1]	**(1)** It sets out the City of London Corporation's Climate Action Strategy from 2020 onwards. It highlights the climate emergency and outlines the approach of the corporation for the first six years.

Location	Policy Level	Policies Titles	Summary of the Standards / Requirements
		• **The London Plan 2021: Greater London Authority (GLA) policy** [2] • **The City of London Corporation Carbon Options Guidance (COG) Planning Advice Note (March, 2023)** [3]	**(2)** Sets out Planning Policies for referable schemes. The Policies related to carbon and retrofit include: Policy SI 2 Minimising Greenhouse Gas Emissions, Policy SI 7 Reducing Waste and Supporting the Circular Economy. There are also associated guidance documents that set out clear policy deliverables to help achieve these aims. **(3)** The guidance is designed to provide consistency for applicants that conducting WLC optioneering evaluations at early project stages. This is designed to encourage and maximise reuse, where possible. A toolkit accompanies this guidance to enable a consistent format for reporting to be established. It also requires third party review of the options.
	External and Emerging initiatives	• **No direct national policy** • **Royal Institution of Chartered Surveyors (RICS)** Whole Life Carbon Assessment for the Built Environment, 2nd Edition (2023) [1] • **Low Energy Transformation Initiative (LETI)** Climate Emergency Retrofit Guide (2021) [2] • **NABERS UK** [3]	**(1)** The 1st version was prepared to be a world-leading standard for consistent and accurate carbon measurement in the built environment and is used as the basis of the GLA's WLC Guidance March 2022. The 2nd version covers all buildings and infrastructure throughout the built environment life cycle. **(2)** It sets practical advice on getting existing domestic buildings to achieve net-zero emission targets. Currently, LETI has not published a guidance for non-domestic buildings yet; however, LETI is planning to publish this guidance in the future. **(3)** Operational energy performance rating based on in-use performance that can be used for meeting the GLA energy requirements under the 'Be Seen' energy policy, which requires major developments monitor and report actual energy performance.

Global Context – Current energy performance of buildings

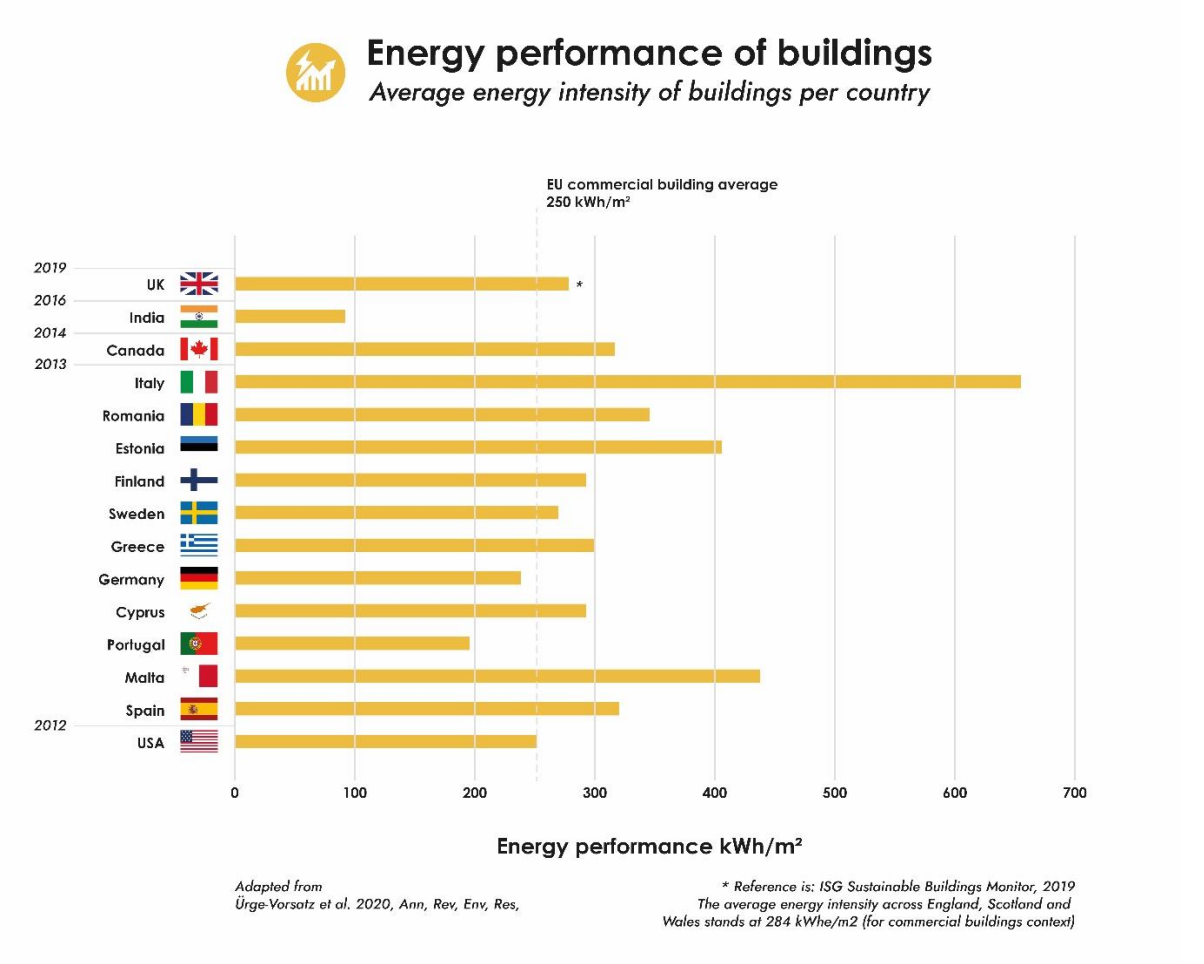


Figure 10: Energy Performance of Buildings, source: Urge-Vorsatz et al., 2020.

Buildings around the world vary in energy performance, with the majority of commercial buildings across countries ranging between 180-300 kWh/m²/yr (see Figure 10). The variations of average energy intensity relate to local climate conditions, heating and cooling requirements and local building standards. In comparison, the UK has an average of energy intensity of 284 kWh/m²/yr for commercial buildings (ISG, 2019) (Construction Management, 2021), above the EU average.

In the UK the Better Buildings Partnership Real Estate Environment Benchmark (REEB) data set (Better Buildings Partnership, 2023) have also analysed member data on Energy Use Intensity. Its 2022 Insights report used pre pandemic data from 2019-2020, for 1,275 commercial properties. The 2020 environmental benchmarks show a typical practice air-conditioned property would have a EUI of 234 kWhelec-eq/m² NLA/yr with good practice being 167 kWh elec-eq/m² NLA/yr. Current design targets are trying to achieve considerably lower EUIs of 90-70 kWh elec-eq/m² NLA/yr, which is a significant reduction based on the above data.

REEB 2020 Energy Benchmarks for Offices Chart (Better Buildings Partnership, 2023)

England Policy & Regulation

Current policy in England is focused mainly on regulated energy performance and associated carbon emissions. This is based on design assumptions and does not reflect the real-world emissions from energy consumption. Consultation on operational energy reporting (Introducing a performance-based policy framework in large commercial and industrial buildings, March 2021) has taken place, however like MEES this closed in June 2021 and no summary outputs, or indication of requirements has been provided. This needs to be addressed urgently, design teams are quite disconnected from performance in reality.

National policy for non-public authority buildings only accounts for carbon emissions from regulated energy emissions through building regulations Approved Document Part L. Part L is based on a set of standardised assumptions and does not account for unregulated energy emissions and does not account for actual energy use, hence the misalignment between predicted and in use emissions.

Emissions arising from other areas of a building's lifecycle such as the embodied carbon from construction, demolition, and decommissioning are not included. Assessment focused on embodied carbon emissions is voluntary and not covered in most planning policies (except in some local planning requirements such as in London). There is an urgent need for consistent policy to require consideration of emissions across a buildings entire lifecycle and therefore taking full accountability of the environmental impact arising from construction and in use.

The National Planning Policy Framework (NPPF) 2021, Chapter 14 Meeting the challenge of climate change, flooding, and coastal change Paragraph 152 states that: "*The planning system should support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change. It should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions, minimise vulnerability and improve resilience; encourage the reuse of existing resources, including the conversion of existing buildings; and support renewable and low carbon energy and associated infrastructure*." However, more guidance on what approach to take is required in order to achieve this.

A summary of the adopted and emerging carbon-related regulation in England is outlined in the Table 2.

Table 2: *Summary of carbon-related policies in England*

Area	Adopted Policies/Regulation at National level in England	Emerging Policy** at national level in England	Local Policies & Commitments in England
Refurbishment Specific Related	None specifically although NPFF wording does want planning system to '*…shape places in ways that contribute to radical reductions in greenhouse gas emissions.*' NPPF is a framework interpreted regionally and locally.	None at the current time that relate to specifically requiring refurbishment	Determined by Local Authority / Region / Borough None at the current time that relate to specifically requiring refurbishment.
Operational Energy & Carbon	Part L (Interim uplift 2021) Minimum Energy Efficiency Standards (MEES)- EPC min. E	The Future Buildings Standard (2025) MEES update to minimum EPC B by 2030. Performance based framework for large commercial buildings requiring annual	Determined by Local Authority / Region / Borough Often based on a percentage improvement over Part L Regulated Target emissions rating. Some local LZCT percentage generation targets

Area	Adopted Policies/Regulation at National level in England	Emerging Policy** at national level in England	Local Policies & Commitments in England
		performance-based ratings for commercial buildings over 1,000m^2	Some policies require reporting of energy in Use (i.e. the GLA 'be seen' requirements) Some London boroughs have in use reporting requirements for first few years of occupation Public Authority building must have a Display Energy Certificate (DEC) if it meets certain thresholds. This is based on energy in use but is not monitored yearly and is valid for 10 years.
Embodied Carbon	None	Part Z proposal for Embodied carbon in Building Regulations in very early stages. Embodied Carbon Research Project – CPD4124072 to review the practical, technical, and economic impacts of carrying out whole life carbon assessments	Determined by Local Authority / Region / Borough A few Local Authorities require WLC reporting as part of planning, however scopes can be varied an inconsistent or even not defined. London is covered by the GLA criteria which several boroughs have adopted for non GLA referable applications
In Use Carbon Emissions reporting	UK net Zero by 2050.* Streamlined Energy and Carbon Reporting (SCER)		Determined by Local Authority / Region / Borough

*The Climate Change Act commits the UK government by law to reducing greenhouse gas emissions by at least 100% of 1990 levels (net zero) by 2050.

**Potential future policy, based on consultation or industry groups:

MEES (Uk Gov, March 2021): https://www.gov.uk/government/consultations/non-domestic-private-rented-sector-minimum-energy-efficiency-standards-epc-b-implementation

A Performance-Based Policy Framework in large Commercial and Industrial Buildings in England and Wales (UK GOV 2021) https://www.gov.uk/government/consultations/introducing-a-performance-based-policy-framework-in-large-commercial-and-industrial-buildings

https://part-z.uk/ - Proposal to Parliament for

Uk Government research study: https://www.gov.uk/guidance/live-research-studies-commissioned-by-dluhc-january-2023-onwards

In terms of carbon monitoring, there are piece of legislation such as the Streamline Energy and Carbon Reporting (SCER) this requires businesses to include their energy use (including electricity, gas, and transport) emissions and an intensity metric in their annual Directors'

report for financial years beginning on or after 1 April 2019. This does not provide the exact procedure for measurement, and there are no obligations to reduce carbon emissions, although a narrative on energy efficiency measures must be disclosed every financial year. The SCER covers scope 1 and 2 GHG emissions in line with the GHG Protocol. Reporting scope 3 emissions is voluntary, but strongly recommended.

4. Benchmarks & Targets

Several studies and reports have been produced to demonstrate how the UK's built environment can transition towards net-zero. These have presented their understanding how the UK should be designing buildings to meet the climate change targets set by the UK Climate Change Act.

UK Green Building Council Net Zero Pathway – Macro Level Industry Target

The UKGBC has estimated the total allowance for the built environment in terms of heading trajectory for 2050 for net zero construction industry based on a year to year. The projected emissions are based on a 2018 baseline, which is the most recent and complete dataset for UK emissions currently available. The following key milestones and policy interventions are anticipated to take place to enable such transition. According to the UK GBC 'Net Zero Whole Life Carbon Roadmap, these include:

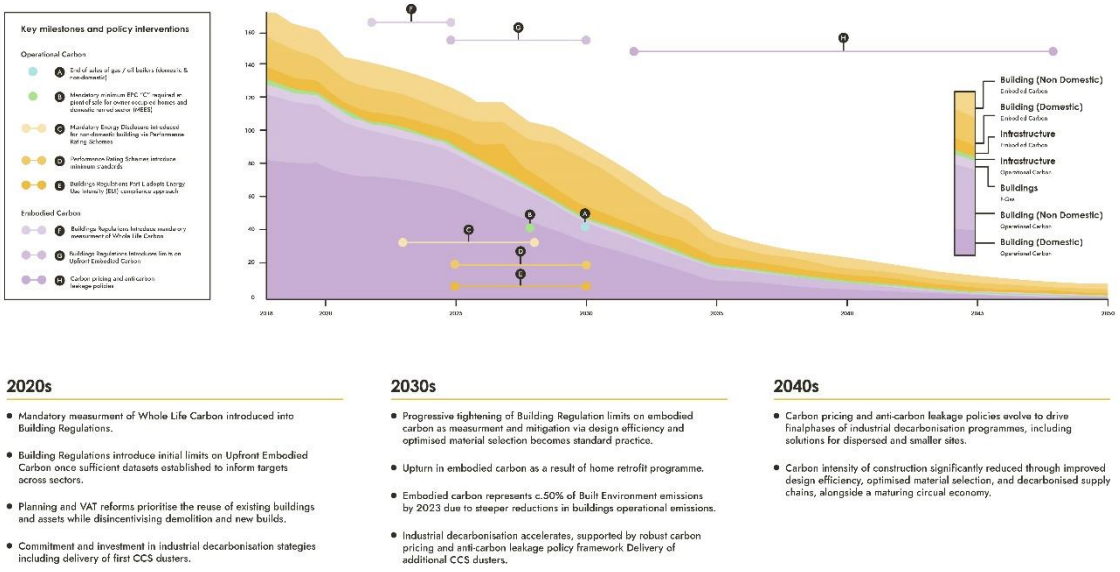


Figure 11: Net Zero Trajectory showing projected emissions from the Built Environment through to 2050

Targets & Benchmarks – Embodied and Operational Carbon

As part of industry commitments and guidance, indicative benchmarks have been provided to guide the industry in relation to embodied carbon targets to achieve net zero. These are summarised in Table 3 below. The performance targets proposed by various industry players and advisors can be used to inform decision making process and tracking project performance. These benchmarks are in regular evolution as more analysis, data and understanding is being established by the industry, which will inform the policy-making process.

Retrofit and refurbishment projects can enable developments to reduce their embodied carbon and operational carbon. The retention of building elements enables a development to avoid embodied carbon that would otherwise be emitted through new materials. A low carbon property can be delivered by prioritising low embodied carbon materials and by promoting the circularity of construction materials and products. Similarly, retrofit of energy efficient building services and shifting from fossil fuel-based to

electric-led heating systems can aid to reduce emissions associated to operational use of a building. To ensure low carbon benefits are realised, measurement, recording and Evaluation of data should take place to verify the effectiveness of retrofit measures.

Table 3: Carbon Metrics/ Benchmarks / Targets

Metrics	Benchmarks & Targets	Target breakdowns	Lifecycle modules	Offices
Embodied Carbon kgCO$_2$e/m^2	**GLA Benchmarks**	**WLC Benchmarks**	A1-A5	950
			A-C	1400
		Aspirational WLC Benchmarks	A1-A5	600
			A-C	970
	RIBA 2030 Climate Challenge Targets	**Business as Usual (BAU)**	A-C	1400
		2025 Target	A-C	< 970
		2030 Target	A-C	< 750
	LETI Targets *Including substructure, superstructure, MEP, façade & internal finishes*	**Business as Usual (BAU)**	A1-A5 *	1000
		2020 Target	A1-A5 *	< 600 + 30% reused materials and 50% reusable building at end of life
		2030 Target	A1-A5 *	< 350 + 50% reused materials and 80% reusable building at end of life
			A-C **	< 750
Operational Energy kWh/m^2/yr GIA	**RIBA 2030 Climate Challenge Targets**	**Business as Usual (BAU)**	associated with B6	130 DEC D (90)
		2025 Target	associated with B6	< 75 DEC B (50) and/or NABERS Base build 5
		2030 Target	associated with B6	< 55 DEC B (40) and/or NABERS Base build 6
	LETI Energy Use Intensity Targets	**2020 Target**	associated with B6	*55* ***
	UKGBC Net Zero Carbon Targets for Whole Building Energy	**2020 – 2025**	associated with B6	130
	–2025 - 2030		90	
	–2030 - 2035		70	
		Paris Proof Target (2035 – 2050)		55

* *Excluding carbon sequestration*
** *Including carbon sequestration*
*** *Excluding renewable energy contribution*

5. City of London – a local perspective

Introduction

The City of London is one of the world's leading international financial and professional services locations and a driver of the UK economy, continually innovating and developing new business areas and flexible ways of working.

The City is also a very dense and intensely used area with a high overall level of greenhouse gas emissions, largely because of the energy needed to serve over 600,000 daytime users. A significant amount of emissions also arises from the demolition and construction of new buildings, including embodied carbon arising from the production, transportation and disposal of products and materials.

The future growth of the City needs to take place in a sustainable and inclusive way, incorporating the principles of 'Good Growth' set out in the London Plan. These principles ensure that London remains resilient to our changing climate and is green and healthy; with clean air, easy access to green space and more efficient buildings supplied by cleaner energy.

Current Position

Based on EPC data, refurbishment and investment will be required by owners and occupiers to bring buildings in line with standards for businesses in the City. A proportion of institutional grade leases (approximately 32m sq ft10) may not currently comply with EPC regulation, with a rating below C (as illustrated by Figure 12). It is anticipated many businesses will implement changes required to adhere to EPC changes. Conversion of Grade B stock to Grade A, or to best in class is possible in some cases, however this can be challenging.

Many assets in the City are historic, including over 600 listed buildings and 26 conservation areas. Heritage assets can impose additional constraints on development, and the financial case for retrofit can be difficult to make, particularly in terms of additional costs and limitations on the potential to deliver modern office requirements, whilst at the same time conserving or enhancing the significance of the heritage asset. In some limited circumstances, where Grade B offices are obsolete, cannot be viably refurbished and there are wider sustainability and planning benefits, there may be a case for demolition (Arup, 2023).

We note that lower EPC-rated offices may face a 'perfect storm' from the market's 'flight to quality'. In the wider London and UK context, these locations perform well in terms of amenities. However, they are perhaps at greatest risk of becoming stranded assets. It should be noted that whilst EPC ratings provide a measure for understanding potential stranded assets, it should also be complemented on a site-by-site basis with specific NABER rating data for individual premises, to accurately understand a building's real energy performance across energy, water, waste and indoor environment (Arup, 2023).

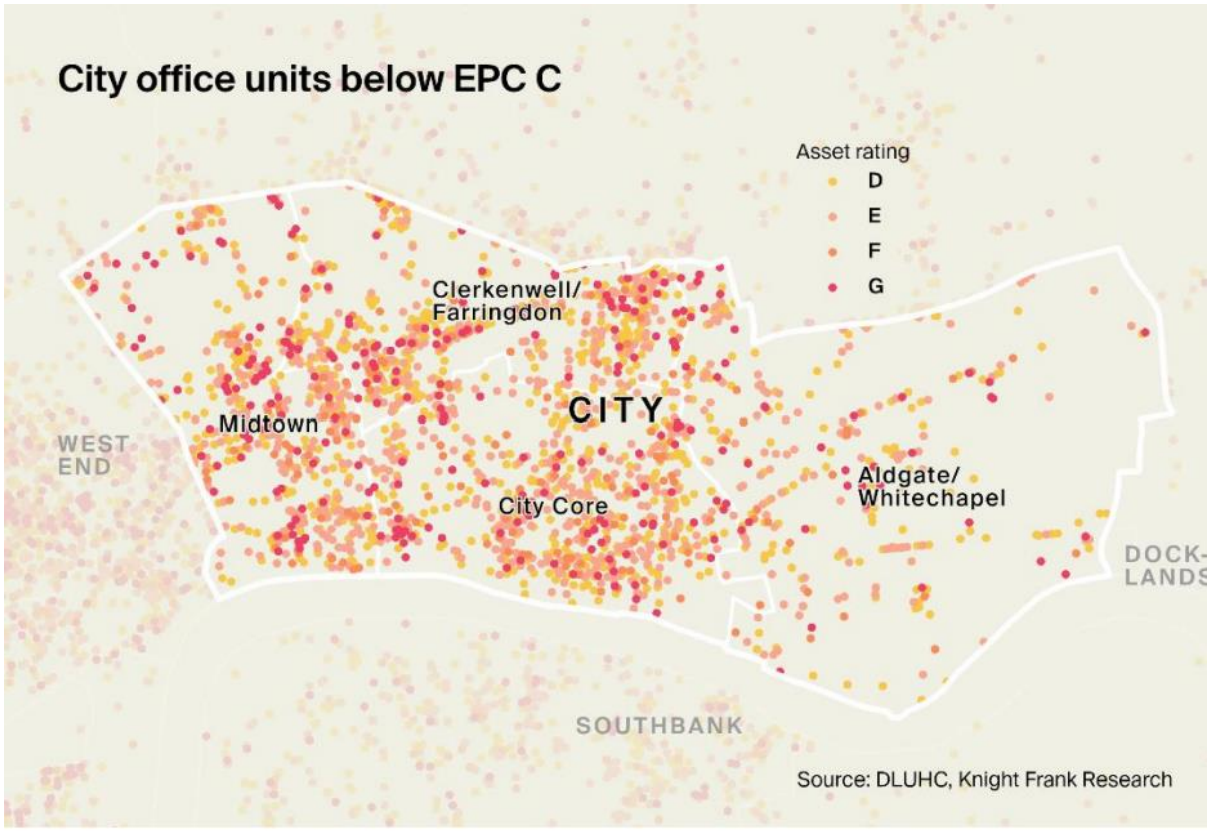


Figure 12: Building Energy Performance Certificate (EPC) Rating in the City of London, below C

The City is developing a framework of policies, guidance and action plans which seek to support the retrofitting of existing buildings. The following provides an overview:

Climate Action Strategy (2020): this Strategy includes goals for the City Corporation to be net-zero in its own operation (including its buildings) by 2027 and for a net-zero Square Mile by 2040. Achieving these goals assumes a significant increase in the rate of building refurbishment and retrofit in the City and a shift away from the traditional 'demolition and re-build' model.

Carbon Options Guidance (2023): this Planning Advice Note is a new optioneering exercise for planning proposals in the City of London, allowing an accurate comparison of development types, ranging from refurbishment to the more substantial redevelopment of a site. The carbon optioneering process enables the holistic consideration of carbon impacts, sustainability outcomes and wider planning objectives to meet the goals of the City's Climate Action Strategy and enable a net zero future.

The guidance is published alongside a 'Carbon Options Tool', which provides a consistent presentation of the assessment results.

https://www.cityoflondon.gov.uk/services/planning/sustainable-development-planning-requirements

'Planning for Sustainability' Supplementary Planning Document (SPD) (2024, draft): this SPD sets out guidance, requirements, and processes for the environmental sustainability aspects of proposed development in the Square Mile. The SPD seeks to achieve an ambitious and high quality outcome for the environmental sustainability of development in the City of London, in line with the Local Plan 2015 and the forthcoming City Plan 2040.

City Plan 2040 - 'Retrofit First'(draft): The City Corporation is in the process of developing a new City Plan 2040. One of the key policy features is a 'Retrofit First' approach to development.

This policy will encourage applications that promote new ways of thinking about repurposing buildings as the most effective way to drive down carbon intensity of development and create a unique sense of place. It will further encourage shifting the creative focus of architects, engineers, and designers to the transformation of existing buildings into sustainable, characterful, and interesting architecture

The following sets out key actions to develop an exemplar City scheme:

- Adopt a retrofit first approach that is informed by a carbon optioneering assessment (see Carbon Options Guidance Planning Advice Note).
- Consider the optimal use of an existing building that would enable a retrofit approach while supporting strategic land use policies.
- Engage creative architects, engineers and designers that focus on the opportunities of existing buildings and transform the exterior and interior to the highest environmental and design quality.
- Ensure that retrofit schemes achieve the highest possible level of energy efficiency, climate resilience, health and wellbeing, and occupier amenity.
- Assess the opportunities of the local context and sustainability aspirations for a site to develop the best practice circular economy and low carbon strategy.
- Seek specialist heritage expertise for historic buildings to identify sensitive solutions for retrofit.

Heritage Buildings Retrofit Toolkit (2024, draft): The purpose of this toolkit is to provide clear and actionable guidance for owners, occupiers, and caretakers of historic and listed buildings, to help them take steps to reduce carbon and build climate resilience in their heritage buildings.

The intention isn't to replace or supersede existing guidance on this topic, but to collate and signpost best practice principles and examples. This will provide a resource enabling building owners to confidently start the process of responsible retrofit, build a business case and deliver the adaptations necessary. Whilst this toolkit draws on the historic environment of the Square Mile, referencing typologies that are most significant to the City's unique character, it is equally relevant to towns and cities in the UK and around the world who are exploring how to adapt their historic buildings for a sustainable future.

https://www.cityoflondon.gov.uk/services/environmental-health/climate-action/climate-action-projects/supporting-the-square-mile-achieve-net-zero

Local Area Energy Plan (LAEP) (2023)

The LAEP sets out a route map and priority intervention areas for transitioning the energy system in the Square Mile to net-zero by 2040, in line with the ambitions of the Climate Action Strategy. The recommended pathway to a net-zero energy system by 2040 is a blend of deep retrofit interventions applied to the City's building stock and heat networks,

using both centralised and decentralised heat pumps. The Plan highlights the importance of connecting building decarbonisation to planned changes in the wider local energy system.

https://news.cityoflondon.gov.uk/city-of-london-corporation-approves-local-area-energy-plan-to-deliver-a-net-zero-square-mile-by-2040/

6. Case Studies of Commercial Building Refurbishment

Retrofit and refurbishment projects vary in typology, size, and approach. The illustrated case studies within this report aim to convey this. There are projects ranging in uses from offices, retail to public spaces; some that are schedule listed buildings and other that have other types of characteristics. The buildings have been built across several decades, some as early as 1920s and others up to 1990s and refurbished in the past 5 to 10 years.

The Case Studies vary in typology of intervention, which are defined as:

Refurbishment	Modification and improvements to an existing building to bring it up to an acceptable condition. The refurbishment of something is the act or process of cleaning it, decorating it, and providing it with new equipment or facilities.
Retrofit	The act of providing something with a feature not fitted in the original construction or a replacement of a component. Often this refers to building systems upgrades, however if can refer to improving fabric and or glazing. This work generally improves amenities for the building's occupants and the overall building performance. **Light retrofit**: *focus on performance optimisation, basic remodelling, replacement, or adaptation of existing building elements which tend to focus on a single aspect or feature (lighting upgrades, optimisation of building controls and operation, etc).* **Deep retrofit**: *focus on significant works of size or scale that result in a fundamental change to the building structure and/or services. This can be represented as a collection of light retrofit enhancements or individually disruptive measures, such as major plant replacement.*

Due to varying timelines, regulatory developments, and increase in awareness and measurement of carbon, there is differing levels of data availability and data quality reported.

It is important to note that the case studies collected within this report aim to provide a snapshot of refurbishment practice in the City and beyond. The City Corporation's intends to continue to collect data and develop a pool of case studies, best practice examples and useful data set moving forward. There have been other reports that have also collated case studies such as JLL, LETI and New London Architecture.

It is important to note that the evolution in standards, requirements and analysis make it difficult to compare projects across time. It is clear from the case studies that improvements in the quality and transparency of data and changing policy are making this easier for more recent projects. Also, behind each of these projects there is context that needs to be understood, and constraints that can affect performance that should be acknowledged.

To demonstrate the wide spectrum of opportunities that may exists in this space, a selection of case studies has been compiled. These are summarised below and the full case studies can be found in **Appendix A**. They aim to shed light on the challenges and opportunities related to refurbishment of buildings located within urban districts, which aim

to tackle net zero carbon standards within the commercial building stock. These projects showcase specific approaches or contained elements that enable commercial properties to achieving low carbon design and depict the contributions that retrofit projects may have in the advancement towards a net zero future.

We see a trend of case studies which have lower carbon compared to an equivalent new build. Table 4 shows the performance versus the LETI / RIBA carbon metrics.

It should be noted that this is a rather simplistic analysis, as there will be variations between stage of project and performance. In addition, analysis and industry skill is improving, so too is guidance for evaluating embodied carbon. Theses case studies have not all been third party verified and are evaluated to different stages.

Generally, as more detail and more materials are added, specially evaluated to a project the greater the embodied carbon. Lifecycle embodied carbon can also be tricky as it is determined by the number of replacements, which in offices can vary substantially based on bother materials life but also lease length, over a 60-year reference period this can mount up.

Table 4: *Case Studies verses carbon benchmarks for offices*

Total Case Study Projects: **18** Total with A1-A5 (upfront carbon) provided: **15** Total with A1-A5, B1-B5, C1-C4 life cycle embodied carbon provided: **13**	**Metric ($kgCO_{2e}$ /m^2 /GIA)**	**Number achieving LETI / RIBA 'Metric'***
LETI 2020 (Band C) (A1-A5)	600	12
LETI 2030 (Band A) (A1-A5)	350	8
RIBA 2030 Challenge 2025 (A1-A5, B1-B5, C1-C4)	970	10
RIBA 2030 Challenge 2030 (A1-A5, B1-B5, C1-C4)	750	7

**at current the time and based on information provided relative to project stage.*

8 of the projects are currently in line with the LETI 2030 metric for upfront carbon. When you consider several of the projects have had little to no structural intervention it shows how challenging this metric is to achieve. In line with this, 10 projects perform in line with RIBA benchmark Challenge 2025 of 970 $kgCO_{2e}$ /m^2 /GIA, whilst the remaining 7 falling within RIBA benchmark Challenge 2030 of 750 $kgCO_{2e}$ /m^2 /GIA. There are less projects capturing modules B1-B5 and C1-C4. There is lack of data in relation to the assumptions and replacement cycles (e.g. for MEP).

In terms of carbon from energy in use, it is more challenging to compare projects with accuracy. This is due to the methods used from evaluating operational energy in the design and construction phases. Most case studies have carried out estimation based on a process such as TM54 or projects in earlier stages based on NABERS DFP. There is variation in estimations, and context of the works undertaken need to be considered rather than just looking at the numbers (e.g. listed facades).

Carbon factors used to convert energy use into mass of CO_2 also vary. This affects the final carbon estimations and therefore inhibit the possibility to compare such metrics. It would

be reasonable at design stage to use current energy performance as a worst case, but this is not always the case. The New RICS WLC Professional Standard (Sept 2023) should aid consistency in future.

Planning policy could align with best practice for carbon estimations/predictions and mandate consistent metrics in future. One thing is clear, the industry needs to get better at feeding back actual building performance to design teams. Post-occupancy evaluations may support in data collection and bridge the 'performance gap' between building design and use. It is worth noting that in London the GLA requires operational reporting under the 'Be Seen' energy policy for GLA referable project. Several London boroughs have also adopted this approach, beyond referable projects.

Some of the case studies are based on as built information, however the majority with available data are based on design information, and hopefully as part of this project as-built information will be fed into the database that the City of London is hoping to compile. The intention is for case studies to be updated as projects progress.

Table 5 is a summary of the case studies and performance. It is important these are read in the context of the detailed case studies provided. Full detail of the case studies can be found in **Appendix A**.

Table 5: *Case Studies summary*

Project name & Location	**Project type & RIBA Stage**	**Design team***	**Whole Life Carbon *Module A-C (excl. B6 & B7) kgCO2 e/m2 GIA**	**Upfront Embodied Carbon elements *Module A1-A5 (excl. seq. carbon) kgCO2 e/m2 GIA**
1 Appold Street London, UK	Deep retrofit RIBA Stage 2	**Applicant:** Bluebutton Properties UK Limited **Developer:** British Land **Project Manager:** Opera **Architect:** Piercy & Co **Structure:** AKT II **MEP:** Hilson Moran (after planning) **Sustainability:** Hilson Moran	621.4	495.5
3 Sheldon Square London, UK	Refurbishment RIBA Stage 5	**Applicant :** British Land **Developer:** U+I **Project Manager:** Opera **Architect:** Morris and Company **Structure:** Heyne Tillet Steel (HTS) **MEP:** Ramboll **Sustainability:** Ramboll	321	104
50 Finsbury Square London, UK	Refurbishment RIBA Stage 6	**Applicant :** Great Portland Estates **Developer:** Great Portland Estates **Project Manager:** Blackburn & Co. Limited	1,041	270

		Architect: Doone Silver Kerr **Structure:** Heyne Tillet Steel **MEP & Sustainability:** Hilson Moran **WLC:** Arup (after PC)		
62 Threadneedle Street London, UK	Retrofit RIBA Stage 6	**Applicant :** Royal Sun Alliance Insurance **Developer:** **Project Manager:** Jones Lang LaSalle **Architect:** *Rolfe Judd Architects* **Structure:** Watermans Group **MEP:** Elementa **Sustainability:** Mecserve Ltd	40.3	192
81 Newgate (Panorama St Pauls) London, UK	Refurbishment RIBA Stage 5	**Applicant:** Orion Capital Managers **Development manager:** Pella Real Estate Partners **Project Manager:** Arcadis **Architect:** KPF **Structure:** AKT II **MEP:** Chapmanbdsp **Sustainability:** Chapmanbdsp	646	455
100 New Bridge Street London, UK	Refurbishment RIBA Stage 2	**Applicant:** Helical **Developer:** Helical **Project Manager:** Avison Young **Architect:** Gensler **Structure:** ARUP *and* Watermans Group **MEP:** L&P Group **Sustainability:** L&P Group	883	459
160 Old Street London, UK	Refurbishment RIBA Stage 6	**Applicant:** Great Portland Estates and Great Ropemaker Partnership **Developer:** Great Portland Estates **Project Manager:** Jackson Coles **Architect:** ORMS **Structure:** Heyne Tillett Steel **MEP:** Hilson Moran **Sustainability:** Hilson Moran	**N/A**	**N/A**

Coal Drops Yard London, UK	Refurbishment RIBA Stage 6	**Applicant:** King's Cross Central Limited Partnership (KCCLP) **Developer:** KCCLP **Project Manager:** Argent (Development Manager) **Architect:** Heatherwick Studio (Concept), BAM Design (Delivery) **Structure:** Arup **MEP:** Hoare Lea (Concept), BAM Design (Delivery) **Sustainability:** N/A	**N/A**	**N/A**
International House London, UK	Refurbishment RIBA Stage 4	**Applicant:** British Land **Developer:** **Project Manager:** RPP **Architect:** Barr Gazetas **Structure:** Evolve **MEP:** INsignis Consulting **Sustainability:** INsignis Consulting	509.8	322.3
One Exchange Square London, UK	Deep retrofit RIBA Stage 5	**Applicant:** Permodalan Nasional Berhad PNB and LaSalle Investment Management **Developer:** **Project Manager:** M3 Consulting **Architect:** Fletcher Priest Architects **Structure:** Heyne Tillett Steel **MEP:** Sweco **Sustainability:** Sweco	939	525
Pall Mall Manchester, UK	Deep retrofit RIBA Stage 5	**Applicant:** Bruntwood **Developer:** Bruntwood **Project Manager:** Bruntwood **Architect:** Sheppard Robson **Structure:** DW Consulting **MEP & Sustainability:** Ramboll	522	189.6
Portland House London, UK	Refurbishment RIBA Stage 5	**Applicant:** Landsec **Developer:** Landsec **Project Manager:** Opera **Architect:** Buckley Gray Yeoman **Structure:** Parmar Brook **MEP:** Watkins Payne **Sustainability:** Buro Happold	758	348
Quay Quarter Tower Sydney, Australia	Deep Retrofit RIBA Stage 6	**Applicant:** AMP Capital Investors **Developer:** AMP Capital **Project Manager:** **Architect:** 3XN **Structure:** BG&E	**N/A**	818

		MEP & Sustainability: Arup		
The Gilbert and One Lackington Street London, UK	Refurbishment RIBA Stage 6	**Applicant:** Brookfield Office Property Management **Developer:** Brookfield Office Property Management **Project Manager:** Jackson Coles LLP **Architect:** Stiff + Trevillion **Structure:** Heyne Tillett Steel **MEP & Sustainability:** Hilson Moran	250.3	147.1
The Hickman Building London, UK	Retrofit RIBA Stage 6	**Applicant:** Great Portland Estates **Developer:** Great Portland Estates **Project Manager:** Hush PM&C Ltd **Architect:** DSDHA **Structure:** Heyne Tillett Steel **MEP & Sustainability:** Milieu Consult	**N/A**	337
The Kensington Building London, UK	Deep retrofit RIBA Stage 6	**Applicant:** **Developer:** Ashby Capital *and* Janson Urban **Project Manager:** **Architect:** Pilbrow & Partners **Structure:** WSP **MEP & Sustainability:** WSP	1050	700
YY London London, UK	Refurbishment RIBA Stage 5	**Applicant:** Quadrant and Oaktree Capital **Developer:** Quadrant **Project Manager:** Avison Young **Architect:** Buckley Gray Yeoman **Structure:** Watermans Group **MEP & Sustainability:** Hilson Moran	**N/A**	**N/A**
* It covers a limited information about the project team.				

7. Lessons Learned – Insights from Case Studies

The following sets out key lessons learned from the case studies within the context of the policy and market trends set out in the previous sections.

Carbon performance: From a carbon perspective, retrofit and refurbishment often result in lower Whole-life carbon emissions when compared to a new build equivalent (as described in Section 2) and are part of a lower carbon solution to meet to our climate goals.

Business case and viability: decision making is more complex than just using a single viewpoint, such as the 'carbon' perspective. These case studies provide examples of schemes which have sought to combine a viable business case with decarbonisation and wider economic and social value. This is an area of opportunity that the built environment sector can focus on to demonstrate tangible, cost-effective solutions that can also reduce overall net emissions whilst supporting the UK's net zero trajectory.

Net zero targets and ESG: some developers are starting to use impact mitigation as a way forward and funders are beginning to request performance metrics relating to environmental impacts, including Whole life Carbon, as prerequisites for investment. This is particularly true as greater ESG requirements are being demanded from investors. As referenced by UKGBC in their 'Sustainable Investment Practical Guide'(2023), investors, are providing funding to property groups that are subject to sustainability-linked KPIs, meaning that favourable borrowing rates are available when measurable environmental credentials or improvements in the assets are demonstrated (GBC, 2023). There are other examples of funders requesting an ESG-linked credit facility.

Industry standards: schemes like the forthcoming UK Net Zero Building Standard should assist developers to align the design and performance of their schemes with clear principles that define net-zero for various building typologies.

In terms of operational energy there is encouraging progress in terms of closing the 'performance gap' with design performance being assesses in a more detail way than just Building Regulation Part L. For example, the NABERS UK rating scheme for offices sets a high bar for design reviews and requires actual performance to be monitored for a final rating to be provided.

More recent schemes are evaluating carbon from the outset of the project. As more data becomes available better decision making should be made. This trend is anticipated to continue, where more and more projects will evaluate carbon and take learnings and data from best practice examples. Similarly, regulation and policy will shift to enforce embodied carbon considerations and assessments.

Whole Lifecycle Carbon data and benchmarking: the case studies all show good levels of Whole Lifecycle Carbon performance, especially when compared to a new build equivalent. It is challenging though, to compare building on a like for like basis and to understand the detail within the WLC model on just a headline number basis.

For example, a project which has undertaken a more in-depth review may have reviewed more elements, and therefore have a higher emission footprint than a similar project. There

are several variables that can dictate a project's performance. This underlines the need to rationalise and standardise these gaps.

Advice notes, such as the City of London Carbon Options Guidance (COG), are also helping to set uniform metrics, all be it at a very early stage in the decision process. The new RICS Professional Standard 'Whole life carbon assessment for the built environment' 2nd Edition (Sept 2023) which is due for implementation from 1st July 2024 should help bring greater clarity and standardisation to detailed assessments, and what to include at each design and construction stage.

The role of planning policy and Retrofit first: It is likely that planning policy will start to demand better verification and reporting, which would help the industry be more transparent in its decision-making process. The case studies demonstrate that good quality data can provide good insights which in turn can support developing more effective policies to reduce carbon. Better quality and more consistent carbon data can support design teams to more effectively demonstrate performance numbers that can be achieved.

More broadly, a 'retrofit first' approach within planning policy is beginning to emerge which seeks to incentivise the retention of buildings and lower carbon projects. Time will tell whether such policies will assist in bringing clarity to this area, but they should not restrict design-led solutions. Recently, there have been several high-profile disputes between retrofit / refurbishment over new build (for example the flagship M&S building on Oxford Street). These are complex projects which need to consider a significant amount of information and perspectives.

Cost-benefit analysis: based on the case studies, a retrofit / refurbishment solution typically leads to a lower carbon outcome as less new material is needed, especially when structures (which are typically quite intensive) are reused. However, it is important to note that in today's world there are conflicting interests such as maximising commercial floorspace provision, which can hinder the viability of the refurbishment option. In these instances, a cost benefit analysis should be conducted to account both monetary and non-monetary (i.e. carbon/environmental impact) costs and benefits related to the project.

Temporary works: In retrofit projects, careful consideration of temporary works needs to be factored in to reflect the real whole-life carbon of the project. The general rule still stands, however, the teams need to evaluate the options and ascertain the best project approach on a case-by-case basis. The case studies generally show a performance close to or below the 'towards 2030' net zero LETI 600 kgCO2/m^2 target. However, it is challenging to know the depth of the assessment undertaken, and whether results have been verified.

Skills, capacity, and capability: Whole Lifecycle Carbon analysis is still at an embryonic stage in the UK, particularly outside London and other big cities. The built environment industry is upskilling at pace but there is still significant inconsistency in analysis and reporting. Analysis of embodied carbon in detail requires skilled professionals and a standardisation of approach. As a result, the GLA and several London boroughs are requiring third party reviews of analysis to help verify assessments.

Design v as-built: there is also a difference between design predictions and the 'as-built' performance. This is often not intentional but results from on-going design changes, better accuracy in quantity reporting at later stages of projects, and more accurate understanding of the actual materials procured and installed. It is vitally important that case studies from design stages turn into as built reporting and data is fed back into future designs.

Industry ambition: despite the uncertainties and potential inconsistencies, progress developers within the industry have succeeded in setting strong sustainability objectives, driven by their corporate ambitions to reduce their carbon footprint. Key features of this approach include maximising retention, adhering to best practice standards and benchmarks, stripping out fossil fuel-based systems and transitioning to electric-led ones.

Growing evidence base: this report is a contribution to a growing evidence-base related to building retrofit and refurbishment. For example:

- **'Retrofit First, not Retrofit Only – a focus on the retrofit and redevelopment of 20th century buildings' (2023)**: was produced by JLL and the London Property Alliance (WPC/CPA) and calls for action that is urgently needed if we are to tackle the climate emergency and reduce emissions as an industry. The recommendations outlined in the document are specified for two different parties:
  - *property owners*: developing both a portfolio strategy for NZC transition and asset sustainability strategies considering economic, environmental, and social aspects, engaging all key stakeholders to prepare initial project brief, undertaking a robust WLC assessment as well as assessing the range of options to deliver NZC.
  - *policy makers*: improving consistency in national, regional, and local planning policy and applications; prioritising 'retrofit first' rather than 'retrofit only'; request evidence of the assessments of the NZC approaches and the decision-making process; provide robust and consistent guidance on Whole Lifecycle Carbon; as well as ensure the availability of the well-skilled workforce within the planning departments to guide these processes.

- **'Retrofitting Office Buildings: the case for Net-Zero' (2024)**: This report focuses on deepening understanding of how to retrofit large (>1000sqm) commercial office buildings towards net zero, the retrofit measures required, potential impacts, and associated costs.

8. Recommendations

Commercial refurbishment projects have the potential to provide commercially viable option against the 'business as usual' and simultaneously deliver carbon benefits.

To deliver these benefits, a best practice strategy should encompass:

- A robust business case, following a net zero approach and associated funding.
- Good quality building data and /or survey data (i.e. pre-development audit).
- A clear brief with sustainability as its core objective, and pre-agreed carbon targets.
- A slightly different approach to programme – grater upfront work, and potentially earlier engagement of contractors.
- Long-term and circular thinking.
- Transparent and referenceable metrics and the methodology that underpins them.
- Monitoring and verification of expected benefits being delivered, and
- Adopt a portfolio-wide approach against the carbon budget that specifically considers upfront carbon.
- Future asset value factoring in carbon and climate risk

These following sections aim to provide further detail on these considerations to support commercial retrofit projects which follow a net zero approach. These have been determined through the collation of industry best-practice case studies and key lessons learned, which can in hand inform future upcoming projects.

1. Develop the business case with a carbon perspective - Business viability including environmental / carbon impact

A viability business case that is developed and includes an environmental / carbon impact. Carbon impact should be an element accounted for within business viability assessment over the long term. Developing a building construction business case and assessing its viability from a carbon perspective offers several benefits from an environmental and economic standpoint including: maximising emissions reduction potential, enabling cost savings, regulatory compliance, market differentiation, risk mitigation, resilience and future-proofing, stakeholder engagement, access to funding, operational efficiency, long-term value, innovation, and reputation.

2. Obtain existing building data early – Understand the building

The first step for a successful retrofit project is getting a clear snapshot of the existing asset information. As part of the acquisition procedure a due diligence should be undertaken to assess existing building properties, refurbishment potential and sustainability considerations.

This involves data collection and ensuring surveys are carried out right at the start of the project and form part of the brief. Fully understanding the building is key to inform appropriate decision making. Things to consider at this stage include:

- Building characteristics and location, which may limit retrofitting options or result in a unique design opportunity, such as heritage considerations, protected or conservation area,
- Building structure and fabric, condition of external elements and materials used in construction (that could be retained or recycled if replaced),
- Original building operational use and energy consumption,
- Status of building services and plant, and requirements for replacement,
- Operational control and maintenance practices taking place,
- Responsibilities on-site for operating the building between landlord and tenants / owner and occupiers; and
- Risks associated with the property.

A successful project example in high quality data collection for refurbishment measures is 1 Appold Street in the City of London (see case study profiles). 1 Appold Street had good original drawings and information, some of which was recorded on micro dot. The team was able use this building data to provide confidence to the project team and de-risk any unknowns. The Project obtained planning in 2023.

3. Set a brief for the Design team, inform stakeholders, and enable collaboration

One of the key components of achieving significant carbon savings in the projects is to have collaborative and integrative environment during the design process. This primarily starts from a clear brief that is set around carbon savings and impact minimisation.

From the project outset, the client team should have a clear and transparent justification for a new development, identify what is possible for refurbishment/retrofit and what are the constraints/barriers. Organisational vision and agenda towards a net-zero carbon future is an important component of delivering low carbon refurbishment solutions. The commitment of sustainability/design team encourages the client to pursue ambitious carbon reduction strategies since the commencement of the project. This often lacks within projects and when optioneering takes place, it may be that the lowest carbon option/scenario is not selected as other options (e.g. cost-effective option) have taken priority.

The developers' goals regarding carbon savings is a key driver and enables the achievement of significant carbon reductions with financial benefits as well. Maximising the carbon reduction opportunities requires the commitment and involvement of each team member as well as alignment across teams.

4. Establish Your Assessment Criteria

Effective and robust whole-life carbon assessments are based on reliable and realistic data. Every assessment will be project-specific but should be analysed using a consistent approach. For this reason, it is important to identify and collect suitable data in advance to support a comprehensive assessment. Key considerations related to assessment and measurements include:

- Work closely with property manager, facilities/operational manager who are familiar with the building functionalities, operability, maintenance practices and possibly common/recurring issues.

- Set out a request for information (RFI) list that clearly outlines the data entries required for a robust assessment.
- Set a baseline that can be used to compare 'business-as-usual' against retrofit scenario. This is an opportunity to measure and quantitatively demonstrate improvements achieved through refurbishment interventions (for example operational energy performance).
- Set performance targets that can inform decision making, provide clear benchmarks to track project performance in line with best practice standards (i.e. LETI, RIBA, NABERS UK).
- Evaluate the most suitable refurbishment/retrofit interventions that yield the highest carbon savings (either embodied or operational) whilst considering technical feasibility and commercial viability. These should be considered in line with the pre-agreed targets, client expectations, and asset management strategy. Following all reduction measures carbon offsetting should be considered as a last resort. Where used make sure there is a mechanism for this offset cost to be accounted for in the project budget. This may enable lower carbon product replacement to be undertaken, and potential cost savings (when project cost and offset cost is calculated).
- Follow a NABERS UK Design for Performance approach committing to tracking and verification during and after completion of works.

5. Analyse opportunities and challenges.

Once initial assessment is carried out, trends will emerge, and opportunities and challenges will be identifiable for different elements of the building. These may form the basis of the project's business case and a unique selling point.

It is therefore crucial that the analysis is carried out with a circularity and long-term vision, with net zero carbon as the main objective, considering the whole lifecycle of the development and following a Design for Performance approach. Circular thinking involves the promotion of retaining, re-using, repurposing, and recycling of construction materials to reduce the projects Whole Life Carbon and environmental impacts.

A whole life carbon or carbon optioneering analysis are methods of reviewing development options for reducing of embodied carbon through. The optioning process should be used as a tool to inform design decisions and provide planners with suitable information to make planning decisions form a carbon perspective.

Where feasible, projects should prioritise and maximise the retention and reuse of existing materials and building fabric. The case studies (appendix A) have provided the following general insights:

- Identification of opportunities and challenges early in the design process, using a long-term and circular thinking approach.
- Challenges can include unforeseen issues / limitations and/or barriers that can restrict the success of interventions. Some metrics may not be established due to missing building information or restrictions in performance due to a range of factors (e.g., thermal bridging, u-value performance, air tightness, programme, and costs). This is especially the case for fabric performance in listed buildings. Regulatory

developments and forthcoming requirements should be raised early on to anticipate this and to inform the design proposals.

- Opportunities may lie in relation to building's context, location, characteristics, stakeholders involved, and financial incentives/opportunities (e.g., real estate funding/loans based on sustainable performance). There may be opportunity to increase the asset value through a refurbishment project and raise the potential rental income. A business case may be established in circumstances where the project was able to deliver operational cost savings (i.e., from reduced maintenance or reduced energy consumption). Rental premiums may be achieved where interest and occupational demand rises for low and net zero carbon requirements (JLL, 2023). Landlords and investors may recognise the opportunity of increasing the rentability of their properties, enhancing relationship with their tenants, de-risking their assets and portfolios by future-proofing the value of their properties. Keeping tenants satisfied means lower vacancy rates and increased tenant retention in the long-run.

A successful project will identify specific carbon-saving opportunities through retrofitting and refurbishment measures. These may tackle either embodied carbon (through efficient fabric upgrades or retention of external building elements) or address the reduction of operational carbon (through improved building management, optimisation and replacement of building services that are low carbon). Circularity must be at the centre of the retrofit/refurbishment strategy.

The case studies analysed have shed light on several specific areas that building renovation projects could take into consideration:

- **Programme:** Whilst programme savings may be achieved during a retrofit project, additional time needs to be allowed for in the design process to enable teams to obtain data and set out strategies to achieve the project goals and prevent future changes due to new information being obtained. Potentially early engagement form contractors could be sought.
- **Ceiling heights:** There might be some physical constraints regarding the floor to ceiling heights of the existing building structure to deliver a high quality of building environment. However, clear height of buildings can be maximised through designing exposed ceiling, introducing air conditioning systems distributed beneath the floors (CAM-V). 100 New Bridge Street is a great example of a project that already has generous floor-to-ceiling heights and therefore largely retained elements such as floor and frame of the building, saving on carbon emissions.
- **Glazed facades:** Design of glazed facades can help to increase the penetration of daylight and enhance the thermal performance of the existing buildings; therefore, it plays an important role in reducing operational energy and carbon. However, increased glazed areas can increase embodied carbon too and should be considered in the design and optioneering stage.
- **Choice of material replacement:** A key consideration should be around ensuring to keep a high quantity of materials and components within the system. Some materials retained or replaced may play a role in increasing the recycling content of the project or may serve to improve the fabric performance of the building. Kensington case study used 99% plus ISG, demonstrating a high recycled content

value. This project saved 30% of embodied carbon and followed circular economy principles.

- **Retaining sub-structure:** A significant reduction on embodied carbon of a proposed development can be achieved, as a great proportion of embodied carbon is associated with substructure of a building. This can be observed in case studies such as 1 Appold Street and Kensington and 3 Sheldon Square which have high retention rates for sub-structure.
- **Introducing less material and lightweight structural design:** Reducing the structural mass of the design is one of the key principles in reducing embodied carbon. Therefore, there are potential carbon saving opportunities as well as lower costs to use reclaimed materials/components and develop lightweight and efficient structure or structural intervention options. 100 New Bridge Street used lightweight block materials for the walls to reduce structural mass of the building
- **Improved fabric and energy performance:** Older buildings are typically less energy-efficient than newer ones. Retrofitting can significantly improve energy efficiency by upgrading insulation, windows, heating, ventilation, and lighting systems. This reduces energy consumption and operating costs.
- **Design for durability, future adaptability & flexibility:** By retrofitting and refurbishing infrastructure, it is possible to extend their lifespan, avoiding costly replacements and disruptions. Long-term sustainability may allow the assets to evolve over time despite changes in use or operational demand. It may increase resilience of the building and re-risk from future climate change effects. Retrofitting can enhance the resilience of infrastructure to withstand natural disasters and climate-related impacts, contributing to community safety and stability. In addition, it entails less energy and waste in case of future transformations.
- **Preservation of Cultural Heritage:** Many older buildings have architectural or historical significance. Retrofitting and refurbishing these structures allow for the preservation of cultural heritage while making them functional for modern needs. *See an example of case studies: Pall Mall*
- **Innovation/Technology – The use of Digital Twin:** technology provides considerable potential to reduce assets' carbon footprint. It can rationalise and optimise the asset demand / performance by providing continuous live data. *See an example of case studies: The Hickman Building*
- **Replace inefficient technologies and embrace renewable energy and clean technologies:** Refurbishment projects present a great opportunity to replace old, inefficient technologies that may be fossil fuel based with new systems that are more efficient, more sustainable and use renewable sources. This may include replacing gas boilers with air source heat pumps to electricity heating systems, or the introduction of solar photovoltaics mounted on roof space. 100 New Bridge Street is a refurbishment projects that switched from gas to electricity and introduced on-site renewable energy generation.

6. Responsible Investing – Capitalise on Infrastructure

Capitalising on existing infrastructure is crucial for promoting and facilitating more retrofit and refurbishment building projects. Existing infrastructure, such as buildings and urban

infrastructure, represents a significant investment of resources, materials, and energy. Retrofitting and refurbishing these assets can extend their useful life, reducing the need for new construction, which consumes additional resources.

Retrofitting and refurbishing existing buildings often offer a more cost-effective solution compared to constructing entirely new structures. This can make projects financially viable and attractive to investors and developers. The case studies set out in this report showcase the carbon reduction opportunities associated within different projects, but also shed lights on areas that require greater investment.

For example, there is limited coverage of heat networks across London to serve new developments across London and meet the demand of proposed developments in a financially viable way. The UK Government's forthcoming heat zoning regulation may provide an enabling framework for heat network expansion at scale.

7. Review the Performance – Monitoring and Verification

Design for Performance can be followed through by measuring, recording, tracking, and evaluating data to verify the effectiveness of the measures conducted within a project. Following the design, construction, and delivery of retrofit/refurbishment interventions, it is crucial to verify the outcomes.

Monitoring and verification help ensure that the energy-efficient measures implemented during the refurbishment are performing as expected. This validation is essential for confirming that energy-saving goals are met. This exercise can confirm the accuracy of initial assessments and provide a feedback loop for improved design stage approaches and measurements. Data collected through monitoring can reveal opportunities for further improvements or adjustments to the building's systems and operations, leading to even better performance and sustainability outcomes.

Tracking building performance post-refurbishment allows for the verification of cost savings resulting from reduced energy consumption, maintenance, and operational expenses. This information is valuable for both building owners and tenants. In some cases, best practice standards, regulatory requirements, or sustainability certifications (e.g., LEED, BREEAM) may necessitate third party verification and ongoing monitoring to maintain compliance.

Maintaining accurate records of a building's post-refurbishment performance can enhance the asset's value, making it more attractive to potential buyers or investors (e.g. producing a materials passport). Monitoring and verification help demonstrate the return on investment (ROI) of the refurbishment project. This information can be useful for future funding, financing, or investment decisions.

9. Conclusions

The built environment sector is moving towards a trajectory that increasingly values the optimisation of resources and the minimisation of environmental impacts, particularly carbon emissions. Policy and market drivers are shifting to address the climate emergency and some developers are positioning themselves, not only to embrace, but also to lead on the sustainability front.

There is an increasing awareness and expectation from investors related to embodied carbon and circular economy, which enables a rationale and need to carry out early-stage consideration for retrofit and refurbishment options as a viable alternative to new build. Similarly, demand is surging with tenants and occupants expecting and seeking sustainability attributes in buildings. Studies have shown a potential link between buildings with green credentials and premium rents. Overall, a trend is emerging that the industry and all participants should embrace.

The review of international regulations underlines this trend by highlighting how national and city-level climate policies are setting ambitious targets emission reduction. Despite greater emphasis on climate action, there is a need for further guidance and evidence of how this can be achieved.

Refurbishment and retrofit form an important part of achieving low Whole Life Carbon performance as well as 'Circular Economy' goals. Building fabric retention, recycling or reuse of materials and use low embodied carbon are a few ways to establish circularity and reduce whole life carbon.

There is need for quality data, better estimation of carbon performance and standardisation of measurement methods based on life cycle analysis. National policy frameworks need to be created, allowing for some regional adaptions, so consistent approaches can be adopted. The industry recognises the need for change but requires consistency to be able to invest in effective and viable solutions.

This report has collected a series of case studies that showcase current best practice in London and beyond which highlight key lessons learnt. The case studies show that retrofit and refurbishment measures can help address the climate challenge, both in terms of reducing the use of new resources, their associated impacts including carbon emissions.

The case studies show that benchmarking and analysis for carbon impacts has been evolving at a fast pace, making historical comparison challenging. Data, evaluation, and transparency is improving over time, and key metrics are now being looked at all stages of development. It is noted that as performance-built requirements become mandatory, the knowledge, data and reporting is expected to become more accurate and standardised moving forward.

The information gathered shows that, historically, data surrounding both embodied carbon and in use operational energy is scarce. This is correlated to the feedback provided by designers in terms of how the building operates in use from an energy perspective. Nevertheless, positive change is beginning to take place, as policy evolves, and developers seek to report on their actual emissions.

Overall, this report aims to take insights from real retrofit projects and summarises several key best practice recommendations. These include:

1. Collect and analyse existing building data.
2. Ensure the business case also accounts for carbon impact.
3. Evaluate risks and opportunities for the site.
4. Establish a clear strategy for decarbonisation, accounting for comparisons of building types and regulation considerations.
5. Use consistent reporting metrics and review against targets (peer reviewed data is recommended)
6. Consider market maturity – i.e. can lower whole life carbon buildings attract a premium if demand rises?
7. If refurbishment / retrofit is not possible and demolition is required, ensure a justification and plan is in place to have rationalized the demolition and maximise reuse potential of existing materials. This should be communicated to the planners.
8. Report on as built upfront carbon performance and operational energy in use.

If retrofit and refurbishment is not considered, it should be justified, explaining why it is being discounted as an option. Similarly, justification for demolition should be provided to explain the loss of embodied carbon and unfeasibility to extend the lifespan of structures and materials.

This report concludes that retrofitting and refurbishment may not always be the way forward for a project. However it should be considered at early stage of decision making as it may present opportunities beyond solely carbon saving, such as increase asset value, attraction and rentability of property, improved tenant-landlord relationship, benefits to the wider community, investor satisfaction and potential monetary savings.

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Appendix A – Case Studies

These are included as a separate document.

Appendix B – Detailed Policy Review

Global Context – Building Standards

An initial review of the building standards and policies has been undertaken covering different geographical contexts around the globe. This review is based on English-language documents only and available on the public domain. It should be noted that some information may be missing in the instances of unavailability or non-English documentation.

New York State, with a special focus on the New York City

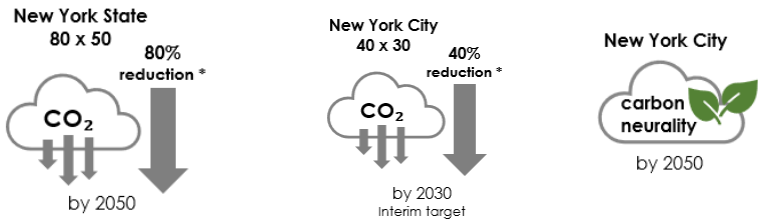


Figure 1: Decarbonisation targets of the NYS

Note: On January 20, 2021, the US rejoined the Paris Agreement

Overview of the state's decarbonisation journey: New York State has made the commitment to reduce GHG emissions 80% by 2050, as known '80 x 50' target. In line with this, New York City (NYC) has specified an interim target of 40% reduction by 2030 (i.e. '40 x 30' target), and has already implemented policies, programs, and initiatives on the path to reach the '40 x 30' Target. According to the OneNYC report (OneNYC, 2019), it is anticipated that the city has taken suitable measures to indicatively achieve interim '40 x 30' target, however, it was highlighted that the efforts alone were not enough to reach '80 x 50' target. Currently, NYC has pledged to hit carbon neutrality by 2050, placing a particular focus on the building sector, as it is responsible of approximately 66% of the city's emissions (JLL, 2022). To fulfil this pledge, NYC requires to rethink its approach to the operation and management of buildings as well as building design and construction in the industry (NYC Congress, 2021).

Highlights in the current policy:

- **Energy efficiency:** The Local Law 85 of 2019 requires any buildings going under renovation or alteration to have designs to comply with the New York City (NYC) Energy Conservation Code (NYCECC) (Anon., 2023).

- **Embodied carbon:** There has been a lack of regulations to mandate accounting of the embodied carbon of buildings in both the New York State and the NYC. However, recent regulation introduced in 2022, Executive Order 23: Clean Construction, emphasises to reduce embodied carbon of building materials and construction equipment. Therefore, it requires the development of guidelines of procurement of low-carbon concrete.

Outlining that energy efficiency in buildings is at top in the agenda: In line with the global trend of focusing on operational energy and operational emissions, NYC has led on reducing operational carbon emissions through the significant efforts in increasing energy efficiency and electrification in buildings. This follows the legislative package of Climate Mobilisation Act (CMA) as a part of the Mayor's New York City Green New Deal.

Energy efficiency in existing buildings and retrofits: Local Law 97 of 2019 requires existing buildings sizing more than 25,000 ft^2 (about 2320 m^2) to reduce their emissions within the '40 x 30' target (NYC Congress, 2021; NYC, 2019). In addition, Local Law 85 of 2019 requires any buildings going under renovation or alteration to have designs to comply with NYC Energy Conservation Code (NYCECC) (Anon., 2023). Furthermore, Local Law 92 of 2019 and Local Law 94 of 2019 mandate for all new buildings and buildings undergoing major roof renovations to allocate all roof space for solar panels **(100%),** green roofs, or some combination of the two **to provide a sustainable roofing zone** (NYC, 2019) (JLL, 2022).

In line with the Local Law 95 and 133 require commercial and residential buildings to measure their annual energy and water consumption to help benchmark energy and water efficiently (NYC, 2019). Since there is a lack of data on how buildings perform, benchmarking of buildings become important to monitor the performance of the buildings as well as offer target and guideline to reduce the impacts of the building. The availability of benchmarks also supports to develop better strategies and more spoken measures ultimately facilitate to make the right investments for interventions.

The table below (**Table 3**) summarises the key NYC laws that contribute to reducing operational carbon emissions.

Table 6: *A summary of key laws regarding the decarbonisation of existing building stock*

Local Laws	The scope related to the decarbonisation of existing buildings
Local Law 97 of 2019	It introduces a building performance standard to cut emissions of the city's buildings and calls for existing NYC's buildings of more than 25,000 ft^2 (about 2323 m^2) to reduce their emissions within the 40 x 30 target (NYC Congress, 2021; NYC, 2019). It also mandates building owners to prepare annual energy efficiency, energy use, and GHG emissions reports annually (New York City Government, 2019).
Local Law 85 of 2019	It requires building designs to comply with NYC Energy Conservation Code for any renovation or alteration project (Anon., 2023).
Local Law 95 of 2019 Local Law 33 of 2018 Local Law 133 of 2016	Benchmarking (energy efficiency grade): They require owners of buildings that have more than 50,000 ft^2 of gross floor area (4645 m^2) and either no residential units or 17+ residential units to annually measure their energy and water consumption (Anon., 2023) (NYC Congress, 2021).
Local Law 92 of 2019 Local Law 94 of 2019	All new buildings and buildings undergoing major roof renovations are required to be covered with solar panels, green roofs, or some combination of the two (NYC, 2019) (JLL, 2022).

To support the design, construction, and retrofitting process of buildings, New York State Energy Research and Development Authority (NYSERDA) has launched a range of programmes as described in **Table 4**.

Table 7: *A summary of NYSERDA programmes focussing on retrofitting existing buildings*

NYSERDA programmes	Key points for existing buildings
Carbon Neutral Buildings Roadmap	• Need for the transition to emission-free electricity and shift away from onsite fossil fuels use in existing buildings (new buildings as well) • Adoption of new carbon neutral construction and adaptive reuse projects to future-proof

	• Advancement of insulation types and other envelope-based load reduction strategies for existing buildings • Thermal energy network systems for existing buildings • Building energy performance requirements for existing buildings and minimum energy efficiency standards mandatory for existing building.
Empire Building State Challenge	• Stating potential decarbonisation solutions for improving the performance of existing high-rise buildings (iconic buildings of NYC), by primarily focusing on operational energy & carbon emissions.
RetrofitNY	• Existing buildings showcased in the NZE by driving dramatic improvements in energy performance.
NYStretch Energy Code 2020	• It was developed to support the State's energy and climate goals by accelerating the savings obtained through their local building energy codes.

> The NYC mandates standards for minimum energy efficiency performance for existing buildings under the NYStretch Energy Code. These are more stringent than state-level code (JLL, 2022) by aiming to achieve a 20% boost in energy savings beyond code for residential, commercial, and multifamily buildings (Caputo, 2018).

Following the mandate of Local Law 97 of 2019 (LL97), approximately 50,000 buildings (59% residential and 41% commercial) are required to drastically cut their carbon emissions within the '40 x 30' target (Margolies, 2022). In addition, the LL97 specifies a benchmark, which is set to achieve an average building emissions intensity for all covered buildings of no more than 0.0014 tCO_2e per ft^2 per year (*about 15 $kgCO_2/m^2$*), applicable for calendar years 2040 through 2049 (New York City Government, 2019). Based on the LL97 of 2019, **Table 5** outlines the annual building emission limits for some of the building types classified with respect to occupancy (*also known as Class Use in the UK*).

Table 8: *Annual building emission limits for building classes (Local Law 97 of 2019)*

Building Classes	**Building emission limits ($kgCO_2e/m^2$)**	
	2024-2029	**2030-2034**
Occupancy Group A: Assembly *(excl. dwelling unit. A building or structure used for gathering, social, civic purposes, etc.)*	115.6	45.2
Occupancy Group B: Business *(offices, public or civic services)*	91.1	48.8
Occupancy Group E: Educational *(schools, academies, libraries, day care facilities, etc.)*	81.6	37.0
Occupancy Group F: Factory & Industrial *(factories, manufacturing buildings, etc.)*	61.8	18.0
Occupancy Group R1: Residential *(dwelling and sleeping purposes, for a period less than one month: hotels, motels, club houses, dormitories etc.)*	106.2	56.6
Occupancy Group R2: Residential *(dwelling and sleeping purposes, for permanent purposes: apartment houses, dwellings, etc.)*	72.7	43.8
Occupancy Group S: Storage (warehouses, storage rooms, etc.)	45.9	11.8
The reference document shows values based on tCO_2/ft^2. Conversion factor for ft^2 to m^2 is 0.092903.		

Real estate developers need to undertake major changes in buildings to be in compliant with the city's carbon commitment thresholds and be on track to avoid the penalties. Regarding the electrification of space heating, in 2021, the NYC announced a ban on natural gas in newly constructed buildings that is expected to come into effect from 2027

for buildings with seven storeys high, and from 2023 for all other buildings (New York City Council, 2021). The implication of electrification of space heating, as required by LL97, has raised questions as to whether the current grid can meet the increasing demand (Margolies, 2022).

Summary & insight: Although a wide spectrum of measures has been taken at city level in NYC, only considering operational carbon emissions will not be enough to enable the city to fully decarbonise. There is need to also address embodied carbon emissions to achieve the ambitious goals NYC has set by 2050. The industry of the built environment in the city should therefore adapt and move towards a whole life cycle carbon approach to encompass both operational and embodied emissions (NYC Congress, 2021).

California

Overview of the state's decarbonisation journey: California has introduced a new whole building embodied carbon policy within the 2022 California Green Building Standards Code (CALGreen), Title 24, Part 11, which will be effective from 1st July 2024. This pioneering move marks the first whole building lifecycle assessment (WBLCA) policy in the United States. The amendment provides three compliance path options that can be elected by design professionals to meet the new standards, as per the Figure below.

Proposed Mandatory and Voluntary Carbon Reduction Measures for Non-Residental Buildings

	Existing Voluntary	Mandatory 50,000 sq ft (project aggregate)	Tier 1 50,000 sq ft (project aggregate)	Tier 2 50,000 sq ft (project aggregate)
Building Reuse	75% of the structure and enclosure to be reused.	45% of structure and enclosure to be reused.	75% of the structure and enclosure to be reused.	75% of the structure and enclosure to be reused, AND 30% of interior non-structural elements to be reused.
Whole Building Lifecycle Assessment (WBLCA)	10% reduction from baseline	10% reduction from baseline	15% reduction from baseline	20% reduction from baseline
Prescriptive Approach		175% of IW-EPD GWP limits; concrete 130% of ready-mixed GWP values	150% of IW-EPD GWP limits; concrete 130% of ready-mixed GWP values	IW-EPD GWP limits; concrete 130% of ready-mixed GWP values

The 2022 CALGreen includes a reserved mandatory section for the deconstruction and reuse of existing structures, as well as Tier 1 and Tier 2 voluntary measures. It also requires mandatory Whole Building Life Cycle Assessment (WBLCA), with the intent of indirectly conserving energy and resources. The WBLCA conducted should achieve at least a 10% improvement in environmental impact for specific building components.

The carbon reductions build on California's Buy Clean California Act (BCCA) of 2017, extending the scope of projects covered significantly, and adding to the list of covered materials to include concrete. The compliance paths include one based on reuse of at least 45% of an existing structure; one based on specification of materials that meet specified emission limits, and a third performance-based path that allows use of a Whole Building Lifecycle Assessment analysis.

Hong Kong

Decarbonisation:

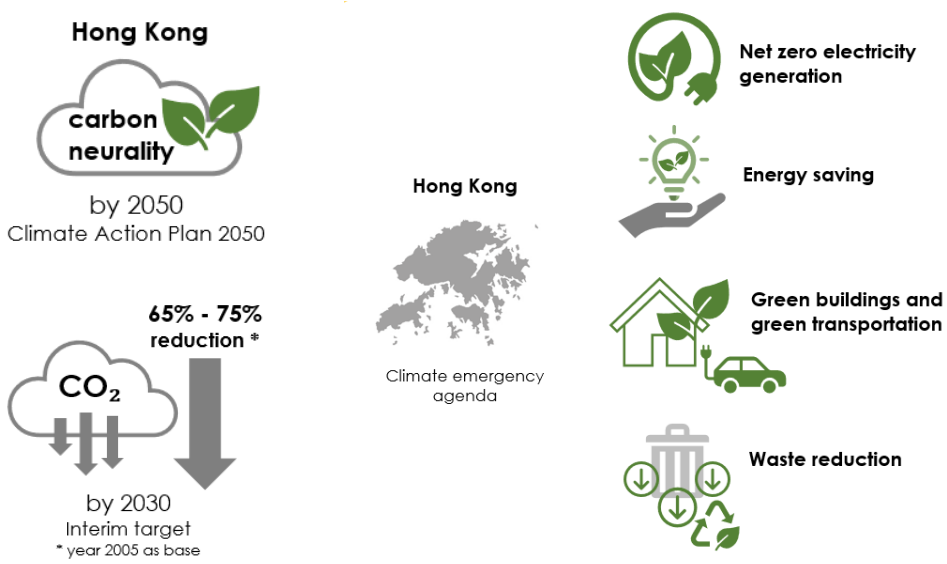


Figure 2

Data source: (Civic Exchange, 20

In Hong Kong, electricity generation is responsible for 66% of the nation's carbon emissions. The building sector is still the major energy consumer and responsible for the 90% consumption of electricity generated in the territory accounting for over 60% of GHG emissions generated in 2019 (Hong Kong's Climate Change Action Plan 2050, 2021). Based on the best available data (EMSD, 2018), Hong Kong is home to many private and government-owned buildings, indicated as more than 42,000 and 8,000 respectively. In addition to the existing building stock, the rate of new build per year was between 300 and 500. It is therefore urgent for Hong Kong to act for decarbonising the building sector, focusing on both new and existing buildings.

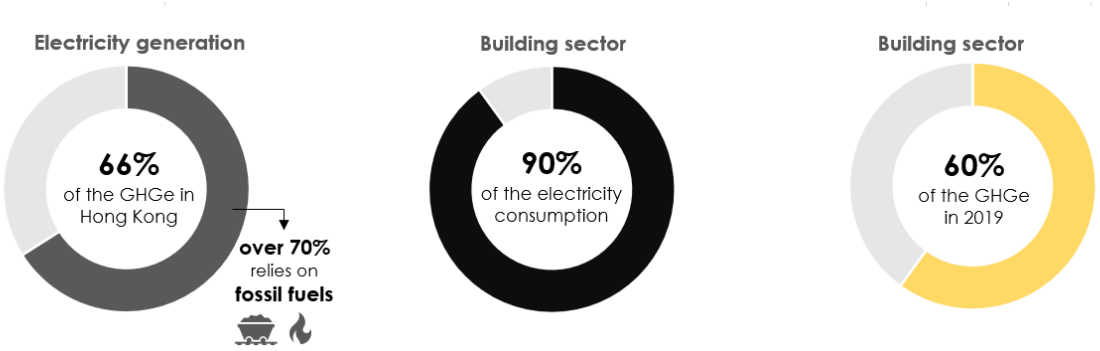


Figure 3 Hong Kong Statistics related to energy and carbon (data source: Hong Kong's Climate Change Action Plan 2050, 2021; EMSD, 2018)

Highlights in the current policy:

- **Energy efficiency:** The Energy Saving Plan for Hong Kong's Built Environment 2015~2025+ (2015) draws attention to reducing energy consumption by looking at the demand-side of energy in Hong Kong to become highly energy efficient by 2025.

- **Embodied carbon:** There has been a lack of regulations mandating the accounting and reporting of the embodied carbon of buildings in Hong Kong. **However, there are some voluntary schemes which are run by Hong Kong Green Council, the Construction Industry Council (CIC), and Hong Kong Green Building Council (HKGBC).**

Energy efficiency in the current policy: The government's policies focus on the supply side of the energy, although the demand side is responsible for a considerable part of the overall emissions. Therefore, it is critical to address the high energy consumption that Hong Kong is experiencing. For this, a requirement has been set out to optimise operational energy performance of both new buildings and existing buildings in the city. This has been mandated through rigid policies, stricter standards, and public visibility of energy efficient buildings (Civic Exchange, 2020).

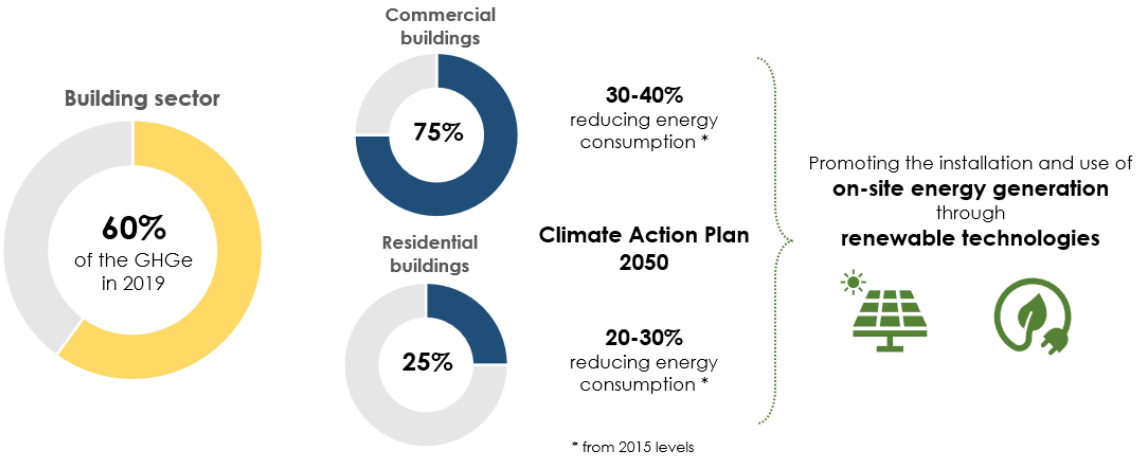


Figure 4

Table 9: *A summary of policies focussing on building energy-efficiency in Hong Kong*

Policies regarding building energy efficiency	**Highlights and key areas focussed on**
The Building Energy Code (BEC)	• Aims to address and reduce high energy consumptions. • The new edition uplifts the energy efficiency standards with an improvement of more than 15 % compared to the previous iteration in 2015
The Building Energy Efficiency Ordinance	• Focussing on 4 key types of building services installation which are air-conditioning installation, lighting installation, electrical installation as well as lift and escalator installation.
The Energy Audit Code (EAC)	• Setting out the technical guidance and details in respect of the energy audit requirements governing the central building services installation.
Source: (The Electrical and Mechanical Services Department, 2022)	

As a private sector professional body and partner to the Government, the Hong Kong's Green Building Council (HKGBC), launched a couple of programs which are the following:

- **HKGBC Benchmarking & Energy Saving Tool (HK BEST):** It is developed to promote better energy performance for commercial and office buildings. It provides a comparison practice for the energy consumption of buildings with other similar buildings and identify potential energy improvement measures. In addition, it gives an appropriate class of recognition to which have achieved outstanding energy performance amongst their market peers.
- **ACT-Shop Program:** In 2016, the programme launched, and it adopts the 4T's operation framework, which namely Timeline, Target, Transparency and Together. The main aim of the programme is to assist building owners to enhance the energy performance of the existing buildings by implementing a knowledge-based energy management and retro-commissioning practices in their buildings (HKGBC, n.d.).
- **BEAM Plus Scheme:** It is the leading initiative to offer independent assessment of building sustainability performance by primarily focussing on to enhance the health and wellbeing of building occupants, to reduce the environmental impact of

buildings, as well as to make buildings more efficient and emit less carbon (HKGBC, n.d.)

- **RCx Retro-commissioning:** It is a cost-effective systematic process to check an existing building performance and identify energy saving potentials for operational improvement. It also offers a systematic training programme for practitioners, professionals, and service providers to fill gaps in knowledge and practice (HKGBC, n.d.).

Embodied carbon measures: There are some voluntary schemes which briefly given below:

- **Carbon Assessment Tool (CAT):** It is an online tool which is designed by the Construction Industry Council (CIC) to create a database of embodied carbon for construction materials, measure the impact of materials and site activities, analyse the carbon performance of the projects as well as establish carbon reduction targets for the industry. The tool is integrated into a voluntary building certification scheme, BEAM Plus NB to promote carbon reduction (Civic Exchange, 2020).
- **Green Product Certification (GPC):** Within the collaboration of CIC and HKGBC, this scheme is designed to classify and certify construction materials and products. The scheme consists of two main streams: Carbon Labelling Scheme and HK G-PASS. The former focusses on only carbon footprint information about the materials, the latter is about overall sustainability rather than focusing on carbon emissions (Civic Exchange, 2020).
- **Hong Kong Green Label Scheme:** This scheme was developed by the Hong Kong Green Council, and it certifies environmentally preferable products through a label, called Green Label. With this, it aims to encourage manufacturers to supply products having a good performance in terms of environmental performance emissions (Civic Exchange, 2020).

It is worth noting that the reporting of embodied carbon impacts is not mandatory in Hong Kong.

Japan, with a special focus on Tokyo

Japan is one of the countries where high percentage of GHG emissions generated. Under the Paris Agreement, the government committed to reach carbon neutrality by 2050 with an interim target of achieving a 46% reduction of GHG emissions by 2030, compared to 2013 (The Carbon Brief, 2018). In line with this, Tokyo, Kyoto, and Yokohama and 931 other local governments announced their commitment to net zero carbon emissions by 2050 as well (Ministry of Environment Government of Japan, 2023).

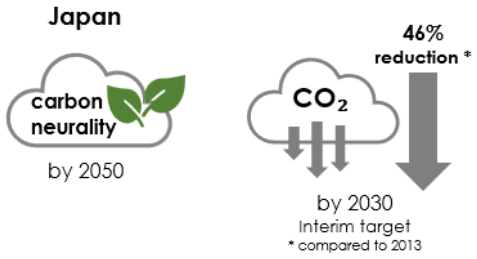


Figure 5 Japan's statistics related to carbon emissions

Highlights in the current policy:

- **Energy efficiency:** For non-residential buildings (≥2000 m²), it has been mandatory to be compliant with the minimum energy efficiency standards and obtain a certification of conformity with standards since 2017. On the other hand, even though the government aims to achieve net-zero energy consumption in all buildings by 2050, there is no national law serving as a renewable energy requirement for buildings in Japan (Morimoto, 2023).

- **Embodied carbon:** There has been a lack of regulations mandating the accounting and reporting of the embodied carbon of buildings at national level. Similarly, there are lack of voluntary examples of developments that have conducted embodied carbon and WLC assessments.

Energy efficiency in the current policy:

In Japan, the built environment is responsible for approximately 30% of total energy consumption of the country; therefore, energy efficiency and renewable energy are high in the government's agenda. Even though the government aims to achieve net-zero energy consumption in new constructed buildings, as well as houses by 2030, the best available data in 2020 shows that only 0.42% of new constructed buildings and nearly 24% of new built houses were net-zero energy assets. Therefore, the target to achieve net-zero energy consumption all buildings and houses (both existing and new constructed buildings) by 2050 is considered to be highly challenging (METI, 2022) (Climate Acton Tracker, 2023). The latest amendment in the main energy efficiency law, the Building Energy Efficiency Act, took place in 2022 and started to be implemented in 2023. Despite the installation of PV panels was considered, it was not included in the Act. Therefore,

there is no national law serving as a renewable energy regulation for buildings in Japan (Morimoto, 2023).

In Japan, compliance with minimum energy standards and obtaining a certification of conformity with standards for non-residential buildings with a floor area of 2000 m^2 or more is mandatory. This mandatory regulation aims to cover all new built non-residential and residential buildings from 2025 onward. In response to the obstacles in achieving net-zero energy in energy-intensive high-rise buildings, Japan plans to streamline height restrictions to energy saving renovations (REthink Tokyo, 2022).

Embodied carbon in the current policy:

There has been a lack of regulations to mandate the accounting and reporting of the embodied carbon of buildings at national level. However, it is promoted to incorporate using more timber in both new constructions and renovations. Timber use is advocated as a building material in construction as a way for achieving carbon neutrality, yet there is no reference of the implications related to embodied carbon. **Regarding the best available sources, increasing the use of timber in buildings is not clearly highlighted as an action within the embodied carbon context. However, it is associated with achieving carbon neutrality in built environment.** In terms of the limitation on building heights, it is planned to be relaxed to enable the increased use of the wooden buildings (16 metres or less).

Tokyo:

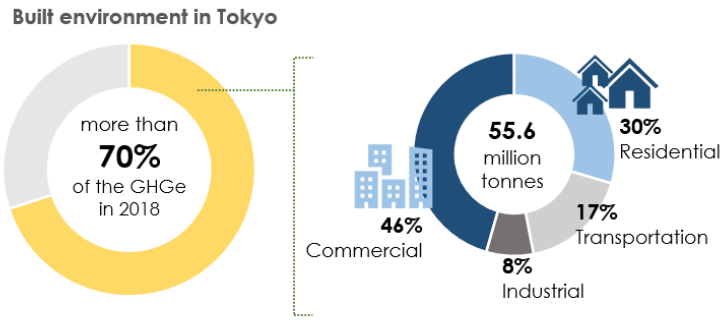


Figure 6

With a special focus on Tokyo, there is a significant amount of energy consumed by the built environment; therefore, there is an urgent need to adopt renewable energy systems in buildings particularly in Tokyo. Although there is no national law serving as a renewable energy regulation for buildings at national level, the Tokyo Metropolitan Government (TMG) amended its ordinance to reflect this urgency in 2022. Within this context, it is required for buildings **within a certain threshold of size** must install photovoltaic panels from 2025.

Due to the abundance of high-rise buildings in Tokyo, the TMG introduced a program, The Cap-and-Trade scheme, to introduce additional requirements for reducing carbon emissions in those existing large-scale buildings and companies. This scheme represents

the world's first urban-based emissions trading system. Following this, two more programmes have been developed to target new buildings and small-to-medium buildings too. With these mechanisms, TMG encourages building owners to identify their carbon emissions and implement energy efficiency measures. TMG also provides Low Carbon Benchmarks to enable building owners to understand and contextualise the energy efficiency performance of their buildings (Tokyo Metropolitan Government, 2021).

European level policies and programmes

In 2015, the EU and all its members have committed to the implementation of the Paris Agreement and aim to reach carbon neutrality by 2050 as a long-term goal. Based on 2020 data, it is indicated that approximately 75% of the EU building stock is energy inefficient. This resulted that the building stock was responsible for 40% of energy consumption and 36% of GHG emissions. It is also stated that retrofitting the existing building stock could reduce the EU's total energy consumption by 5-6% and lower carbon dioxide emissions by about 5%. However, the annual renovation rate was estimated to be around 1% of the national building stock. Yet, the rate should be at least double to meet the targets (European Commission, 2020). Therefore, to achieve the ambitious targets of carbon neutrality by 2050, key measures to improve energy efficiency in the existing buildings are required.

In 2019, the European Commission developed the European Green Deal (EGD) with the aim of making the EU's economy sustainable. It provides an action plan and includes a package of policy initiatives which aim to set the EU on the path to a green transition by reducing GHG emissions to at least 55% below 1990 levels by 2030 then reaching climate neutrality by 2050 (European Commission, 2019). To raise the 2030 ambition and put forward a comprehensive plan on how to achieve the targets set in the EGD, the Commission prepared and adopted the 2030 Climate Target Plan (European Commission, 2020). Although both the EGD and the 2030 Climate Target Plan are not enforced laws, they inspire legislations in member states. Therefore, in 2021 European Climate Law enacted the targets into law (Frizberg, 2022).

Within the EGD, some key frameworks, packages and strategies have been introduced. These are explained in detail below.

A Renovation Wave for Europe:

Due to the energy inefficient building stock in the Europe, the Commission presents a strategy, 'a Renovation Wave for Europe', to boost the annual building renovation rate to facilitate meeting the decarbonisation targets. The main objective of the strategy is to at least double the annual energy renovation rate of residential and non-residential buildings by 2030 and to foster deep energy renovations (European Commission, 2020).

On this basis, the Renovation Wave focuses on 3 main areas: (i) tackling energy poverty and worst-performing buildings, (ii) public buildings and social infrastructure, (iii) decarbonising heating and cooling. In line with these, some of the key principles are proposed, these include:

- ***Energy efficiency first***: Puts emphasis and prioritises energy efficiency measures.
- ***Affordability***: Aims to make sustainable and energy efficient buildings widely available for everyone (in particular lower-income households and vulnerable areas).
- ***Decarbonisation and integration of renewables***: Due to that most of the existing building stock relies on fossil fuels as a source for operational energy for the buildings, this principle promotes the integration of renewables to decarbonise the built environment.

- ***Life cycle thinking and circularity***: Focus on minimising the building footprints and emphasises the resource efficiency and circularity as key strategies to reach decarbonisation. It also promotes the use of naturally sourced materials that can absorb and store carbon **(such as materials derived from plants, trees, and soil).**
- ***Tackling the twin challenges of the green and digital transitions together:*** Highlights the important potential of integrating smart systems into the buildings on enabling the highly efficient and zero-emission buildings.

To achieve a truly net-zero carbon building stock, the strategy acknowledges that there is a need for a shift from considering the design, construction and operation of buildings independently from one another, and towards whole life-cycle considerations. The consideration of embodied carbon has started to be implemented or agreed in some countries including the Netherlands, France, and Denmark; while it is still in the planning stage in Finland and Sweden (BPIE, 2021). It is worth noting that renovation projects may in some cases increase embodied carbon through:

- Minimum retention of existing structure
- Additional floors/storeys
- Use of higher carbon intense materials (with higher carbon footprint).

The Fit for 55 Package:

Within the goals of the EGD, the Fit for 55 Package consist of a set of inter-connected proposals to modernise the existing legislation in line with the EU's 2030 climate target and introduce new policy measures to help bring about the transformative changes.

Figure 1 presents the main areas outlined in the Fit for 55 Package.

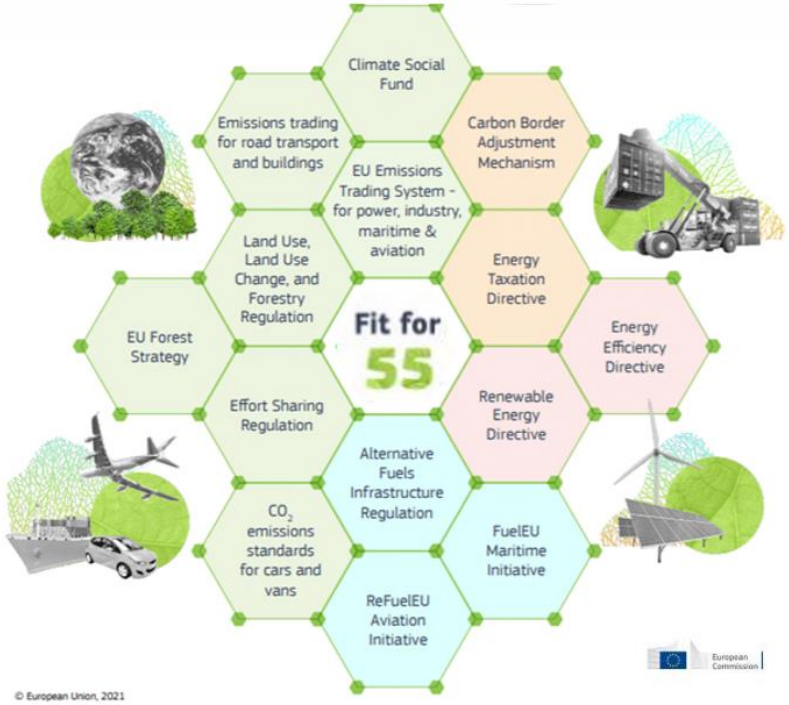


Figure 7: *The main areas in the Fit for 55 Package (Source: European Union, 2021).*

The Energy Performance of Buildings Directive:

To boost energy performance of buildings and reflect higher ambitions and pressing needs in climate action, the European Commission revised the Energy Performance of Buildings Directive (EPBD) by upgrading the existing regulatory framework in December 2021 (EPB Center, n.d.). This revision puts emphasis on increasing the rate of renovation for the worst-performing buildings. With the help of this, it defines how the EU can achieve net-zero emission and decarbonisation of the building stock by 2050. To achieve this, it sets out the Minimum Energy Performance Standards (MEPS) for new buildings, for major renovation of buildings and for the replacement or retrofit of building elements. It also presents a methodology for calculating the integrated energy performance of buildings as well as introduces an energy performance certification (EPC) for buildings (Wilson, 2023).

EPCs are based on an A-G scale to make it easily identifiable. The commission considers that the availability of EPCs in accessible databases enhances the transparency of the performance of the building stock. While they are essential for identifying the worst-performing buildings that requires urgent renovation at the national level, EPCs provide information on energy performance, the percentage of renewable energy as well as energy costs at the building level. In line with these, EPCs can be used to assess the improvements relative to the investment before and after the works; therefore, they can be a useful tool to provide both quality of renovation and cost-effectiveness (European Commission, 2020). It should be noted that the parameters for allocating buildings to particular EPC classes continue to be defined nationally, while the distribution of buildings across the A-G scale varies considerably between Member States (Wilson, 2022).

A closer look to the MEPS defined at European level, the worst performing buildings, those in Energy Performance Certificate (EPC) classes G or F, are required to be renovated. In addition, public and non-domestic buildings are required to be improved to at least EPC class F by 2027, and to at least class E by 2030. Regarding the residential buildings, it is required to be renovated to achieve at least class F by 2030, and to at least class E by 2033. Member States must then establish specific timelines for achieving higher energy performance classes through new National Building Renovation Plans, in line with their pathway to achieve zero-emission building stock by 2050. Member states are also expected to set national MEPS in line with their National Building Renovation Plans (European Commission, 2021).

The latest recast on the EPBD brings the following issues:

- **A new definition of 'zero emissions building':** This means as '*a building with very high energy performance where the very low amount of energy required is fully covered by energy from the building itself or from locally produced renewables*'. It will be applicable to all new buildings from 2027 and to all renovated buildings from 2030 (Wilson, 2022).
- **National building renovation plans:** The Commission proposed these as a replacement of the *long-term building renovation strategies* to promote the inclusion of concrete targets for renovation by 2030, 2040, and 2050. These plans will require to be renewed in 5-year period and be fully integrated into the 10-year National Energy and Climate Plans (NECPs) (Wilson, 2022).

- **The life-cycle Global Warming Potential (GWP):** The latest recast in EPBD is set to integrate measures for the decarbonisation of buildings. From 2030, this indicator is required to be calculated for all new buildings (applicable to all large buildings > 2000 m^2 from 2027 onwards) (Wilson, 2022).
- **New provisions relating to EPCs:** The validity of period for EPC classes D-G would be reduced to only 5 years (rather than 10 years), to ensure they reflect the latest efficiency standards. EPCs in classes A-C would continue to be valid for up to 10 years (Wilson, 2022).
- **Obligation to issue and display EPCs:** In 2010, it became mandatory to produce and display EPCs for the sale and rental of new buildings; however, it was not required for the existing buildings. The current EPBD requires all new buildings and those undergoing major renovations to have an EPC, as well as 'all buildings' sold or rented out to new tenants (Wilson, 2022).
- **Renovation passports:** The Commission is planning to develop an EU framework for renovation passports. It is believed that the development of national schemes for the renovation passports can facilitate the owners to plan a staged renovation of the building (Wilson, 2022).
- **Smart readiness of buildings:** The Commission is planning to develop a smart readiness of buildings indicator to be applicable to all large non-residential buildings. This would be required to install mandatory building automation and control systems for these buildings. The latest recast on the EPBD aims to change the threshold for the non-residential buildings from '> 290 kW (for large buildings)' to '> 70 kW (for medium to large buildings)'. (Wilson, 2022).
- **Encouraging renewable heating systems:** From 2027 onwards, the Member States would not be able to subsidise the use of fossil fuel boilers (Wilson, 2022). To ensure the decarbonisation of the building sector, the latest revision requires that all new buildings (in the case of being technically feasible) have 100% of on-site energy consumption covered by renewable energy as of 2030, with an earlier adoption as of 2027 for public buildings (European Commission, 2021).

In line with these, it can be stated that clear efforts have been taken to foster more transparency, better comparability, better implementation, and monitoring procedures within the aim of building decarbonisation at EU level (European Commission, 2021).

Ecodesign for Sustainable Products (ESPR):

The Ecodesign Directive has been established in 2009 with the intent to deliver benefits to the environment and businesses by mandating regulations for energy-related productions Rooted on the Directive, the Ecodesign for Sustainable Products Regulation (ESPR) was published in March 2022 to set Ecodesign requirements for specific product groups. It centred on improving the circularity, environmental sustainability as well as energy performance of the products. Therefore, the proposal represents a cornerstone of the Commission's approach to more environmentally sustainable and circular products. While it is still in the drafting stage, it is planned to be mandated to cover the following sustainability requirements (European Parliment, 2023):

- Durability, reusability, upgradability, and reparability,
- Recycled content as well as remanufacturing and high-quality recycling,
- Carbon and environmental footprints,
- Energy and resource efficiency, and
- Digitalisation of product information.

The Construction Products Regulation (CPR):

Adopted in 2013, The Construction Products Regulation (CPR) is a key regulatory framework for construction products. It is construction-specific and centred on the specific needs of the industry to deliver construction products in the European common market through a harmonised format. Its approach is performance based, which means that manufacturers declare information about their products' performances (Construction Products Europe, 2021) via a Declaration of Performance (DoP). Considering the ambitious decarbonisation targets, the CPR amendments should aim to ensure all construction projects, both new and renovation projects, are able to contribute meeting the targets as well as embrace the principles of circular economy (Wardal & Briard, 2022).

Given the large contribution of the construction sector to Europe's GHG emissions, the CPR has an important potential to not only reduce the carbon intensity of Europe's building stock, but also provide impetus for the decarbonisation of the construction materials having carbon-intensive manufacturing processes (Sandbag, 2020)**.**

Level(s) Framework:

Due to lack of a standardised approach to measure the sustainability of buildings, the European Commission introduced a framework, 'Level(s)', as a response to this problem. **It was officially launched on 15 October 2020.** It is a voluntary framework which is based on a life-cycle approach considering whole lifetime of buildings. Therefore, it goes beyond operational carbon performance of the assets; it covers embodied carbon impacts of the buildings and promotes adopting circular economy principles. Within its core macro-objectives (**Figure 10**), the first one, Greenhouse gas emissions along buildings life cycle, considers the life cycle impacts of buildings. **It does not specify any benchmarks. The main aim is setting out a methodology, common language for how to undertake assessments.**

The results are required to be reported in $kgCO_2e$ per m^2 of useful internal area for a 50-year time frame (One Click LCA, 2022).

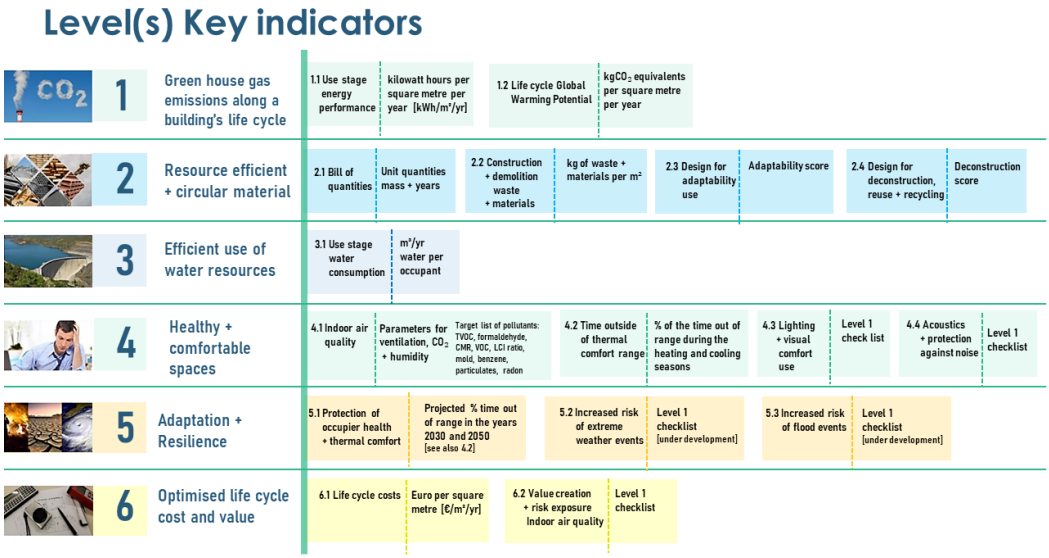

Level(s) Key indicators
1
Green house gas emissions along a building's life cycle
1.1 Use stage energy performance
kilowatt hours per square metre per year [kWh/m²/yr]
1.2 Life cycle Global Warming Potential
kgCO2 equivalents per square metre per year
2
Resource efficient + circular material
2.1 Bill of quantities
Unit quantities mass + years
2.2 Construction + demolition waste + materials
kg of waste + materials per m²
2.3 Design for adaptability use
Adaptability score
2.4 Design for deconstruction, reuse + recycling
Deconstruction score
3
Efficient use of water resources
3.1 Use stage water consumption
m³/yr water per occupant
4
Healthy + comfortable spaces
4.1 Indoor air quality
Parameters for ventilation, CO2 + humidity
Target list of pollutants: TVOC, formaldehyde, CMR, VOC, LCI ratio, mold, benzene, particulates, radon
4.2 Time outside of thermal comfort range
% of the time out of range during the heating and cooling seasons
4.3 Lighting + visual comfort use
Level 1 check list
4.4 Acoustics + protection against noise
Level 1 checklist
5
Adaptation + Resilience
5.1 Protection of occupier health + thermal comfort
Projected % time out of range in the years 2030 and 2050 [see also 4.2]
5.2 Increased risk of extreme weather events
Level 1 checklist [under development]
5.3 Increased risk of flood events
Level 1 checklist [under development]
6
Optimised life cycle cost and value
6.1 Life cycle costs
Euro per square metre [€/m²/yr]
6.2 Value creation + risk exposure Indoor air quality
Level 1 checklist

Figure 8

France, with a special focus on Paris

Decarbonisation

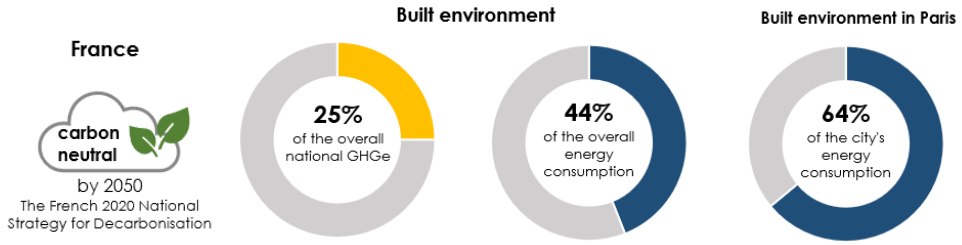


Figure 9

The building sector in France accounts for almost 25% of national GHG emissions and is responsible for 44% of energy consumption (Agora Energy Transition, 2022). In Paris, the energy consumption of building sector accounts for 64% of the city's energy consumption (CDP, 2019). In response to this, the city prepared a Climate Action Plan for Paris that aims to achieve the decarbonisation of all buildings (as well as all sectors) by 2050, in line with the (SNBC) (Agora Energy Transition, 2022). In addition, the city has an interim target for new buildings to be operationally net zero carbon by 2030. In line with the regulatory enforcements, several programmes, and initiatives both the national and regional level, are monitored to achieve the decarbonisation goals (Castellazzi, et al., 2022). For example, the Territorial Energy Renovation Platform (*Plateforme Territoriale de Rénovation Énergétique – PTRE*) provides financial, technical, and legal support on dwelling renovation projects to the individuals to achieve this (Bordier, et al., 2018).

Highlights in the current policy:

- **Energy efficiency:** It is mandatory to have an EPC for new and existing buildings when sold or rented as well as undergo major renovations. France's Energy Transition Law encourages new constructions to have low-energy and low carbon profiles.

- **Embodied carbon:** From 1st of January 2022 onwards, it is required to calculate whole life cycle emissions for all residential, office, and primary or secondary educational buildings applying for a building permit. The RE2020 regulatory calculation method is to use for the assessments.

To meet these ambitious targets, in 2016, the government prepared a pilot programme, called Énergie Positive & Réduction Carbone (E+C-) for the regulatory method and tools. Its methodology is based on two performance levels regarding carbon and energy efficiency (One Click LCA, 2018). This programme provided a basis for a new environmental regulation, called RE2020, was introduced in 2021 that provides more detail and emphasises the need to reduce, not only operational carbon, but also embodied carbon following a whole life carbon perspective (JLL, 2022). Moreover, it significantly tightens the existing energy efficiency requirements on the built environment and

specifically aims for a 52% reduction in embodied carbon emissions arising from all new buildings by 2031 (in comparison to 2015). This is in line with the Paris' decarbonisation strategy by 2050 (Kone, 2022; ACAN, 2021). In addition, RE2020 promotes radical transformation of construction techniques and materials used to enable a market lower carbon content materials for construction (Agora Energy Transition, 2022). It is now mandated by French policy that all new public buildings are required to be constructed with at least 50% timber or other natural materials (Crook, 2020). Moreover, this new regulation requires new developments to undertake a whole-life carbon assessments via dynamic life-cycle approach. It concerns initially all new residential projects, secondly offices and primary and secondary school buildings, and lastly specific tertiary buildings such as, hotels, shops, gymnasium (Ministère de la Transition énergétique, 2023). Through dynamic life-cycle approach, the RE2020 proposes an ambitious threshold for embodied carbon emission of 100 $kgCO_2e/m^2$ which favours low-embodied carbon materials, biobased materials, and timber (RE2020, 2020).

Table 7 provides a brief information regarding the thresholds for the construction-related emissions for different types of residential buildings (Ministre de la Transition Écologique, 2021).

Table 10: *Based on RE2020, the thresholds for construction-related emissions of the types of residential buildings*

Building types	**Thresholds ($kgCO_2e/m^2$)**			
	2022	**2025**	**2028**	**2031**
Single-family houses	640	530	475	415
Apartment buildings	740	650	580	490
Offices*	980	810	710	600
Educational buildings *	900	770	680	590

* Source: https://www.actu-environnement.com/ae/news/RE2020-decret-exigences-bureaux-batiments-enseignement-39197.php4

The RE2020 also sets some requirements to control the consumption limits (Bureau Etude Thermique, 2022):

- The annual primary heating consumption of a new building should be less than 12 kWh/m^2 per year.
- The total primary energy consumption is required to be less than 100 kWh/m^2 per year.

An overall renovation roadmap leading to Nearly Zero Energy Buildings has been introduced by the government (Energy and Climate Law, revised in 2019). This strategy addresses the obligatory renovation of existing building stock which has excessive energy consumption and requires that each renovation (deep renovations including staged renovations) is compatible with the roadmap guidance. The renovation obligation is expected to come into force in January 2023. This obligation addresses two building types

with poor energy performance (based on the DPE[3] results) including dwellings and tertiary buildings over 1000 m² (Castellazzi, et al., 2022).

With the adoption of RE2020, France has strengthened labelling and building codes for new construction. The energy performance certificate of buildings, DPE, is based on two main criteria: its primary energy consumption and its GHG emissions. Figure 2 shows the scale of DPE for dwellings.

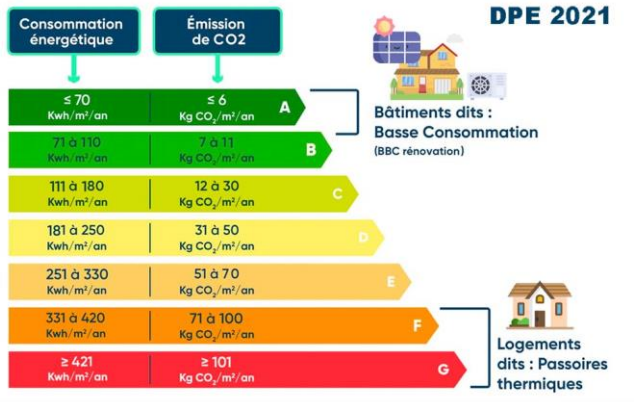
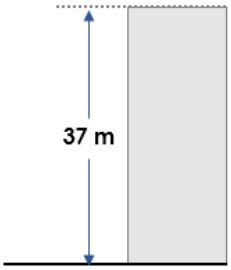


Figure 10: *DPE classification for dwellings (HBS France, 2021)*

Regarding the DPE classification, it should be noted that the building will be classified according to the worst performance between these two thresholds. For example, if the energy consumption of a dwelling is 190 kWh/m² per year but its CO_2 emissions are estimated at 68 $kgCO_2/m^2$ per year, it will be classified E instead of D.

It has been estimated that 17% of the building stock is classified within the F and G, as the worst performing buildings based on the data published by ADEME (MTE, 2020). Therefore, the government is strengthening building codes and labelling efforts, notably through the reformed DPE and the Low Consumption Building Renovation labelling. **The government passed legislation in 2020 detailing its minimum energy performance standards for non-domestic buildings. From 1 January 2030, it will be prohibited to occupy or use any office building without having at least an DPE C rating** (McAllister & Nase, 2023). Starting from 2022, it is required for the dwellings to have mandatory energy audits prior to their sale or rental. From 1 January 2023, it is required a minimum energy performance criterion of 450 kWh/m² year in final energy in the definition of "decent housing". A dwelling cannot be rented if its performance is greater than this threshold (International Energy Agency, 2021).

Paris:
The new local plan, the Plan Local d'Urbanisme (PLU), has adopted in the city and it introduces a height limit for new buildings. Therefore, it allows the construction of the buildings no more than a 37-metre height. With this limitation, the regulation emphasises the challenge on optimising environmental performance of tall buildings due to having both higher energy consumption levels in their operation and embodied carbon intensive design in their construction (Gerrard, 2023).



[3] Diagnostic de Performance Energétique (Energy Performance Diagnosis), is a French EPC. It was introduced in 2006 and is issued for both existing and new buildings (Bordier, et al., 2018).

Germany, with a special focus on Berlin

Decarbonisation

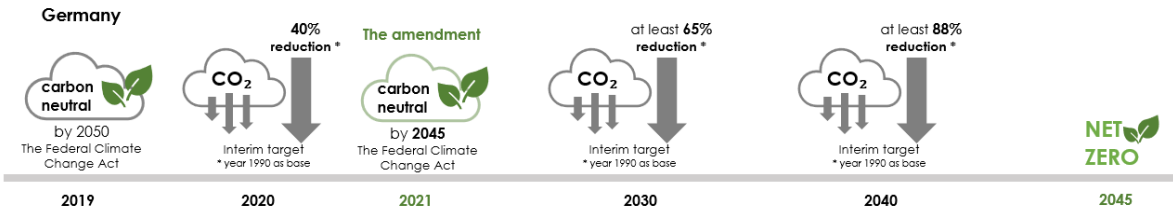


Figure 11

Data source: (BMWK, 2022).

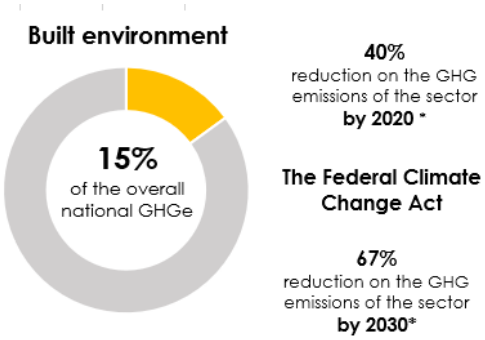


Figure 12

At national level, Germany aims to be carbon neutral by 2045 under the Federal Climate Change Act. **However, Berlin has more ambitious target and has committed to ensure that all new buildings and constructions will be climate-neutral by 2030, and all buildings will be operated net zero by 2050** (JLL, 2022). As an interim, Germany aimed to reduce GHG emissions of the building sector by 40% (comparing the 1990 level) by 2020, however it narrowly achieved this target. The building sector has been the only sector that failed to meet the interim target. Furthermore, the country aims to achieve a 67% reduction in the sector's emission until 2030 (BMWK, 2022). Major efforts are needed to achieve the ambitious reduction targets (DGNB, 2021).

Highlights in the current policy:

- **Energy efficiency:** It is mandatory to have an EPC for new and existing buildings when sold or rented as well as undergo major renovations (Buildings Performance Institute Europe, 2017). **In May 2023, the government has started to regulate energy efficiency targets for buildings. For renovated non-residential buildings, it is required to meet at least EPC C (around 300 kWh/m².a). Regarding new built non-residential buildings, the minimum requirement is EPC B (or A, around 200 kWh/m²a)**

- **Embodied carbon:** There has been a lack of regulations mandating the accounting and reporting of the embodied carbon of buildings at national level, therefore, the practice has been in voluntary basis. The German Sustainable Building Council (DGNB) has set out requirements for accounting embodied carbon (EC) emissions.

Energy efficiency in the current policy: Germany is one of the pioneer countries that has been applying regulations and measures to increase energy efficiency performance of buildings (Economidou, et al., 2020). Like other countries, Germany's existing building stock creates a challenge to reach firm decarbonisation targets. Based on the BMWK report (BMWK, 2022), it is indicated that majority of emissions in the building sector is arising from burning fossil fuels inhibiting Germany to reduce the sector's energy demand. It is therefore imperative that several key measures are undertaken including energy-efficient renovations, increase of electrification (of heating and transport), and growth of renewable energy technologies. To achieve the targets, the Federal Government revised the legal requirements to create a coordinated and single modern law, the German Buildings Energy Act *(Gebäudeenergiegesetz, GEG)* introduced in 2020. The GEG legislation introduces mandatory standards for energy performance of new construction, existing building stock and the use of renewable energy for heating and cooling buildings (Federal Ministry of the Interior and Community, n.d.) (Castellazzi, et al., 2022). Following this regulation, 50% of the energy for heating demand of new buildings is required to be generated by renewable energy sources by 2030 (BMWK, 2022).

> GEG 2023 update - **Energy efficiency in buildings**: The requirements for both new construction and redevelopments to limit the environmental impact of energy demand for heating and hot water. To achieve this, a part of the building's energy supply needs to be covered by renewable energies (Verbraucherzentrale, 2023). From 2023, it is required to install photovoltaic (PV) or solar thermal energy systems for new buildings and existing buildings undergo a major renovation. The installation area should be at least 30% of the gross roof area of the buildings (JLL, 2022).

- EPC classes in Germany are based on a A-H scale with a subclass for class A, A+. It is mandatory to have an EPC for new and existing buildings when sold or rented as well as undergo major renovations (Buildings Performance Institute Europe, 2017). **In May 2023, the government has started to regulate energy efficiency targets for buildings. For renovated non-residential buildings, it is required to meet at least EPC C (around 300 kWh/m².a). Regarding new non-residential buildings, the minimum requirement is EPC B (or A) around 200 kWh/m²a).**

Embodied carbon in the current policy:

There has been a lack of regulations mandating the accounting and reporting of the embodied carbon of buildings at national level, therefore, the practice has been on a voluntary basis. The German Sustainable Building Council (DGNB) has set out requirements for accounting embodied carbon (EC) emissions. Within the voluntary certification, undertaking LCA is mandatory part of the scheme. The DGNB set a reference value for the embodied carbon of the construction as 9.4 $kgCO_2e/m^2a$ (*where a represents 50-year lifetime of buildings, equals to 470 $kgCO_2e/m^2$ for 50 years, 564 $kgCO_2e/m^2$ for 60 years*). The reference value is below the value determined in a study by the German Federal Environment Agency as 10 - 16 $kgCO_2e/m^2a$ (*500 – 800 $kgCO_2e/m^2$ for 50 years*) for new buildings (DGNB, 2021).

The DGNB also developed an assessment and rating system, the BNB assessment[4], to be applicable for only new federal buildings. The assessment system became mandatory in 2011 and it initially focussed on office buildings. The methodology and some parts of it are based on whole building LCA, and brings a certificate based on the performance of the building. The system relies on a national LCA/EPD database, ÖKOBAUDAT -developed by the Federal Ministry for Housing, Urban Development and Building, and bespoke calculation rules. The performance of the building is determined by weighting of scores for different environmental impacts to produce a single overall environment impact score; therefore, it helps to specify performance limits for benchmarking and comparison practices against these limits (AECOM, 2019). After introducing requirements for new federal buildings, the government started to implement LCA requirements for refurbishments for existing federal buildings as well. In line with these, it can be clearly seen that considering the embodied carbon emissions of the buildings is gaining importance at national level. However, the building sector in Germany could not achieve its sectoral reduction targets a second time since 2021 (Bundesministerium für Wirtschaft und Klimaschutz, 2022). Therefore, there is an urgent need to develop strategies to achieve the country's decarbonisation target (Weinfeld, et al., 2023).

There are some external initiatives related to the energy efficiency, including EnerPHit. EnerPHit is a certification programme offered by the *Passivhaus Institut* for retrofitting buildings, that aims to deliver energy efficient buildings. It creates a benchmark for renovations and serves as a guideline for the modernisation of existing buildings by ensuring the buildings have reasonable thermal protection. It can be applied for residential and non-residential buildings (Passive House Institute, 2016).

[4] Bewertungssystem Nachhaltiges Bauen für Bundesgebäude, (https://www.bnb-nachhaltigesbauen.de/en/assessment-system/office-buildings/)

The Netherlands, with a special focus on Amsterdam

Decarbonisation

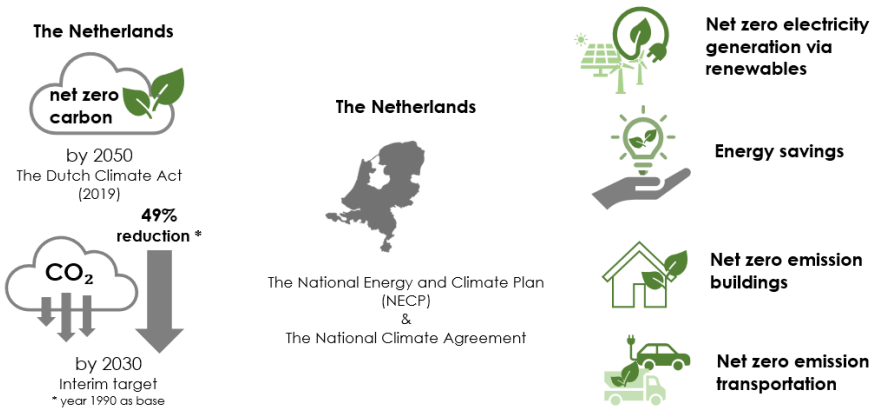


Figure 13

Source: (International Energy Agency, 2021) (The Government of the Netherlands, 2019).

Focus on built environment

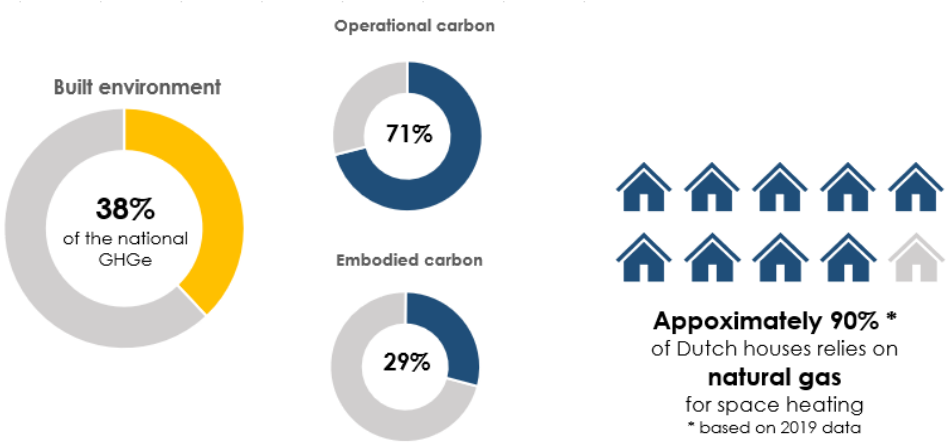


Figure 14

Source: (Fraunhofer ISI, 2022)

In the Netherlands, construction and building regulations are defined under the Building Decree 2012. It sets the minimum requirements in terms of energy efficiency, embodied carbon, health, safety and construction and demolition work for all structures (Rijksdienst voor Ondernemend Nederland, 2022).

Highlights in the current policy:

- **Embodied carbon:** Under the Building Decree 2012, all new residential and new office buildings over 100 m² are required to undertake a whole-building LCA via a national assessment method, MilieuPrestatie Gebouwen (MPG). **The MPG is based**

on a weighting methodology on the environmental categories. Therefore, it specifies building LCA limits based on €/m²/a.

- **Energy efficiency:** The Building Decree has been recast with stricter energy performance requirements which includes the requirement for new buildings owned by the government and ~~house~~ government agencies to be nearly zero energy from December 2018 onwards (Cruchten, 2020).

- **Energy Performance Certificate:** It is mandatory to provide a registered and definitive energy label (EPC rating) for both residential and non-residential buildings to the buyer or tenant in the case of selling or renting the buildings.

- **Limiting values for the energy performance of offices:** It is required for every office building larger than 100 m² to have at least **EPC C** level or above, from January 2023 onwards. This requirement is applicable to existing office buildings as well. **Currently, MEES targets only office buildings at the national context.**

Energy efficiency in the current policy: In addition to the Building Decree, a package of laws and regulations are also applicable for buildings. As from 2019, it is mandatory for companies to report on which energy saving measures they have implemented with a 4-year period (Odyssee-MURE, 2021). Furthermore, in line with the EU EPBD, a national EPC classification is defined. The class range is defined between the A to G, with subclasses for class A (A+++++, A++++, A+++, A++, A+, A).

From 2021, energy labels are based on a new method, the NTA 8800 certification. This method aims to include more details about the energy performance of the buildings and is applicable to both new and existing constructions. The EPC levels are based on the BENG 2 (primary fossil energy consumption, kWh/m²) requirements. The validity of EPC labels currently lasts 10 years (Rijksdienst voor Ondernemend Nederland, 2022). **Currently, it is required for every office building larger than 100 m² to have at least EPC C level or above. Furthermore, the government intends to increase the minimum standard which is projected to be required for all offices to have at least EPC A level by 2030** (McAllister & Nase, 2023).

Despite the ambitious limiting values for the energy performance in office buildings, the research undertaken by Savills Research in 2021 indicates that 11% of the office stock in the Netherlands does not meet this legislation criteria and more than 32% of the office stock has not any energy label at all yet. The report also highlights the speed of sustainability renovations for offices is not in line with the objectives of the government; therefore, it is projected to see more demand for the energy efficient offices than the availability of them in 2023.

Embodied carbon in the current policy: The Netherlands is a pioneer country where embodied carbon was specified under a public policy. Since the Building Decree 2012 came into force in January 2013, it is required to account as well as report embodied

carbon impacts of all new buildings over 100 m². The regulation has not been applicable for renovation and refurbishment works undertaken in existing buildings. To calculate building's environmental profile, a national and standardised assessment method, MilieuPrestatie Gebouwen (MPG), was developed by the government.

The MPG assessment concerns carbon emissions of the use of materials; therefore, it excludes the operational carbon impacts (Module B6) and water use (Module B7). The scope of assessment is specified to cover foundations, floors, supporting structures, façades, roofs and building installations. To undertake embodied carbon assessments, a national EPD database and several tools have been also provided. Therefore, the MPG assessment is limited to materials available in the database.

Figure X shows the process flow of undertaking the MPG assessment method.

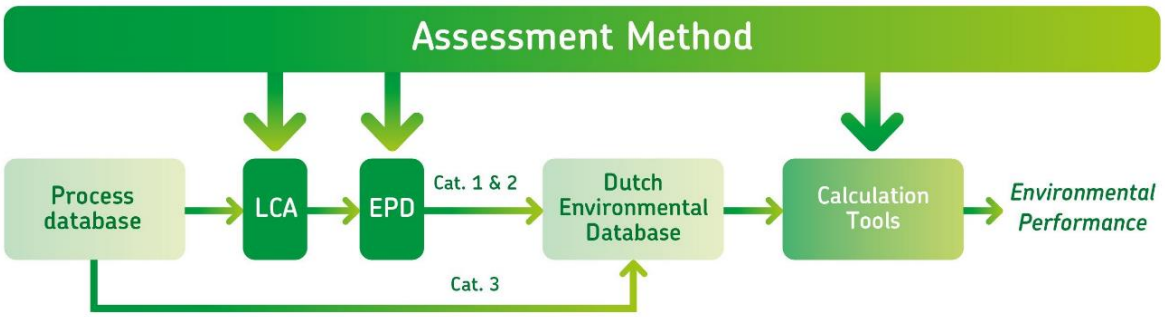


Figure 15 MPG assessment methodology (source: Nationale Milieu Database, 2023)

The MPG, based on a weighting methodology on the environmental categories, assigns the impacts into the shadow price indicator. It specifies building LCA limits within the format of €/m²/a. In 2018, the initial limit value for all buildings was specified as 1.0 €/m²/a. However, in 2021, the limit value was tightened for all residential buildings to 0.8 €/m²/year, while the value stayed the same for office buildings (One Click LCA, 2022).

As an external initiative, DGBC introduced a nationwide plan, *The Paris Proof Commitment: Delta Plan for Sustainable Renovation* in line with the national targets declared within the Paris Climate Agreement in 2015. The main objective of this plan is providing transparency on actual energy use and CO_2 emissions in buildings by monitoring and reporting the actual figures (DGBC, 2020).

In line with the Paris Proof Commitment, DGBC indicated threshold values for some of the building types for new constructions and renovations as an attempt regarding the limiting embodied carbon emissions.

Table 8 shows the limit values for embodied carbon applicable for new constructions (DGBC, 2021).

Table 11: *In line with the Paris Proof structure, embodied carbon thresholds for new constructions*

	Embodied carbon ($kgCO_2e/m^2_{GFA}$)			
Building type	**2021**	**2030**	**2040**	**2050**
Single family home	200	126	75	45
Multi family home	220	139	83	50
Office	250	158	94	56
Retail	260	164	98	59
Industry (distrubition center)	240	151	91	54

Table 9 shows the limit values for embodied carbon applicable for renovations (DGBC, 2021).

Table 12: *In line with the Paris Proof structure, embodied carbon thresholds for renovations*

	Embodied carbon ($kgCO_2e/m^2_{GFA}$)			
Building type	**2021**	**2030**	**2040**	**2050**
Single family home	100	63	38	23
Multi family home	100	63	38	23
Office	125	79	47	28
Retail	125	79	47	28
Industry (distrubition center)	100	63	38	23

Overall, it is highlighted by the Dutch Green Building Council, DGBC, (2021) that the efforts on existing building stock are required to reduce their operational emissions as well as their embodied carbon emissions when undertaking sustainably renovation. Whilst for new constructions, the DGBC advised that the primary focus should be on reducing embodied carbon primarily.

Specific focus on Amsterdam: In 2020, The Climate Neural Roadmap 2050 was published by the City of Amsterdam, Spatial Development and Sustainability (SDS). According to this roadmap, the following areas have been emphasised:

- *Sustainable heating:* There is an urgent need for a shift from dependency on natural gas for space heating to alternative sources for heating to save energy. The city aims to develop a sustainable heat distribution as well as maintaining, extending, and greening the existing heat sources.
- *Energy efficient buildings*: The city is planning to put a tougher set of mandatory instruments, for new built dwellings and offices. As an example, it will be mandatory for all offices in the city to get EPC A rate from 2030 onwards (SDS, 2020).
- *Moving towards circular economy*: The city aims to be a completely circular by 2050; it is believed that moving towards a circular economy helps significantly to reduce CO_2 emissions by increasing the use of recycled and biobased materials in construction (Municipality of Amsterdam, 2020).

Denmark, with a special focus on Copenhagen

Decarbonisation

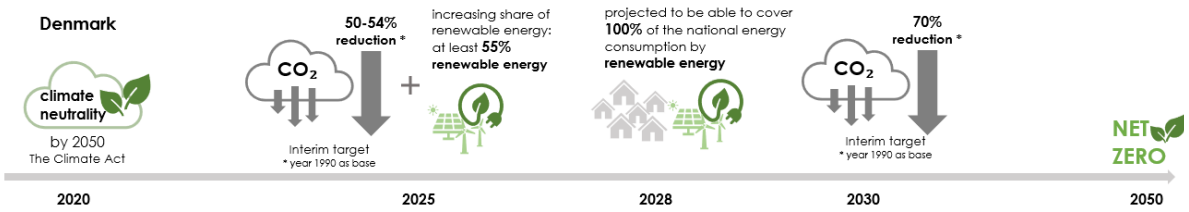


Figure 16

Focus on built environment

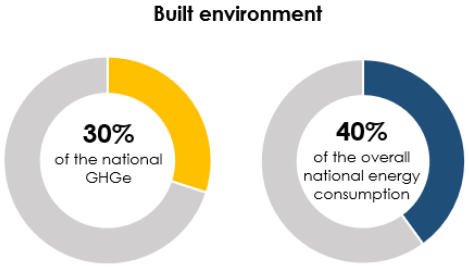


Figure 17

Source: (State of Green, 2022)

Highlights in the current policy:

- **Embodied carbon:** The National Strategy for Sustainable Construction introduced limitations for embodied carbon emissions for; these came into force in 2023. All new buildings required to undertake LCA; yet only large buildings (>1,000 m^2) must meet the limits. New buildings (>1,000 m^2) must comply with a carbon emissions limit of **12 $kgCO_2e/m^2$ per year**

- **Energy efficiency:** The energy efficiency requirements apply to new buildings as well as reconstruction and refurbishment of the existing building stock (Ramussen, 2021).

- **Energy performance certificate of buildings:** It is mandatory to carry out regular energy labelling of buildings. From 2010, it is required for all new buildings to have a minimum **Danish EPC ranking of A** (Nykredit Group and MOE, 2022). However, the minimum energy performance standards for existing buildings (not undertaking renovation) have not been introduced yet (Ramussen, 2021).

> The Building Code 2018 -BR18 is one of the main policy instruments to achieve energy savings and applicable to new construction and renovation works. It is revised every 5 years to align with the technological developments (State of Green, 2022).

> The 2020 Green Housing Agreement, launched in May 2020, highlights the comprehensive refurbishment measures specifically prepared for the council housing sector (Danish Ministry of the Interior and Housing, 2021).

Energy efficiency in buildings, the current policy:

Approximately 25% of the energy consumption in existing buildings is used for space heating and hot water. Thus, enhancing the energy performance of the existing building stock becomes important measure to achieve the green transition. Within this aim, the Danish government has set ambitious energy policies and measures. In the context of the BR18, **it is required for renovations in existing buildings to reduce the need for energy supply by minimum 30 kWh/m² per year. There are two categories (Renovation Class 1, and Renovation Class 2) within this framework. Table X shows energy performance framework for renovation of existing office buildings.**

Table 13: *Energy performance framework for existing buildings undertaking renovation*

Offices, schools, institutions, etc.	kWh/m² per year + kWh/year per heated floor area	Energy Label (EPC)
Renovation Class 1	71.3 + 1650	A2020
Renovation Class 2	135 + 3200	C

Table adapted from Kiviste, Musakka, Ruus, & Vinha (2023) and Ministry of Transport, Building and Housing (2018).

In addition, renewable energy must constitute part of the total energy supply in both new and existing buildings (except for listed buildings, churches, and building worthy of preservation) in the case of this is technically possible and financially viable (Ministry of Transport, Building and Housing, 2018) (Kiviste, et al., 2023).

As a part of these measures, EPCs or Energy Labelling has been used in Denmark since 2006 in accordance with the EU EPBD, and it is mandatory to have an EPC for (i) sale and rental of buildings, (ii) new buildings, and (iii) public buildings greater than 250 m² usable floor area (State of Green, 2022). These are valid for 10 years in Denmark (JLL, 2022). In addition, EPCs with building-specific data are required to be publicly available online. Based on the recent data, half of the building stock in Denmark already has EPC (State of Green, 2022).

Embodied carbon in the current policy:

Within the aim of reducing environmental impacts of the built environment, the Danish Ministry of Interior and Housing has launched the national strategy, the National Strategy for Sustainable Construction, in April 2021. It aims to tightening targets for operational carbon emissions and introduce limits for embodied carbon emissions for buildings. The strategy makes previous voluntary regulations into mandatory and strict ones from 2023 onwards. Denmark entered a new phase in 2023, becoming a pioneer country which

introduces mandatory embodied carbon limits into the regulations (Danish Ministry of the Interior and Housing, 2021).

The Danish strategy requires to undertake an LCA calculation for buildings below 1,000 m^2, without a threshold limit for whole life carbon emissions (CO_2e). However, for larger buildings (>1,000 m^2), an LCA is required as well as meeting the threshold limits. The strategy has a step-by-step phasing for the limits. The initial limit value is 12 $kgCO_2e/m^2$/year. Currently, the strategy is applicable only for new buildings no matter the building type is (Danish Ministry of the Interior and Housing, 2021).

Figure 20 shows the step-by-step phasing and scaling up of CO_2 requirements.

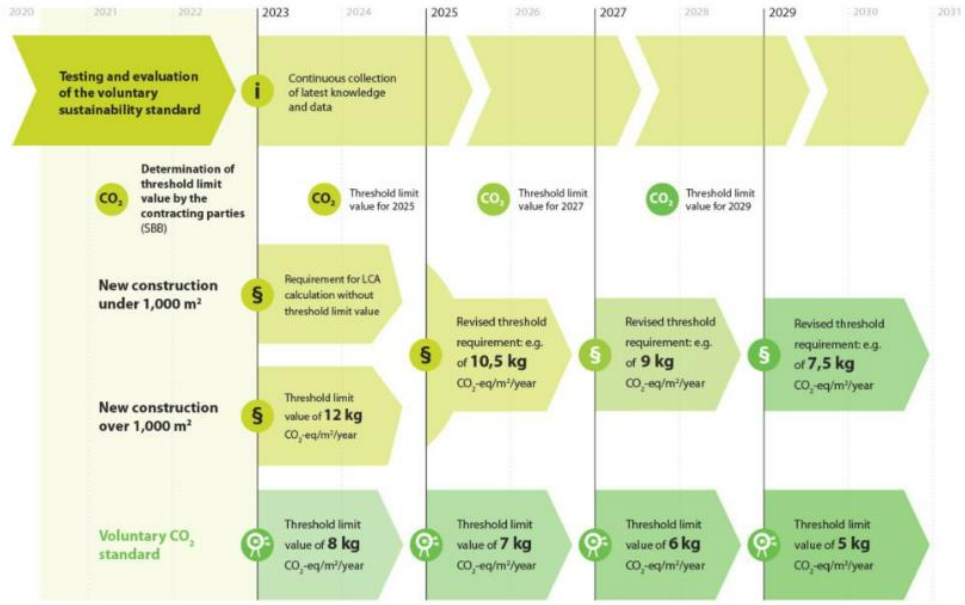


Figure 18: *Step-by-step phasing and scaling up of CO2 requirements within the National Strategy for Sustainable Construction, Source: Buro Happold and Danish Ministry of the Interior and Housing (2021).*

> It should be noted that not all modules in an LCA calculation must be calculated and documented in compliance with the requirement. The LCA methodology in Denmark, Bygningsreglement, only covers *Module A1-A3, Module B4, Module B6, Module C3-C4, and Module D.* Module D should be reported, although it should not be included in compliance with the limit value for buildings over 1,000 m^2 (Bygningsreglement, n.d.).

The Danish government stated the importance of the development of a national LCA and LCC calculation tools to present the complex results of the analyses in a user-friendly and transparent way to help reduce lifecycle impacts of buildings. The first versions of LCAbyg and LCCbyg were launched in 2015 (Rasmussen & Birgisdottir, 2016). Primarily, LCAbyg is used for new constructions. The recent updated version, LCAbyg 5.0, provides users to compare renovation measures. On the other hand, it is also promoted by the government to develop a national material database by covering both generic data representing typical materials used in Denmark and material specific data, such as EPDs in the Danish construction industry within the aim of conducting better LCA (Danish Ministry of the Interior and Housing, 2021).

Copenhagen:

As a metropolis and capital of Denmark, Copenhagen aims to be the world's first carbon neutral capital city by 2025; therefore, the city council prepared the 'Copenhagen 2025 Climate Plan' to achieve this aim. The climate plan presents 5 main categories, namely energy consumption, energy production, green mobility, incentives, economy, and investments; then it outlines major goals for each category.

Figure 21 shows the major goals regarding the energy consumption specified in the plan.

Figure 19

To achieve the city's ambitious goal, the city council also highlights that there is a need for cooperation between authorities, companies, knowledge institutions as well as people living in Copenhagen. Energispring, as a part of the Copenhagen 2025 Climate Plan, is a partnership between large building owners, administrators, and interest organizations in Copenhagen. The partners represent 26% of the total building stock in the city. This partnership involves a confidential sharing of data to create a benchmark for heat consumption as well as promote energy efficient operation and renovations (Energispring, n.d.). **However, Copenhagen is unlikely to achieve its net zero pledge mainly due to its reliance on immature technology hindering the adaptation and installation of carbon capture and storage (CCS) systems. The installation of these systems was supposed to reduce 20% of the city's emissions, whereas the rest of it was projected to be reduced by switching its power and district heating systems to biomass, wind and solar, renovating buildings to make them energy efficient and improving public transport** (Christiansen & Hougaard, 2022)**. The company which is appointed for the installation of the CCS technology failed to meet the requirements to be eligible for state funding. Although Copenhagen could not meet its objective, Denmark keeps its leadership position in decarbonisation among other countries** (Szumski, 2022)**.**

Regarding the circularity, Copenhagen has an ambitious plan for waste and resource management, called as Circular Copenhagen, which aims to bring the circular economy into practice. Within this plan, overall targets include 1) reaching 70% recycling of municipal solid waste by 2024, 2) tripling reuse rate in 2024 from 2018 levels, and 3) achieving 59,000 tonnes CO_2e reduction in line with the city's decarbonisation targets (Circular Cities Declaration, n.d.).

United Kingdom, with a focus on London

In response to the climate emergency, the UK government prepared the UK Climate Change Act, and it passed in the parliament in November 2008. The act was the first national framework legislation in the world to be prepared for providing a comprehensive and overarching law for climate change mitigation and adaptation. It set legally binding emission reduction target including 80% reduction by 2050, based on 1990's levels. In 2019, this target was updated with a more ambitious agenda, which now requires the state to reach net zero by 2050, across all sectors as long-term goal (CCC, 2020).

The act also comprises of short-term goals that set legally binding limits over five-year periods, called as carbon budgets (see **Figure X**)

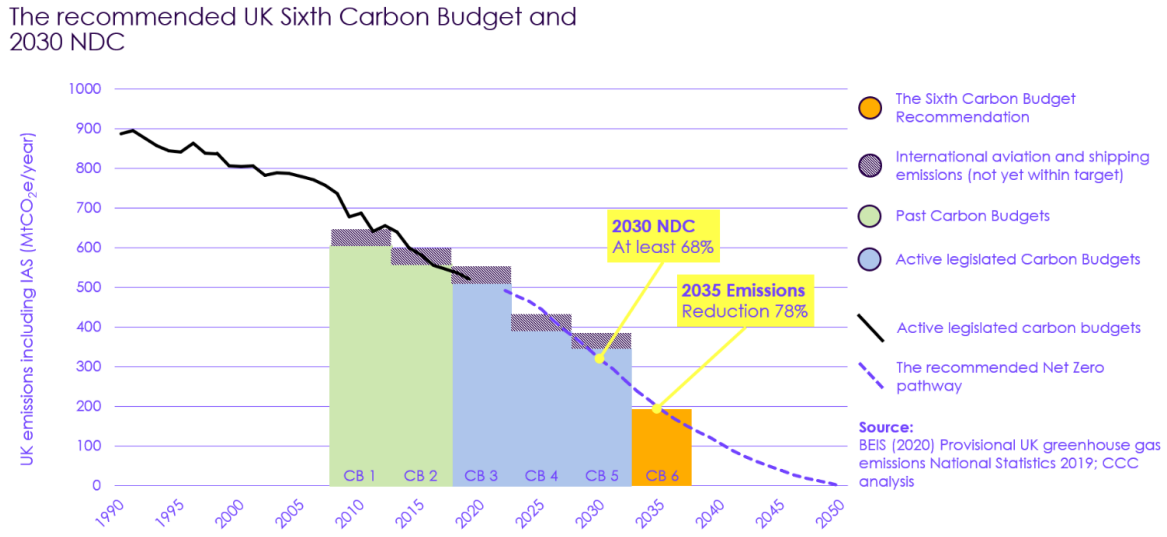


Figure 20: *The UK's carbon budgets and the recommended sixth carbon budget (BEIS, 2020)*

As mentioned in the Section 1, the built environment (buildings and infrastructures) is responsible for 25% of the UK's GHG emissions (UKGBC, 2021).

The heating demand for buildings in the UK is one of the main sources of the national GHG emissions; it accounts for approximately one third of the annual carbon footprint of the UK. For this reason, there is urgency to primarily decarbonise and electrify the heating systems in buildings through retrofit.

Both new and existing buildings in the UK are required to be decarbonised by adopting energy efficiency measurements such as phasing out fossil fuel based heating systems as well as accelerating the shift to using electricity for heating demand, introducing heating systems powered by renewables, and integrating smart technologies in order to facilitate for achieving the UK's 2050 net zero emission goal (HM Government, 2021) (UKGBC, 2021).

Highlights in the current policy:

- **Energy efficiency:** It is mandatory to meet minimum energy efficiency standards (MEES) for all both privately rented domestic and non-domestic buildings by requiring landlords to obtain at least an EPC E rating. **As a future regulatory target for the non-domestic buildings, it is required to have a minimum rating of EPC C by 2027 and EPC B by 2030.**

- **Embodied carbon:** The National Building Regulations 2010 has not regulated the whole life cycle emissions of buildings yet. However, Part Z, an industry-proposed amendment to the regulations, was proposed in 2022 outlining potential requirements for the assessment of whole life carbon emissions and limiting of embodied carbon emissions for all major building projects. These regulations are currently under consultation and are expected to be introduced as mandatory requirements by the government in December 2023 (Environental Audit Committee, 2022).

Energy efficiency in the current policy:

The standards were introduced by the UK government to increase the energy efficiency of the worst-performing privately rented buildings and ensure the quality and thermal comfort for occupants. Since 2008, the minimum energy efficiency standards (MEESs) require all properties across the UK to report on their EPC rating, using A-to-G rating scheme. The regulations came into force in April 2018 for both privately rented domestic and non-domestic buildings by requiring landlords to obtain at least an EPC E rating. In 2021's government consultation, it was proposed a future regulatory target for the non-domestic buildings to have a minimum rating of EPC C by 2027 and EPC B by 2030. The Government confirmed that the future trajectory for the non-domestic MEES will be EPC B by 2030 (HM Government, 2020).

Focussing on operational energy performance of buildings, some of the key policies and regulations at national level are summarised in the **Table 11** below:

Table 14: *Summary of key policies and regulations in the UK*

Key policies and regulations	Adopted Year	Brief explanation
Minimum Energy Efficiency Standards (MEES) Regulations	2008	A future regulatory target for the non-domestic buildings to have a minimum rating of EPC C by 2027 and EPC B by 2030. [1].
Future Buildings Standard (FBS)	2025 *anticipated to be adopted*	Aiming to deliver highly energy efficient non-domestic buildings by using low carbon heating. Primary focus is new buildings, but it includes policy regarding works to be undertaken on existing buildings [2]. It is expected to come in to effect from 2025.
Building Regulations - Part L Interim Uplift 2021 for Existing and New Non-Domestic buildings	2021	An uplift to the energy efficiency standards for existing and new non-domestic buildings. It came into force in June 2022. • Fabric-first approach focussing to improve insulation and airtightness by targeting a 27% reduction in carbon emissions [3]. • The introduction of a new metric, 'primary energy' to place more emphasis on reducing energy demand and on-site renewable energy generation [4].

Building Regulations - Part L Interim Uplift 2021 for Existing and New Domestic buildings	2021	An uplift to the energy efficiency standards for existing and new domestic buildings. • Fabric-first approach focussing to improve insulation and airtightness [3]. • Introducing the requirement of PV installation to be 40% of building foundation area for new domestic buildings [3]. • Moving away from fossil fuel-based heating: no gas boilers accepted moving forward to.
PAS 2038:2021 Retrofitting non-domestic buildings for improved energy efficiency	2021	Setting out requirements for retrofitting non-domestic buildings for improved energy performance. Except for dwellings, it covers all commercial and non-domestic buildings as well as multi-residential buildings where some facilities are available for communal use. It promotes to undertake a 'whole building' retrofit process therefore, it represents a significant milestone to accelerate the uptake of energy efficient retrofits [5]

[1] (HM Government, 2020)
[2] (RIBA, 2022)
[3] (Grainger & Morris, 2021)
[4] (City of London Corporation, 2023)
[5] (BSI Knowledge, 2021)

Embodied carbon in the current policy:

It should be noted that decarbonising the built environment requires to take measures focused on the entire lifecycle of buildings, with the aim to reduce not only operational carbon emissions, but also embodied carbon emissions. Despite this acknowledgement, the UK government has yet to introduce mandatory requirements to undertake whole life carbon (WLC) assessment for buildings in line with other European countries such as the Netherlands, Denmark, and France. Currently, the UK government is working on finalising the evaluation of different methodologies employed by these countries to develop future policies regarding WLC assessments, and these mandatory regulations (Part Z) are expected to be introduced by the government in December 2023. Although there is a lack of mandatory requirement to undertake WLC assessments at national level now, local authorises, such as the Greater London Authority, are currently mandating it for the projects being proposed within their jurisdictions (Environental Audit Committee, 2022).

Greater London Authority (GLA)

The GLA has set several requirements that are aligned and possibly more ambitious than national regulation with the intent of delivering low carbon and net zero developments. Although these are not a national regulation, it is currently the only policy in force in the UK that delivers effective results, and which affects a big proportion of the country's population. The GLA has set an example to follow and is often used as a comparable benchmark across the UK.

The Mayor of London's London Plan 2021 requires proposals referable to the MGLA to be net zero carbon. Within the aim of minimising carbon emissions, the London Plan Policy SI 2 sets out the strategies for GLA referable projects. Within this policy, Part F requires development proposals referable to the GLA should calculate whole life-cycle carbon emissions through a nationally recognised whole life cycle carbon assessment and

demonstrate actions taken to reduce life-cycle carbon emissions. There is a separate GLA (London Plan) policy guidance document - Whole Life Cycle Carbon Assessments (WLCA) Guidance, March 2022 - which sets out the requirements applicants must undertake. Reporting requirements and the scope of the assessment are defined in the London Plan Guidance for WLCA (Greater London Authority, 2022). Although WLCA reporting is required at pre-application, application, and post-completion stages of schemes that are referable to the GLA, it is also encouraged for all non-referable major developments. All studies account for a 60-year life-cycle period, as standard. Provisions for a different assessment period can be established if accompanying explanations are provided.

As recognised an industry leading guidance, it contains a detailed methodology and list of information to be included for materials across several Life Cycle Assessment (LCA) modules as well as including requirements for reporting emissions for demolition of existing assets on site and from refrigerants.

The Mayor of London's London Plan 2021 sets out a clear energy hierarchy for net zero operational carbon emissions. It defines the process required for reducing these emissions, clarifying local priorities for heating, and cooling strategies, setting minimum target savings and local carbon offsetting mechanisms. The carbon savings targets are based on regulated operational carbon and a 30-year lifecycle. It is targeted with at least a 35% on-site reduction in regulated carbon emissions beyond Part L 2021 of the Building Regulations. On the other hand, reporting unregulated carbon is encouraged through the design process and building infrastructure provision. Other policy requirements are in place for on-site energy generation and energy storage.

The Mayor of London's 'Energy Assessment Guidance, published in June 2022, clearly outlines reporting requirements for planning applications to demonstrate that the proposed climate change mitigation measures comply with London Plan energy policies, including the energy hierarchy and energy performance metrics in terms of Energy Use Intensity for regulated emissions (EUI). It also introduces a new 'be seen' stage to calculate whole building EUI (including unregulated emission), to monitor and report its energy performance post-construction. This will help to ensure that the actual carbon performance of the development is aligned with the Mayor's net zero carbon target.

The 'Be Seen Energy Monitoring Guidance', (September 2021) explains the process that needs to be followed and reporting requirements to demonstrate compliance with the London Plan policy addressing the monitoring, verifying, and reporting of energy performance after a building's practical completion ('Be Seen' level of the Energy Hierarchy). It also requires undertaking analysis for regulated and unregulated energy loads using a process such as TM54 (it is aligned with the London Plan guidance for 'Whole Life-cycle Carbon Assessments (WLCA)' module B6 approach.

Greater Manchester Combined Authority (GMCA) and Manchester City

In response to the national call for tackling climate change (UK Climate Change Act, 2008), Manchester, as one of the pioneer cities in the UK, launched a city level plan for climate action in 2009, called Manchester: A Certain Future. Between 2010 and 2020,

direct carbon emissions of the city were successfully reduced by 54.7% with exceeding the target (41%) specified within the agenda. However, reports from the Intergovernmental Panel on Climate Change Summit showed that delaying global carbon reductions was projected to be resulted catastrophic impacts on climate; therefore, highlighted a drastic shift on global targets (Manchester City Council, 2023). As a response to this, Manchester strengthened its commitment by revising its zero-carbon target from 2050 to 2038 and declared a climate emergency, Climate Change Action Plan, in 2019 by highlighting six priority areas for action, namely (i) buildings, (ii) renewable energy, (iii) transport and flying, (iv) food, (v) consumption behaviour, and (vi) green infrastructure and nature-based solutions (Manchester Climate Change Agency, 2020).

Within the Climate Change Action Plan, the city council has also developed some standards and strategies. As one of them, the Manchester Low Carbon Build Standard is in line with the best practice guidance from the BRE and the RIBA and aims to reduce the carbon impact of both new-build developments and retrofit projects delivered by the council. This was endorsed in December 2020 and accepted as a key action to help move towards the council's 2023 target (Manchester City Council, 2020).

As the second biggest source of carbon emissions, after transportation, the built environment is responsible for 76% of Manchester's direct emissions (Manchester Climate Change Agency, 2022). Therefore, it is required for urgent actions on decarbonising of building sector. The city is committed to achieve carbon neutrality from 2023 only for new buildings, and 2038 for all buildings. Given the city's existing building stock, in July 2021, the council introduced the Greater Manchester Retrofit Task Force to reach an average of 61,000 domestic retrofits a year and an average of Energy Performance Certificate Rating C or Display Energy Certificate B on all non-domestic buildings by 2030 (Greater Manchester Combined Authority, 2021). The recent figures show that 26% of the city's carbon emissions are from domestic buildings and 51% of them are energy inefficient with an EPC rating D-G, based on the cumulative data between 2008-2022[5] (Department for Levelling Up, Housing & Communities, 2023). Most domestic carbon emissions (71%) come from space heating and hot water. In terms of commercial buildings' emissions, this rate is 48%. Given these, the city policies have been focussing on energy efficient retrofits and highlighting the need for a shift to electrified heating (Manchester Climate Change Agency, 2022).

In line with the city's decarbonisation strategy, a roadmap to net zero carbon in the context of new buildings has been prepared in 2021 and it highlights a new Manchester Standard 2023. Based on this new standard, it is restricted for all new developments to have onsite combustion of fossil fuel. To promote low-carbon energy supply, it is required for all developments to assess the viability of onsite renewable generation. There is a minimum requirement of 40% solar technologies installation for the developments with SE/SW facing roof(s) (Manchester Climate Change Agency, 2021). ***Table 12*** *highlights the targets specified in the Manchester Standard 2023.*

Table 15: *Targets in the Manchester Standard 2023*

To reduce	Domestic targets	Non-domestic targets

[5] The information is based on the number of EPCs lodged on the Register by Local Authority, and by Energy Efficiency Rating (EER).

Energy demand	• Energy Use Intensity (EUI) < 60 kWh/m^2 GIA/yr *(covering both regulated and unregulated consumption)* • Ultra-high energy efficiency consistent with space heating demand of 15-20 kWh/m^2/yr	• Office developments only, Energy Use Intensity (EUI) < 75 kWh/m^2 GIA/yr from 2023. • *For other building types, targets are not currently available.*
Embodied carbon	• Major developments, Upfront embodied carbon < 500 kgCO_2e/m^2 GIA	• Office developments, Upfront embodied carbon < 600 kgCO_2e/m^2 GIA (excl. sequestration) with future uplift set out in advance • Retail developments, Upfront embodied carbon < 550 kgCO_2e/m^2 GIA, with future uplift set out in advance • *For other building types, targets are not currently available.*
Further information: https://www.manchesterclimate.com/sites/default/files/Roadmap%20to%20Net%20Zero%20Carbon%20-%20Report.pdf		

West of England Combined Authority (WECA)

The West of England Combined Authority (WECA) consists of four local authorities which include Bath and North East Somerset Council, Bristol City Council, North Somerset Council, and South Gloucestershire Council. The WECA has set an ambitious plan targeting to reach net zero carbon by 2030. In September 2020, the authority prepared an action plan, Climate Emergency Action Plan, to achieve this target (WECA, 2020).

As outlined in the action plan, the built environment is one of the largest contributors to GHG emissions in the region. It is especially stemming from the energy source used for meeting the heating demand in buildings. Therefore, the main focus in retrofitting policy is increasing the energy performance of buildings by reducing the reliance on fossil-fuel based heating, and accelerating the installation of low carbon, energy efficient heating systems. In addition, the authority is planning to mandate to achieve at least EPC C rating for retrofit projects as a medium-term action between 2024-2028. It is also required for new developments and existing buildings that projected to have a retrofit/refurbishment process to deliver 10% Biodiversity Net Gain from early 2023 (WECA, 2022). To support the retrofit targets, is the action plan outlines the need to improve the available retrofit skills that currently rely on small and micro businesses in the region (WECA, 2023).

With regard to the embodied carbon, the WECA are working on introducing the whole life cycle carbon assessments as a part of future policy in each authority's local plan (Bath & North East Somerset Council, 2021).

Bath and North East Somerset Council (B&NES)

In line with the UK National Planning Policy, the B&NES outlined the strategies to support the national commitments towards a low carbon future and has declared a climate emergency. The B&NES council has committed to be carbon neutral by 2030 and aims to lead the decarbonisation journey within the WECA district (Bath and North East Somerset Council, 2021). To reach this target, some of the local policies have been established. These are outlined in the **Table 13**.

Table 16: *Examples of local policies regarding the decarbonisation aim*

	Subcategories	Highlights
Core Strategy	CP1- Retrofitting Existing Buildings	The policy highlights retrofitting of energy efficiency measures and encourages the appropriate use of micro-renewables in historic buildings. • Requirement to reduce regulated carbon emissions by 10-20% (*still in consultation process*) from a baseline of Part L through use of renewable energy. • Requirement to achieve EPC C rating or above when change of use to House of Multiple Occupation (HMOs).
	CP2- Sustainable Construction	The policy brings a requirement to maximise energy efficiency in new buildings. It is in line with the planned implementation of the Future Homes Standard (FHS). In case FHS is not implemented, the policy introduces the following requirements for residential (R) and non-residential buildings (NR): • A minimum operational carbon emissions reduction of 10% (R) and 15% (NR) through fabric performance from a baseline of Part L 2013, • A minimum operational carbon reduction of 35% through on-site renewable energy for both R and NR • Offsetting remaining operational emissions that can't be mitigated on site through a financial contribution (applicable for R and NR)
	CP3- Renewable Energy	This policy sets minimum level of renewable electricity and heat generation levels to achieve by 2029.
Placemaking Plan	SCR1- On-site Renewable Energy Requirement	In line with the CP2, SCR1 brings a requirement to maximise energy efficiency in all major developments (10 dwelling units/1,000 m^2 or more of floor space) by providing sufficient renewable energy generation to reduce carbon emissions. The rest of the policies outline the issues that required to be addressed within the developments.
	SCR2- Roof-mounted/Building-integrated Scale Solar PV	
	SCR3- Ground-mounted Solar Arrays	
	SCR4- Community Renewable Energy Schemes	
	Whole Life Cycle Carbon Assessment	This is a new policy introducing requirements for reducing whole life cycle carbon emissions of new buildings (*still in consultation*). Therefore, it is required for the following developments: • For large scale developments (more than 50 dwellings/5,000 m^2 or more of floor space) • For all major developments (10 dwelling units/1,000 m^2 or more of non-residential floor space).

Source: Bath & North East Somerset Council, Development Management Policies
https://beta.bathnes.gov.uk/local-plan-core-strategy-and-placemaking-plan-partial-update/development-management-policies

The new Local Plan encompasses requirements focused on embodied carbon assessment. It requires to attention on only for Substructure, Superstructure and Finishes among the building elements due to their high share of emissions. The Plan also advocates to have early involvement and discussion about embodied carbon at early design stages. Lastly, it also highlights the need for the availability of comprehensive databases to undertake accurate assessments. Within this policy (SCR8), it is required for large scale new-build developments to submit an embodied carbon assessment and comply with the newly introduced threshold limit of 900 $kgCO_2e/m^2$ (covering the embodied carbon impacts of substructure, superstructure, and finishes).