ARUP

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Tall Buildings: Rising to the Net Zero Challenge

A pathway to a sustainable future with reference to London and New York

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City of London Corporation
Foreword

London and New York are two great global cities. Through film and popular culture, the skylines of Lower Manhattan and the City of London are instantly recognisable to millions of people; many of whom may not have even set foot in them.

Tall buildings form an integral part of their international profiles. But more than hollow emblems, they are the engine rooms of growth and prosperity for the US and UK's economies in areas such as finance, technology and other knowledge intensive sectors.

By facilitating high levels of employment density, tall buildings have sustained the agglomeration benefits in our respective business districts for many decades. These include innovation, knowledge transfer and highly skilled jobs, resulting in better pay for City workers. The excellent infrastructure of public transport in The City and Lower Manhattan means too, that Greater London and New York are more sustainable than their car-dependent rivals, as the public transport networks account for the majority of journeys into and out of these centres.

But as this report makes clear, as with many world cities, London and New York face major long-term challenges - not just in economic terms - but in ensuring we can deliver long term, sustainable futures. Whilst there are differences in approach and timelines, Arup's analysis highlights that city governments in both jurisdictions have assembled an ambitious set of policies and programmes designed to tackle carbon emissions and help to deliver on "Net Zero".

Reducing the net impact of carbon associated with the construction, refurbishment and operation of real estate - in both the public and private sectors - is integral to tackling environmental concerns. That is why the City of London's Climate Action Plan has put improving the sustainable performance of buildings, at its heart. We are confident in our targets to reach Net Zero for both embodied and operational carbon emissions by 2040 - ten years earlier than national planning goals. From the introduction of Carbon Options Guidance on the whole life carbon impacts of building redevelopment, to a pioneering 50-megawatt sustainable power purchase agreement, or our skills for a sustainable skyline initiative, the City is proud to be at the forefront of ensuring it delivers on its promises to become more sustainable and in turn, an increasingly attractive place to work and invest.

As businesses increasingly look to play their part in securing sustainable growth and prosperity for all parts of the country, the City of London stands ready with its Business Improvement Districts, the City Property Association and its entire community of workers, residents and visitors, to secure the long-term sustainable future of the central London economy. By detailing New York City's experiences in this sphere, this report makes an important contribution to helping us understand how we can do that even better. It perhaps too has some ideas for our greatest global city rival and friends across the pond.

Deputy Shravan Joshi MBE
Chairman, City of London Planning & Transportation Committee

EC BID
Foreword

The tower cluster in the City of London and the one in Lower Manhattan are internationally recognised centres of commerce, innovation, and economic growth. Despite occupying relatively small land masses, both areas punch well above their weight. The Eastern City tower cluster is home to over 80,000 jobs with economic output in excess of £11 billion per annum.

While there is rightly much talk about the economic strength of the Square Mile, and these awe-inspiring vertical communities we have created, we must also face up to the impact they have on the environment. For those of us involved in shaping the future of this unique part of the City I think we have duty to ensure the positive opportunities outweigh the negative impacts.

Just as the City has been at the heart of the global financial services innovation for decades, companies in our footprint are now driving the ESG agenda across the financial and other knowledge intensive sectors. Our growing Fintech economy will have a crucial role to play in achieving net zero goals and spurring green finance innovation. More broadly across other sectors, having strong green credentials is not just a nice to have, but is crucial to retaining talent, supporting employee wellbeing and is good for business.

EC BID is well placed to foster this growth and enterprise, encouraging new ideas, greater collaboration, sharing success and attracting new occupiers. Through an ambitious delivery plan, our aim is to create a more sustainable, agile City with a greater sense of social purpose. In delivering this work we must also hold a mirror up to ourselves, and scrutinise the impacts of our commercial activities, operations and bricks and mortar.

Our work must be insight led. The upcoming commissioning of a long-term public realm vision, where the BID will work with our partners at the City of London Corporation to enhance and create more green spaces across the EC area, providing valued space for people and nature, is an important step. So too are reports such as this one. Through a focused insights programme, we are determined to understand the scale of the challenges, and indeed the opportunities.

I'd like to thank the Arup team for their work on this report, which provides us with some very clear next steps as we continue to work together on the path to net zero. One of the recommendations is for the businesses within the tall building cluster to work together to boost climate resilience, whilst ensuring the area continues to be a thriving economic hub. Here the BID has a big role to play. I would add that maintaining the economic sustainability of this area must remain a priority for us all - this will enable us to achieve our ESG goals, and wider economic benefits will be felt far beyond our boundaries.

Ultimately, this is about arming ourselves so we can act and work collectively with our business community, public sector partners and other global cities, such as New York, sharing ideas and innovations to tackle what is surely one of the biggest challenges facing the world.

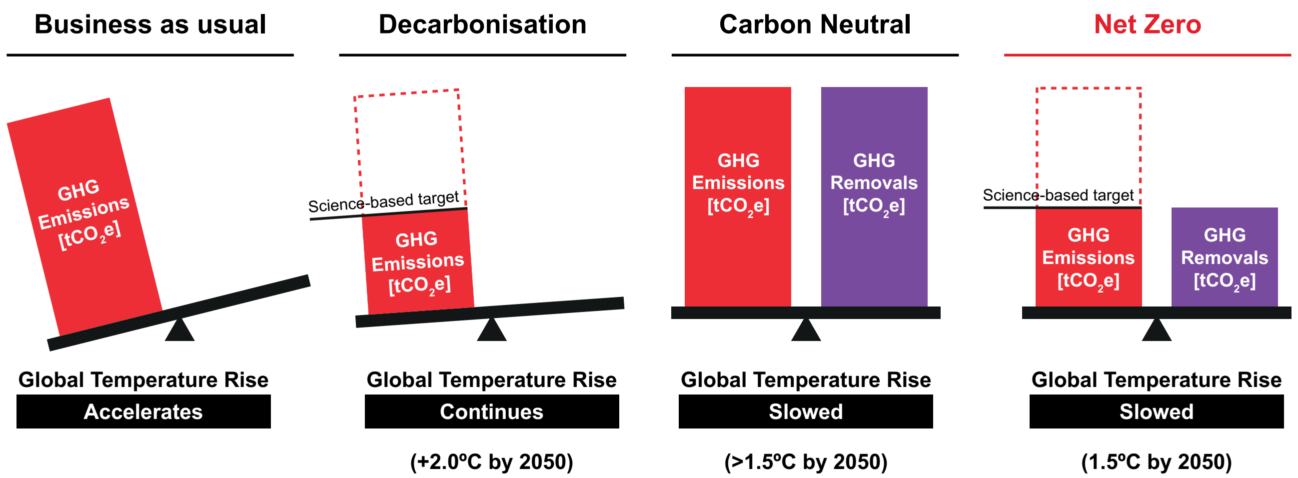
Nick Carty
Chair, EC BID

Executive summary

London and New York are known globally as centres of international finance, business, and commerce, attracting people from all over the world for both work and leisure. They both possess two of the most famous city skylines in the world largely made up of tall buildings.

This report explores the key opportunities for the tall building clusters in the leading business hubs of Lower Manhattan and the City of London, to become more environmentally sustainable and to deliver on the net zero challenge. In this way they can maintain their positions as leading resilient centres of growth and productivity for many years to come.

Net Zero is the first milestone that we need to globally achieve to mitigate the impacts of climate change. It is important that a consistent terminology associated with Net Zero is adopted. For the purpose of this report, the definitions are based on generally accepted industry best practice.



Business as Usual	Business As Usual (or Do Nothing or Climate Inaction) assumes that there will be no significant change in people's attitudes and priorities, or no major changes in technology, economics, or policies, so that normal circumstances can be expected to continue unchanged.
Reduction	Reduction is where the sum of all Greenhouse Gas (GHG) emissions has been reduced below a science-based target in alignment with the Paris Agreement of limiting global temperatures to 1.5˚C above pre-industrial levels.
Carbon Neutral	Carbon Neutral is where the sum of all related Greenhouse Gas (GHG) emissions has been balanced with responsible offsets.
Net Zero	Net Zero is where all related Greenhouse Gas (GHG) emissions have been reduced, beyond science-based target in alignment with the Paris Agreement of limiting global temperatures to 1.5˚C above pre-industrial levels. These residual emissions are subsequently responsibly offset to achieve a sum total of zero emissions.

Science-based targets provide a clearly defined pathway for governments, industries, companies, projects, and individuals to reduce Greenhouse Gas (GHG) emissions, to meet the goals of the Paris Agreement to limit global temperatures rises to 1.5˚C above pre-industrial levels.

Improving the resilience and sustainability credentials of our building - demonstrating how they meet science-based targets - adds to their marketability and value[1]. This can drive change.

Tall building clusters in Lower Manhattan and the City of London are internationally recognised centres of commerce, innovation and economic growth, making major contributions to the GDP of their respective regions and countries.

London	New York
The City in London makes up 0.001% of the UK's area but accounts for 4% of the country's total GVA[1].	Lower Manhattan makes up less than 1% of New York's area but generates close to 10% of its GDP and jobs[2].

Tall buildings present different sustainability and environmental challenges than their shorter neighbours. Tall buildings require a higher investment of embodied carbon to construct than less tall buildings - due to the more onerous structural performance requirements, vertical transportation space and operation requirements, as well as the need to support increased building weight.

At key milestones when decision making for the future of the building is taking place, tall buildings will usually always be kept and refurbished, whereas for shorter buildings the arguments for and against demolition can be much more balanced. This is typically since the taller the building, the greater the demolition emissions and the greater the emissions for building new. Hence, the embodied carbon in existing tall buildings could be considered a valuable environmental and economic asset which shouldn't be discarded lightly.

But tall buildings bring benefits in terms of agglomeration[4]. Whilst other forms of high density development can do the same, it is notable that the City of London is the most productive location in the UK. Lower Manhattan's position is not dissimilar; it represents just one percent of NYC's land area but almost 10% of the city's economic output[3].

For both clusters the key environmental and sustainability challenges are also similar. To make meaningful impact and ensure tall buildings are fit for the future, there is a need to:

1. Increase retrofit feasibility for existing tall buildings:

   – reduce operational carbon.

   – eliminate the use of fossil fuel within building systems.

   – extend life - adapt and re-use as a priority over building new.

   – add value and longevity to existing tall buildings.

2. Take a new approach to new tall buildings:

   – Rigorous and robust requirements for new tall buildings at planning stage

   – Leverage the opportunities for the community and area.

   – Create a resilient city by maximising collective influence.

   – Collective planned investment outside - and inside - the footprint of the building.

3. Maximising collective influence and aspiration can optimise the shared benefits for both cities. Our recommendations for the City of London cluster include:

   – Maintaining and enhancing clear targeted policy, drawing on NYC (and other world city) experience.

   – Incentivising early reductions in carbon emissions.

   – Further incentivising investment outside the boundary lines of private sector developments to deliver a more attractive, sustainable public realm.

   – Collaborating to build on shared benefits, ultimately amplifying impact for the area and community.

Tall buildings can play a significant part in environmental improvements. When they perform well, they can add to their value individually and as part of a successful business district.

Introduction

This report investigates the key strategies that can be used to enable the City of London's tall building cluster to become more environmentally sustainable, and to rise to the net zero challenge. It explores why we build tall, and the opportunities and challenges that come with it.

This report compares the City of London's Tall building cluster with Lower Manhattan's to determine what they can learn from each other; what has been driving change and what are the key opportunities for improvement. The recommendations for the City of London's tall buildings cluster are outlined in the Key Opportunities and Next Steps chapters of this report.

To help us seek the opportunities it is necessary, first, to understand:

– What we mean by "tall" buildings

– Why we build tall - including economic, commercial and agglomeration benefits

– How we build tall - touching on the design challenges that tall buildings present

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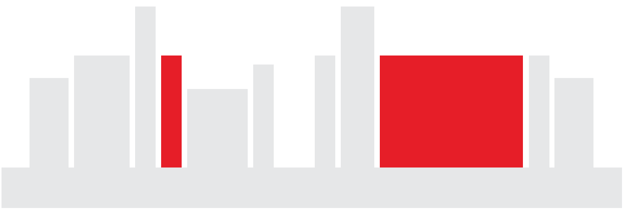
What do we mean by 'tall buildings'?

Definitions of tall buildings can vary, but they are generally informed by the height of the building, local context, and certain technology features. The following have been largely adopted by tall building designers from the Council on Tall Buildings and Urban Habitat (CTBUH)[5].

Building height

This report adopts the CTBUH definition, which identifies tall buildings as having at least 14 storeys or reaching a height of 50 m (164 ft) or more. However, there are several definitions of "tall buildings", including those that have been adopted for specific geographies.

Buildings that are considered tall in one location may not be considered tall in another.



Buildings that are slender may appear taller than those that are more expansive.

London

The London Plan[6] proposes a default height of tall buildings as 6 storeys or 18 m (59 ft) to the floor of the top storey, which mirrors the Building Safety Act (2022)[7].

Due the relative density, the City of London Corporation defines tall buildings as those exceeding 75m above ground in height.

Additionally, the City Corporation is required to refer applications to the Mayor for buildings that exceed 25m above ground height in the Thames Policy Area.

New York

In NYC, building height is constrained depending on the "Floor Area Ratio". Each zoning district has an FAR which, when multiplied by the lot area of the zoning lot, produces the maximum amount of floor area allowable on that zoning lot.

For example, on a 10,000 square foot zoning lot in a district with a maximum FAR of 1.0, the floor area on the zoning lot cannot exceed 10,000 square feet.

In Lower Manhattan, the FAR ranges from 4-15.

Context

Whether a building is considered tall depends partly on the height of the surrounding buildings. A 100 m (328 ft) building erected in Lower Manhattan would not appear tall compared to its neighbours. This principle is reflected in London's planning guidance, with the GLA adopting a lower threshold[6] for a "tall building" than the City of London[8], acknowledging the urban sprawl of the city.

Context is also important to consider when deciding where a tall building may be appropriate. A 20 storey building located in an otherwise low -rise area is likely to place a greater burden on the existing infrastructure than in a tall building cluster. Additionally, it may have unintended impacts for the surrounding buildings (e.g., reducing access to views and light or creating unwanted environmental wind impacts at street level.)

Tall Building Technologies

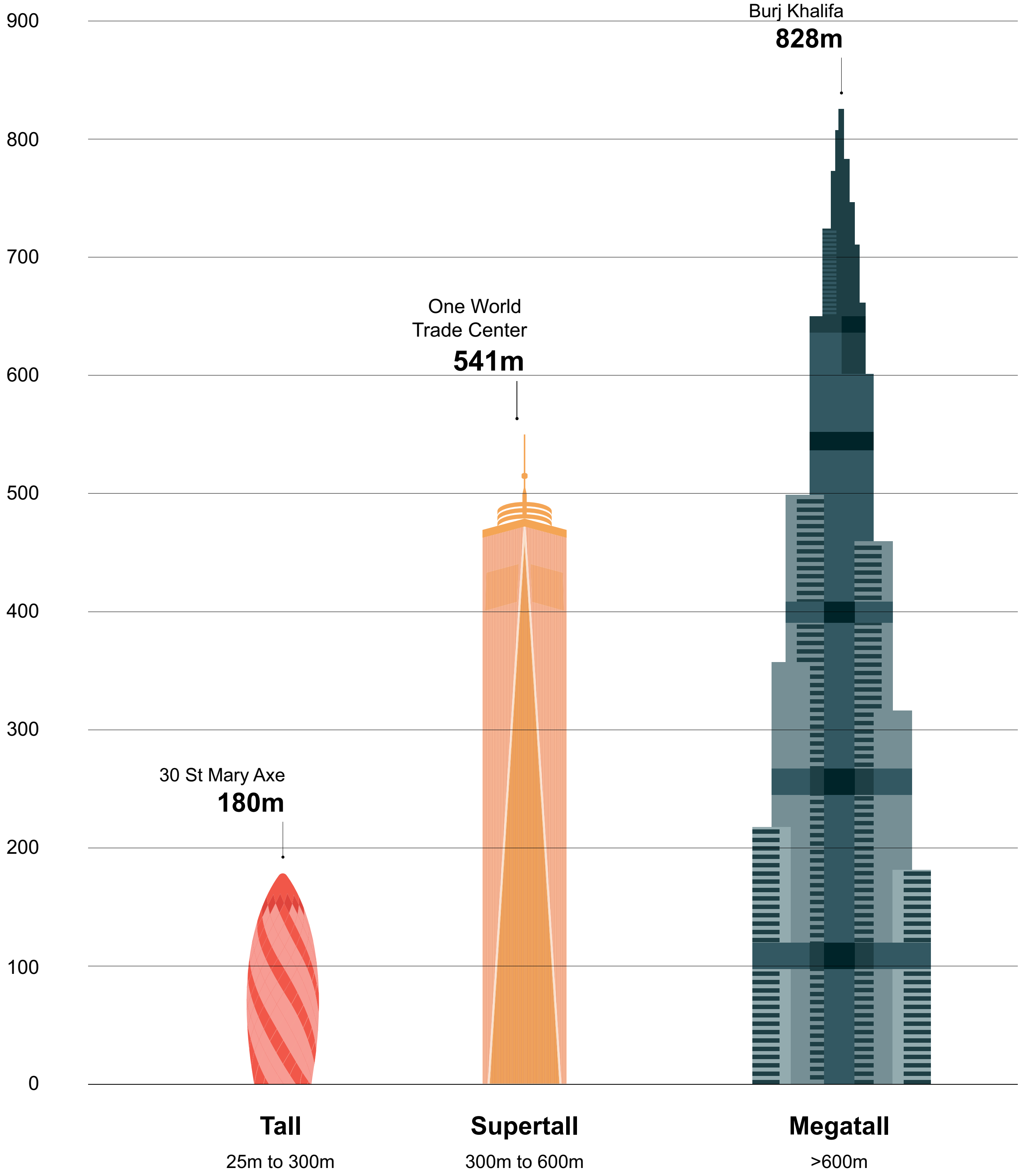
Taller buildings are subject to higher lateral loads and might have external bracing systems, outriggers, or dampers to optimise structural performance. Taller buildings will often have enhanced vertical transportation technologies, like lifts/elevators and require specific building services system designs[10], such as pressure breaks for hydronic systems approximately every 100 m (328 ft), around 20 storeys. Building specific fire engineering solutions might also be required.

Proportion

As well as the above, CTBUH[5] also suggests that building proportions play a role in them being recognised as tall. They state that some buildings which are not particularly high but are slender give the appearance of being tall and conversely that the large floorplate of some high buildings exclude them from being considered tall. However, from a design perspective many of the specific challenges associated with tall buildings exist regardless of the floorplate size.

Maps show City of London Borough in relation to GLA area [9].

Different categories of tall



Although once the tallest building in the world, One World Trade Centre has now been usurped by many much taller buildings from the Megatall category. No buildings in London are yet considered Supertall.

Why do we build tall?[12, 13]

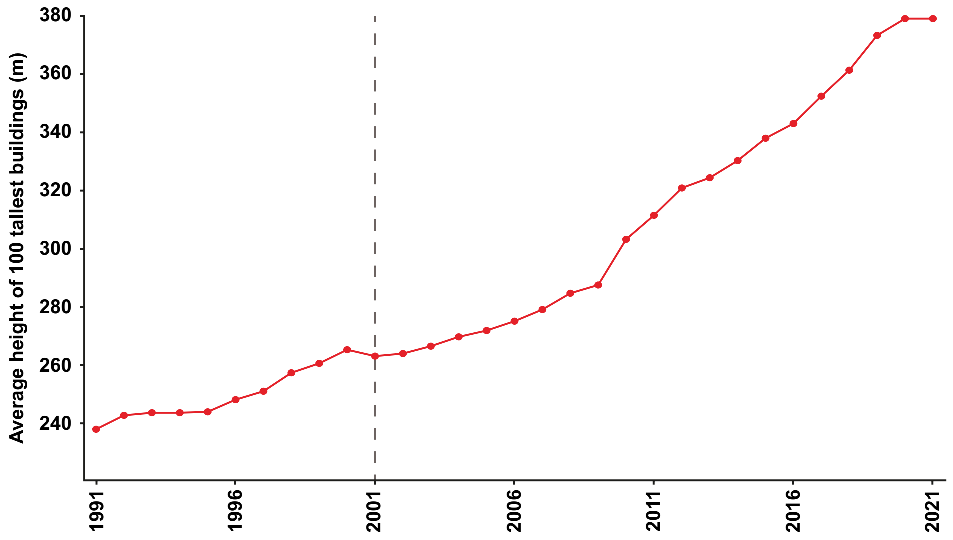
The economic cycle may affect the ebb and flow of tall building construction, but the decades long trend is clear. A 2021 report by the Skyscraper Centre notes that the number of tall buildings in the world has been increasing and 84% of all tall buildings in existence were built after 2001. Most of these buildings are either office (45%) or mixed-use (24%).

The economically viable height of a tall building is, in simple terms, a function of the value of the resultant asset and the cost of construction process. As technology advancements have driven down costs, the economic heights possible have increased. This is why the height of buildings has been growing slowly over time.

At the same time, public transportation systems has improved, supporting the daily movement of people to city centres en masse. As the number of tall buildings have increased so has our ability to maximise agglomeration benefits, enhancing the productivity benefit dense city centres are able to generate.

A valuable asset

Tall buildings allow developers to leverage more value from a single plot of land. The typically city centre location of tall buildings also offers benefits to users, such as connections to large transport hubs and valuable public amenities. Finally, tall buildings are favourable to service providers, as they can deliver goods more cheaply and efficiently for a large number of people. This allows them to be more efficient economically and environmentally. However, although buildings are able to maintain an intrinsic value, unlike some other types of investments, tall buildings' value can decrease dramatically if the economy is struggling.[14]



This graph shows the gradual increase in average building height since 1991. [12]

Placemaking

The skylines associated with tall buildings become synonymous with global cities, their calling cards, creating the iconic city image. This adds to their wider 'value'. The City of London has recognised this in the creation of their Destination City flagship policy.[15]

As well as the creation of iconic skylines, tall buildings can have an impact on an individual scale. They are symbols of economic growth and success, a physical manifestation of corporate and civic power[16]. At times of peak construction, competition in building height has played a part in pushing building heights ever higher[17].

The World Trade Center embodied this concept, with the Twin Towers successfully becoming a symbol of the US's global economic dominance. Their symbolic significance allowed them to have a real-world impact, with marketing campaigns featuring the buildings responsible for boosting economic activity and tourism, in a time of financial and social troubles in the city[16].

An enabler for agglomeration

Bringing people and companies close together, agglomeration, can foster many benefits including increased productivity [1]. Companies in denser areas benefit from a larger shared pool of potential suppliers and customers. The density also enables closer collaboration across complimentary industries, rather than splitting a city into 'use districts', which is more typical in the US. The high 'bump factor' increases chance meetings between acquaintances, accelerating the knowledge transfer of ideas and innovation, increasing productivity for all.

In market-oriented economies, agglomeration occurs organically, and potentially without the catalyst of tall buildings however in areas of high land value, such as Lower Manhattan and the City of London, dense low rise construction may not be a viable option. As urban areas prosper with newer technologies, developers seize the opportunity of empty infill plots investing in taller buildings to maximize space. People and firms occupy these new buildings, generating further economic activity that reinforces the cycle.

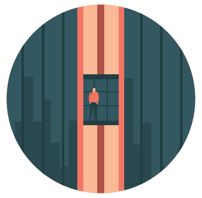
Sustainability and environment

The historical drivers for tall buildings are evident, however, in today's social and environmental landscape we must evaluate their value and impact more closely to ensure they are sustainable.

Calculating the overall environmental impact of tall buildings is challenging, however, as they have a reach far beyond their site boundaries and they can contribute to creating cities with lower overall environmental impacts per worker, resident or unit of economic output.[20]

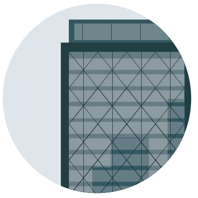
Understanding the complete impacts and challenges throughout the life of a tall building, crucially unlocking ways to utilise existing tall buildings for longer, will help us maximise value and balance our emissions across the built environment, which is crucial for the drive to net zero for the city. Later in this report, we explore some of these opportunities in more detail.

How do we build tall?



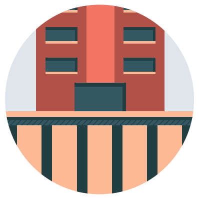
1. Vertical Transport

The invention of the passenger lift by Elisha Otis (first used in a New York department store in 1857) was instrumental in enabling the construction of tall buildings[21]. Today lifts play a major role in occupant movement, emergency escape strategies and plant replacement. As a building increases, the space required for additional lifts to higher floors reduces the floorplate efficiency, particularly on lower floors, and increases the embodied carbon investment.



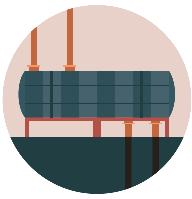
2. Wind Effects

As technological advancements have allowed us to construct taller, lighter buildings, dynamic wind effects have started to govern structural design. Interventions such as additional structural damping and adjustments to building form may be used to reduce the impact. Wind tunnel testing, and CFD (Computational Fluid Dynamics) Modelling at early stages of design, enable better prediction of effects on the buildings and therefore result into more efficient design.



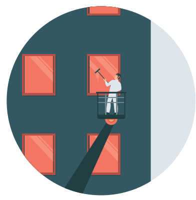
3. Foundations

Tall buildings typically use piled foundations, with basements generally getting deeper with increased heights above ground which helps with over-arching load balancing. Designs are influenced by factors such as soil composition, earthquake risk and local obstructions. For example, One World Trade Center's foundations are built around the existing train network[22].



4. Pressure Breaks

Hydronic systems in buildings over 100 m (328 ft) may require special interventions due to the potential pressure build up in pipework. Pressure breaks, such as break tanks or heat exchangers, can be installed roughly every 20 storeys, or high pressure rated pipework used.

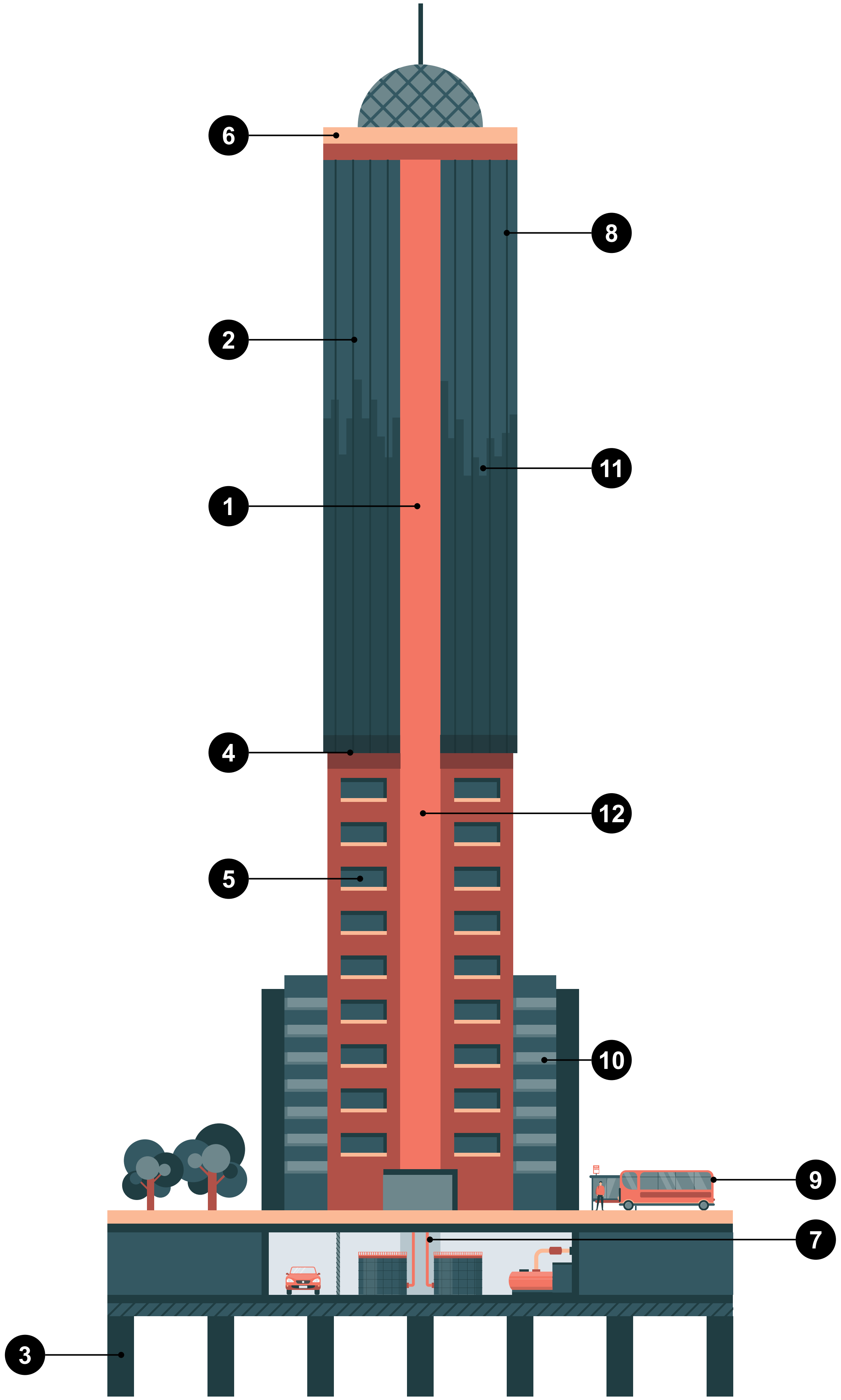


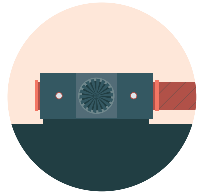
5. Facade Maintenance

Tall buildings require specialist access systems, known as building maintenance units, to enable façade maintenance and cleaning. These are often installed at roof level with a crane or monorail system used to lower a cradle down the side of the building.

6. Public Spaces

Tall buildings often include public amenities such as a plaza at lower levels or a viewing gallery at upper levels. London's 20 Fenchurch Street, AKA "The Walkie-Talkie" houses the city's highest public garden along with a series of bars and restaurants, where the view becomes an integral part of the offering[23].





7. Servicing Strategy

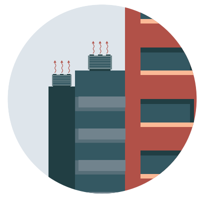
Tall buildings are similar to small communities in terms of their scale and require a complex servicing strategy. Opportunities such as heat sharing and water re-use should be used to reduce demand, but even with these strategies 11% of GIA will typically be required for plant rooms[11].

8. Asset value and height

Studies have shown that for offices and residential apartments tenants are willing to pay a premium for property higher up the building. For offices, it is believed that the primary reasons for this are the enhanced views and the perceived prestige attached to higher properties[17].

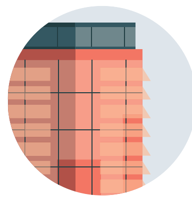
9. Transport connections

Workforce densification and the (typically) urban location of tall or high density buildings, aligns with the locations of public transport nodes, allowing large volumes of workers to use public transport. Hundreds of thousands travel to The City of London[24] and Lower Manhattan daily[25], meaning the impact on emissions could be substantial [26].



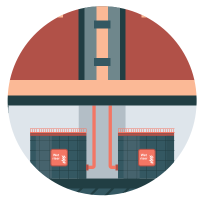
10. Building form

Setbacks and podium levels became a feature of tall buildings in response to New York zoning laws designed to maintain light at street level. Today, they can be used to solve the challenge of limited roof space, relative to GIA, with the additional roof area created used to house external plant.



11. Façade design

Façade design is key to achieve an architecturally striking building that is low carbon through its lifetime. Aesthetic requirements must be balanced with thermal performance, light levels, and solar controls to minimise HVAC loads. Low embodied carbon materials should be used, and material efficiency maximised [11].



12. Fire safety measures

Tall buildings have additional fire safety requirements to ensure there is sufficient time for occupants to escape from all levels in the event of an emergency. These include more onerous requirements around the number of escape stairs, provision of fire compartmentation, sprinklers, wet risers and firefighting lifts/shafts[27].

Comparison: City of London and Lower Manhattan tall building clusters

London and New York

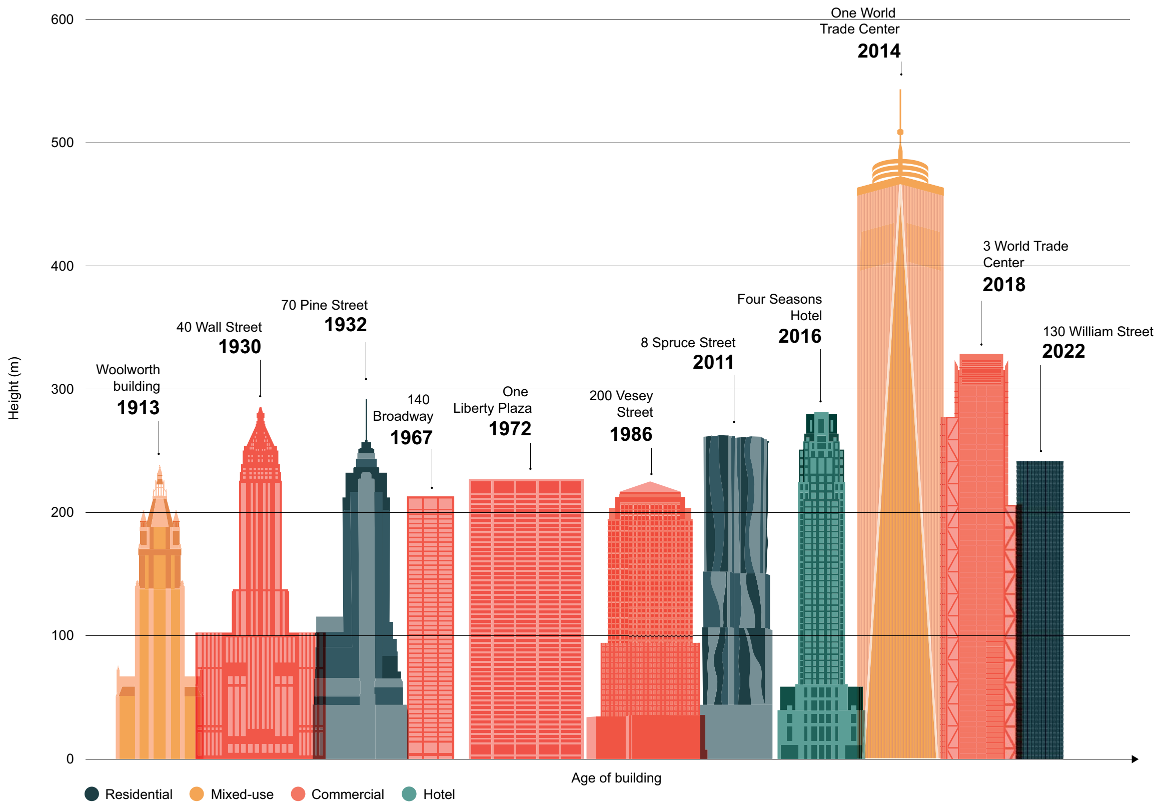
Having described the generic challenges and benefits associated with tall buildings, this chapter looks at the specific tall building clusters in Lower Manhattan and the City of London, their history, the benefits they have brought to their respective cities, and some current challenges and trends. In the final section of this chapter, we talk through the patterns of change we see as a result of policy and economics in each of our cluster locations.

New York was selected as a case study for comparison due to its many similarities with London. They have a comparable population size and are global cities that play a key role in their country's economy. There are some trends that are common to both cities.

Like most cities, neither the City of London nor Lower Manhattan have returned to their pre-pandemic ways of working or levels of office usage. Flexible working patterns have reduced the consistency in the number of people commuting to our tall building clusters, with a pattern of decreased commuting on Mondays and Fridays as of May 2023.[28]

They both have a moderate climate[29 30], however, in recent years recorded temperatures have been rising. Both cities are vulnerable to the impacts of climate change, and are making a push for more environmentally sustainable, net zero buildings to mitigate this.

London and New York both boast iconic skylines, which feature heavily in today's popular culture. These distinctive tall buildings are located in the City of London and Lower Manhattan's tall buildings clusters. These areas - at the financial hearts of the cities - form the focus of this comparison.



New York tall buildings in order of age, coloured by use type.

New York

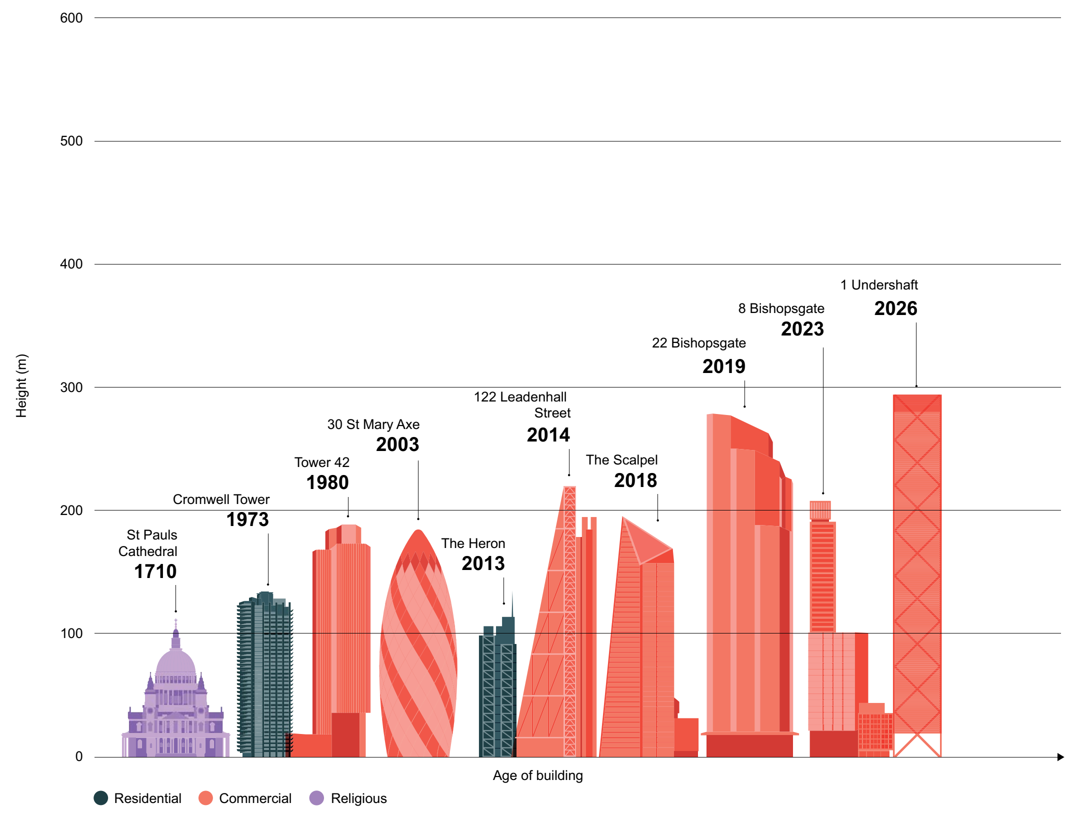
New York City covers approximately 790 km^2 (305 mi2), it is the most international and populous city in the US[29], with over 8.8 million [31] residents. The city is divided into 5 boroughs: Manhattan, Brooklyn, the Bronx, Queens, and Staten Island[29]. In 2019 it had a GVA of $1.2 trillion[32].

Lower Manhattan

Lower Manhattan is located in New York City's smallest borough, Manhattan which covers 58.8km^2 (22.7 sq. mi). In its waterfront location on the southern tip of the island it is bordered by the Hudson River, East River and Upper New York Bay[33]. Manhattan holds immense economic importance to the city and the US.

NY Timeline

- 1913: Woolworth Building
- 1930: 40 Wall Street
- 1972: One Liberty Plaza
- 1986: 200 Vesey Street
- 2014: One World Trade Centre
- 2022: 130 William Street



London tall buildings in order of age, coloured by use type. St Paul's Cathedral is shown due to its significance

London

With a population of 9.8 million people and a geographical area of 1,572 km^2 (606 sq. mi), London is the UK's largest city[28]. It is a global city with over 270 nationalities and 300 languages[35]. London is made up of the Greater London Authority and 33 other local government authorities: 32 London Boroughs and the City of London Corporation[36].

The City of London

The City of London is located in central London along the river Thames, it covers a relatively small area of just 1.12 square miles (2.9 sq. km) but has a much larger impact[24]. It is a key driver of the UK economy, generating over £85bn ($106bn) in economic output annually, or 4% of all UK GVA. Yet, the City only accounts for 0.001% of the UK's size. The City of London accounted for 1 in every 54 British workers in 2021, approximately 587,000. Over half of these were in the financial and professional services sector[2].

London Timeline

- 1980: Tower 42 (NatWest Tower)
- 2003: 30 St Marys Axe (Gherkin)
- 2011: 110 Bishopsgate (Heron Tower)
- 2014: Leadenhall Building (Cheesegrater) and 20 Fenchurch St (Walkie Talkie)
- 2018: 52-54 Lime Street (Scalpel)
- 2019: 22 Bishopsgate
- 2023: 8 Bishopsgate

History of the tall building clusters
New York

In Lower Manhattan, the early 1900s saw the construction of the worlds' first "skyscrapers" with the Metropolitan Life Insurance Company Tower (1909) and the Woolworth Building (1913). The Woolworth Building won the title of world's tallest building when it opened and held the title until 1930 when the Bank of Manhattan Trust Building eclipsed it, followed very soon after by some of the most famous buildings on the New York City skyline.

What caused such a surge for height?

Manhattan being an island pushed developers to build 'up' rather than 'out', with the limited availability of land driving up the cost. In the early days of Manhattan's tall buildings, they were also seen as a speculative investment, helping to increase the speed at which they developed.[37]

1916 saw the introduction of new building zoning laws that created "use districts": splitting the city into designated areas for residences and businesses and limiting the heights of new buildings to up to "two and one-half" times the width of the street, plus five feet (1.5m) for every foot (30cm) set back from the road. Additionally, any building that covered 25% of its plot or less was given no height limit (this remained true until the 1960s). This led to the construction of a series of "set back" buildings during the "roaring twenties", defined by their "ziggurat" form and art deco style. The Chrysler Building and the Empire State Building completed in this time and style, both achieving the tallest in the world at the time of completion.

The taller Empire State building was completed in 1931, just in time to see the effects of a stock market crash as the US descended into The Great Depression of the 1930s, putting a halt to iconic tall building construction in the capital for decades.

Skip forward to the 1960s and new zoning laws promoted the aesthetic conservation of the New York skyline, while rewarding developers for providing public amenities. In exchange for planning approval of additional floor space, developers set their buildings back to create public plazas, creating more (albeit windy) urban spaces for city dwellers to spend time outside.

The Chrysler Building
© Getty Images

These new laws also introduced the concept of air rights, which needed to be purchased alongside the rights to develop a plot of land. In more recent years, due to the transferability of these air rights from one building to those surrounding it, developers have been able to push the limits of heights across the city, leading to an increase in high-rise residential developments.

Terraces on Midtown Green
© Arup

Case study: Midtown Green (competition winners)

Converting extra deep Midtown office floor plates of the 1960's to one which meets the legally required access to air and light for residential units is a geometric challenge. Many conversions have been undertaken with Financial District office buildings, but they tend to have their cores on the side and shallower floor plates than the monoliths of Midtown. Those buildings are often designed with an interior courtyard meeting the minimum requirements but offering compromised unit layouts. In addition, a building such as 1633 Broadway, at over 40 stories, does not lend itself to a central courtyard.

Arup's winning approach was to carve in from the outside and use the relieved structural capacity to build above. This load re-distribution approach facilitates unit layouts on the 25ft (7.6m) structural grid with generous, yet not wasteful square footages as is found in Soho loft conversions. The apartment layouts take the NYC Dept. of Housing Preservation & Development design guidelines as the starting point and take advantage of the existing floor area to add comfortable work/study spaces. Internal core area that is unused due to elevator decommissioning or vertical zoning is converted to bicycle and tenant storage.

The final result is an office-to-residential conversion without wasted floor area, many desirable corner units, and much added long-term value.

The 1960s also brought rise to the single-occupant corporate tower, home to the headquarters of the booming industries of the time, such as the JP Morgan Chase Building, and Leverhouse (a monolithic skyscraper to house the corporate giant UniLever).

Gone are the days of the masonry façades with punched windows and spandrels that defined the "pre-war" tall buildings of the financial district. Instead, a new "post-war" typology appeared, firstly in Midtown, with glassy curtain walling, and deep floorplates, providing symbols of capitalism, dominance, and growth. This transition to highly glazed façades was enabled by advancements in structural and HVAC systems. Façades no longer had to include load bearing walls, and openable windows did not need to be relied on for climate control, instead air condition systems could provide fresh conditioned air to serve any depth of floorplate.

Throughout this period, the height limit for economical tall building design was around 80 storeys, due to the conditions for vertical transport. More height meant more occupied floor area which meant more people travelling up and down the building. As each person would always enter at ground level, the lower floorplates were crowded with elevator shafts serving the floors above. Floorplates were crowded with elevator shafts serving the floors above.

Picture shows 1 World Trade Center and 2 World Trade Center, also known as the Twin Towers, prior to 2001

Case study: The Twin Towers

Architect Minoru Yamasaki defied this constraint with his design for the Twin Towers in 1962 by adding the innovation of two "sky lobbies" at floors 44 and 78, breaking up the journey for those travelling to the uppermost floors. Although this meant greater utility of the lower floorplates and enabled the construction of the tallest building in the world (110 storeys, 417 m /1368 ft) for 30 years this meant very long commutes for those occupying the uppermost floors. The twin towers finally surpassed the Empire State Building as tallest building in the World.

The twin towers were an attempt by the Port Authority of NYNJ to revitalise Manhattan, by increasing the supply of office space to the area in a response to office vacancies. This was part of an Urban Renewal movement which saw subsidised private re-development in the city. They were not however, without their critics. Urban theorist, Edward Glaeser, has criticised these projects for "replac[ing] well-functioning neighbourhoods with immense towers that were isolated from the streets that surrounded them".[38]

Following the catastrophic terrorism event of 9/11, the Lower Manhattan area was regarded in a very different light, and both the local planning authorities and the skyscraper construction industry paused for reflection.

There was a call for better redundancy in the means of escape, with improved wayfinding and lighting also. Concerns about the fire resistance of steel led to an increase in the use of concrete as a central core; technological advancements in concrete enabled this shift. Concrete cores were synonymous with glass skin façades, meaning a new architectural movement was on the rise.

With increased use of concrete and additional structure used to provide redundancy, compounded by the impact of highly glazed buildings, the carbon intensity of building tall will have naturally increased.[39]

It wouldn't be until the advent of embodied carbon calculation methodologies being adopted on a grand scale (late 2010s) that the impact of the material of the building would be re-addressed. Modelling software has improved the designers' ability to optimise the energy use and occupancy levels of buildings, leading to leaner designs and greater carbon performance.

London

At the turn of the century, the tallest building in the City of London was Tower 42, at 183 m (600 ft) and 47 storeys. Built in 1980, the skyscraper was the location of NatWest's international headquarters. It was the tallest building in the London until 1990 when One Canada Square completed in Canary Wharf, remaining the tallest in London until the construction of the Shard in 2012.

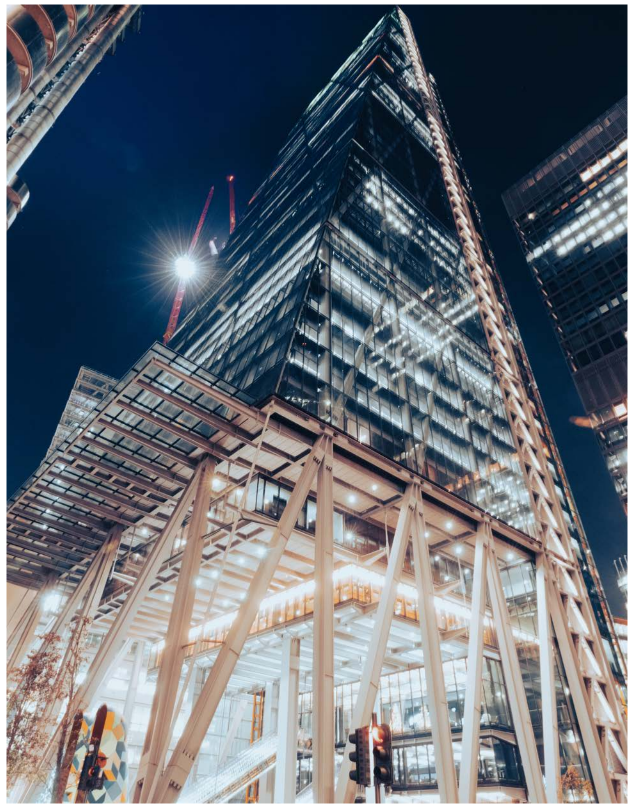
The architecture style of the NatWest Tower, with vertical steel columns on the external façade, mimics the style of skyscrapers in New York's financial sector. The building is now known for its LED lighting displays on the top central portion.

The London skyline has been heavily impacted by the protection of some important lines of sight, initially scribed in the London Building Act of 1894. At this time, members of the royal family were growing concerned and outraged at the number of buildings being constructed that were impacting the views from the Royal Parks of important landmarks such as St Paul's Cathedral. Furthermore, a series of fires following the Great Fire of London resulted in height restrictions of up to 80 feet (~25m). Such planning laws are echoed in the regulatory practices of today, with the implementation of protected sight lines.

These restrictions [40] have significantly impacted the building form in the City of London and surrounding areas. In all, 13 protected corridors are currently in place, which impact the potential development of buildings in this area. They were instrumental in the formation of the Eastern Cluster, which leant itself to taller building developments, due to its position in an area less constrained by view protection rules. The tradition of tall buildings in this part of the City continued throughout the 1930s and 1950s when the cluster was given greater allowances for building height than other areas of London[41].

Tower 42 or the NatWest Tower
© Getty Images

Why build a cluster of tall buildings in the City? Building clusters were adopted in and around the turn of the century following the financial boom of the 1990s thanks to the deregulation of the financial services sector in the 1980s[41]. The cluster in City of London moved away from the more typical campus approaches of the time, brought in part to rival the growth seen in Canary Wharf.



Leadenhall Building from ground level
© EC BID

Case study: Leadenhall Building

A prime example of this planning policy influencing building form is the iconic Leadenhall building. The distinctive triangular form that earned the 'Cheese Grater' its nickname was designed as a sensitive response to the building's location in the background of the view of St. Paul's Cathedral when viewed from the processional route between Westminster and the cathedral along Fleet Street. Its profile leans respectfully away[42] from Wren's masterpiece. Its unobtrusive silhouette in fact allowed for a much taller building, with more lettable space, than would normally be acceptable is such a sensitive location.

Case study: 30 St Marys Axe

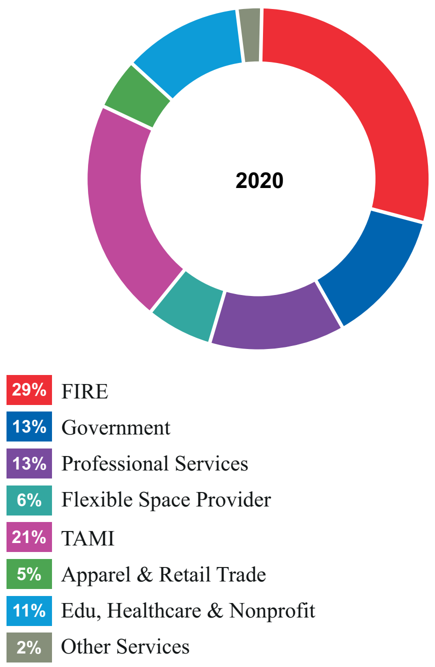
30 St Mary Axe, known fondly as "The Gherkin" is one of the most dramatic landmarks in London. The building's unique form is a response to the constraints of its site. Its shape appears less bulky than a rectangular block, creating public space at street level. It also offers minimal resistance to wind, improving the environment for people on the ground and reducing the load on the building. The building has six spiralling light wells that allow daylight to flood down onto the floors, as well as being an integral part of the ventilation strategy. This allows the building to operate without full air conditioning at certain times of the year.[43]

Following a series of bombings in the early 1990s, plans were drawn up by Foster and Partners for a London Millennium Tower, 92 storeys of office property towering at 386 m (1266 ft) tall, which would make it the tallest in Europe. However, this plan was usurped by a now iconic, yet shorter at only 180 m (590 ft) in height, 30 St Mary's Axe (also known as the Gherkin) which completed in 2003. The Gherkin has since grown in significance and has become a distinctive landmark of the City. The 2000s also saw new planning policy designed to make the cluster more cohesive, by using the proposed Pinnacle development on Bishopsgate as a focal point, with building heights decreasing as they got further away from it. Unfortunately, due to the turbulence created by the 2008 financial crisis, the Pinnacle development was not completed. However, the redesigned 22 Bishopsgate has now taken its place and will form the centre along with the 1 Undershaft development when completed[41].

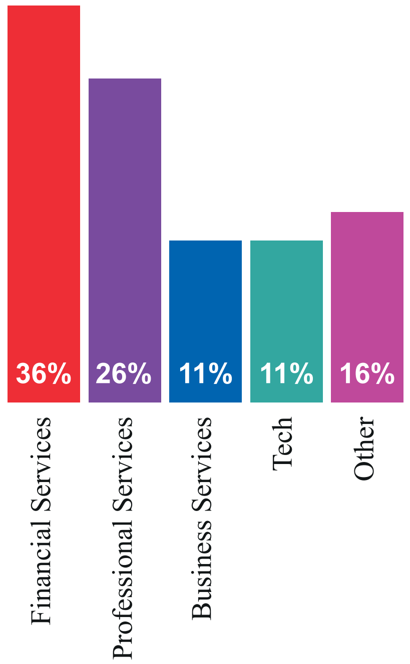
Cluster today
Key figures

Lower Manhattan
Though Lower Manhattan began as a financial and business district, its identity has diversified over the years, creating a thriving area where residential, retail and office developments work in harmony [44]. The cluster has some of the most prestigious property in the city with a high proportion of Class A commercial spaces.

City of London Tall Buildings Cluster
The tall buildings cluster is predominantly made up of offices, with some retail space. The area contains very little residential property, with people visiting the area for work or leisure activities, rather than residing within it. The city has a rich history which is reflected in its architecture today: highly glazed distinctive tall buildings contrast with lower rise heritage buildings.[2]



Lower Manhattan office occupancy by industry, 2020.



City of London jobs by industry.

	Lower Manhanttan	City Cluster
Offices (Commercial)	7,990,000 sq m (86,004,544 sq ft)	1,176,400 sq m (12,662,600 sq ft)
Workers (# of employees)	279,300	587,000
Residential units	34,243 units	7 units
Students residence (units)	2480 units	-
Hotel	9,343 rooms	50 rooms
Retail	676,300 sq m (7,280,000 sq ft) (2019)	69,300 sq m (745,900 sq ft)

New York [3]

Source: City of London [41]

Local factors

Geology
The geology of a city can have a big influence on the spatial development of a city. It can dictate where and how buildings can be constructed. The impact is particularly felt for tall buildings, which rely more heavily on their foundations for stability.

New York
The majority of Manhattan's bedrock is formed of Schist[45], a metamorphic rock. Many of the tall buildings in lower Manhattan use rock anchors that extend into the bedrock as part of their foundation design. The depth to New York's bedrock can vary, even of a relatively small distance. For example, Midtown Manhattan's bedrock is around 11 m (35 ft) deep, but in Lower Manhattan it can be up to 46 m (150 ft) below the surface, meaning foundations need to be drilled even deeper to support the tall buildings in this area. [22]

Recently there have been reports that the area is sinking on average 1-2mm a year, exacerbating the impacts of sea level rises, and flooding risks. The effect is felt even more strongly for those buildings which are not located on Manhattan's bedrock but are situated on some of the less stable sand and clay in the area.[46]

London
The main bedrocks of London are chalk and clay[47], with much of the surface layers consisting of sands and gravel[48]. High-rise buildings in London will typically be supported by deep piles founded in the clay, in some cases end-bearing piles into the lower rock substrates are used.

Climate risks

	London City Cluster[49]	Lower Manhattan[3]
Flooding	By 2080 milder and more wet winters could bring 20% more rainfall. This will put pressure on existing drainage infrastructure and increase the risk of flooding. Rising sea levels will put pressure on existing river defences that protect the City from the Thames.	By 2050 37% of properties in Lower Manhattan will be at risk from storm surges, with this increasing to 50% by 2100. At this time 20% of Lower Manhattan's streets will also be exposed to daily tidal inundation if action is not taken. Groundwater table rise will also put properties at risk of destabilization and expose 39% of streets with underground utilities to corrosion and water infiltration. There will also be increased risk of flooding due to the impacts of extreme precipitation, putting pressure on the combined sewer system
Overheating	By 2080 the City will be experiencing warmer and drier summers - with temperatures increasing by up to nearly 5□. It is predicted that duration of heatwaves will increase by 4 times compared to today.	By 2050 heat waves are predicted to be 250% more frequent and 50% longer, and average New York temperatures to rise by up to 5.7°F.
Water Stress	By 2050 droughts are expected to last 2 times longer than today and by 2080 rainfall to have decreased by a third compared to weather in 1981-2000.	It is predicted that water stress will be the greatest climate risk for New York City[50]. Although localised areas will be impacted greatly by problems such as flooding, the impact of this will be felt throughout city.

Green parks within the city
© EC BID - Mickey LF Lee

Ecosystem impact

Cities can have unintended impacts on the natural world, which can extend far beyond their borders. When designing new buildings, care must be taken to minimise these, and strategies must be implemented to restore habitats and ecosystems already damaged by the urban environment.

New York

Many thousands of migrating birds are killed each year in New York City due to collisions with building glass. The birds struggle to identify the glass as an obstruction or mistake the reflections for habitat. Nocturnal migrating birds are also impacted by the artificial lighting that can attract and disorientate them.

To help reduce these losses, Project Safe Flight was established which monitors collisions, educates related parties, and carries out research to better understand the impact of artificial lighting. They also push for city and state legislation to mandate bird friendly building practices. Their success can be seen with the 2019 introduction of Local Law 15 which requires all new and significantly altered buildings to use bird friendly materials.[51]

London

The City of London is taking proactive action to reduce its impact on biodiversity. Its 2021-2026 biodiversity action plan identifies key species in the area, as well as the sites required to be maintained to protect them. Eight target species were selected to focus conservation efforts on, including raising awareness and conservation actions. The species include bats, bees (wild and bumble), stag beetles and birds such as House Sparrow and Peregrine Falcon.[52]

Drivers and policy

Policies

While there are many policies and initiatives covering tall - and all - buildings in both Lower Manhattan and the City of London, we concentrate on the policies and initiatives aimed at promoting sustainable development and reducing carbon emissions. Where these link with other requirements targeting all aspects of building construction and operation, we have included them as well.

Lower Manhattan is regulated by the City of New York, regulation is a state mandate in the US. The New York State codes also apply to the Lower Manhattan area. The codes are put in place and enforced via building control/permit/zoning at state level. The NYC local laws are imposed by the mayor's office and are more politically driven.

In the UK Building Regulations apply nationally, with the Greater London Authority providing a more local level of guidance via the London Plan- upheld by the local councils. The City of London - as the local council - has power to uphold the Greater London Authority requirements and to add its own policies and initiatives. Hence there are three layers of increasingly aspirational requirements covering the tall building cluster in the City of London.

Key policies address:

- Implementation - big picture considerations beyond the traditional building limits including biodiversity, building heights and wellbeing.
- Design - considerations throughout the traditional design process can improve adaptability for the future and extend the longevity of the development. They can affect the whole life carbon of a new building and impact social value and the city at the ground plane.
- Carbon Responsibility - an evolving set of policies targets operational and embodied carbon emissions, quantifying for developers, owners and occupiers the scope of the emissions for which they are accountable.
- Operation - reduction and transparency of in-operation energy use is an important step in combating climate change. In addition, it is becoming more important for owners and occupiers to understand their consumption and associated emissions.

Further to the legislative requirements, some policies provide financial incentives for the adoption of renewable energy and energy-efficient technologies in buildings as well as low carbon structural, facade and services design and material choices. When implemented together, the policies can effectively facilitate the reduction of energy consumption and carbon emissions, contributing to a more sustainable future and setting both New York and London on the path to net zero.

The table below compares and contrasts key policies from London and New York. In addition to the policies in place, there are other non-regulatory drivers impacting the built environment response to climate change. The most impactful drivers are also listed. Some are international but others are more local. In this case the NY and London versions are compared.

The impact of both policies and drivers shapes the sustainable future of the cities.

	Topic	London	New York	Comparison
Policy				
Big picture	**Whole life carbon**	London Plan Policy SI 2 Whole life carbon assessments are required as part of the local planning policy. The assessment methodology is in development and will become more accurate as the data is recorded. At present there are no penalties for exceeding benchmark levels and there is no regulatory benchmark.	NYC are promoting adaptation of existing buildings - this extends the building life and carbon use. E.g. Midtown Green. Currently retrofit only happens when major capital expenditure is required. E.g., façade upgrade, tenant leaving.	Whole life carbon and embodied carbon are not covered under NY legislature as yet. In the UK there is currently no penalty for exceeding a target nor a requirement for a contribution towards embodied carbon - as there is for operational carbon.
	Climate adaptation	GLA London Plan includes a requirement to prove overheating is not a concern in new buildings. It also includes a requirement to show consideration of flood defence. Both need to be assessed against future climate expectations.		NYC does not have a policy requirement for proof of overheating or other climate adaptation requirements. Buildings can be built in a flood plain with an incentive offered for including retail on the ground floor of residential buildings.
	Biodiversity	London Environment Strategy, includes provisions for biodiversity conservation. The Urban Greening Factor requirement within planning policy encourages diverse plants. A City for Bees and Pollinators focuses on supporting pollinators and their habitats within the City of London. City of London Local Plan and Transport Strategy both target additional urban greening.	The NYC Green Infrastructure Plan promotes green infrastructure practices and provides Streetscape Design Guidelines. LL92/94 of 2019 Green and Solar Roof Requirements; either green roofs or solar on 100% of the roof - excluding plant areas. Local Law 15 of 2020: Bird Friendly Building Design; all exterior glazing must comply with bird friendly design construction requirements.	In both areas councils prioritise local considerations. In London developers are required to demonstrate and comply with set targets for biodiversity when building new. Less prescriptive in London than NY on roof use. There may be an opportunity to incentivise biodiversity outside planning process.
	Well-being	The London Plan: Policy S1: Healthy Streets and Active Travel: promotes creating healthy and inclusive streets that prioritise walking, cycling, and active travel. Policy S4: Social Infrastructure: highlights the importance of accessible and high-quality social infrastructure in promoting community well-being. New buildings require secure bicycle storage, shower facilities. The City of London has a Public Realm Strategy that focuses on improving public spaces to enhance well-being, and a Healthy City Streets Strategy, which aims to create streets that prioritise the safety and well-being of pedestrians and cyclists, reinforced in the Transport Strategy.	NYC Zoning Resolution include Public Realm Requirements: which incorporates provisions such as street-level design, pedestrian amenities, and open space requirements. Energy efficiency incentives provided by Local Law 97 can improve well-being by upgrading building systems, optimising ventilation, reducing energy waste, and enhancing indoor air quality and thermal comfort. Local Law 97 can contribute to comfortable and sustainable indoor environments that positively impact occupant well-being.	Newly introduced policies to consider well-being aspects of urban planning and design. Key to positively impact all those who experience the environment. This is a community benefit - not restricted to building users. In London, this again is enforced during planning for new buildings. How can it be incentivised at other times?
	Height restrictions	The London Plan includes considerations for height restrictions, appropriate design and integration with the urban landscape. Protected sightlines of St Paul's Cathedral and the Palace of Westminster are a legal requirement within London urban planning, limiting the height of developments within the protected sightlines.	NYC Zoning Resolution includes the following regulations: Floor Area Ratio (FAR): influences the height and bulk of a tall building by regulating the amount of floor space that can be constructed. Setbacks: require a portion of the building to be set back from the street, allowing for light and air to reach the street level and reducing the visual impact of tall. structures. Tower regulations: may restrict the upper portion of tall buildings to minimise visual obstructions. Sky Exposure Plane: protects access to sunlight for public spaces and adjacent properties.	Differing policies in New York and London each incur site specific restrictions.
	Social Value	GLA London Plan and The City of London Corporation have power to request applicants to demonstrate Social Value as part of planning process. Commitments can be mandated via S106 agreements.		This is a growing source of potential contribution to public and community good. Through ESG commitments developers and owners are often happy to show their responsibility and to see local improvement as a result.

	Topic	London	New York	Comparison
In design	**Pre-redevelopment optioneering**	Policy SI6 in the London Plan focuses on the efficient use and management of resources in the built environment. The City of London provides guidance and support for pre-redevelopment assessments through its Planning Guidance. This includes making a case for new build rather than retrofit.		Retrofit and reuse is promoted in London to reduce embodied carbon. Adaptability of new buildings must be demonstrated in planning documents. There is a strong heritage body in the UK with an interest in protection of historic buildings.
	Sustainable design and construction	The London Plan includes the following policies: Policy SI1: Sustainable Design and Construction: encourages sustainable design and construction practice. This includes the use of sustainable materials, and waste reduction. Policy SI2: Climate Change Mitigation and Energy: focuses on reducing greenhouse gas emissions and promoting renewable energy generation. Policy SI3: Climate Change Adaptation and Resilience: This policy addresses the impacts of climate change and aims to enhance the resilience of the built environment. It includes measures to address flood risk, urban heat island effects, and other climate-related challenges. Policy SI4: Green Infrastructure and Biodiversity: emphasises the importance of green infrastructure and biodiversity in urban development. Policy SI5: Sustainable Construction Logistics: focuses on minimising the environmental impact of construction activities.		NY as yet not addressing embodied carbon through policy in the same way it is being addressed in the UK. Likewise resilience is now more formally addressed in UK planning although it is still limited in comparison to, say, the EU Taxonomy requirements. Note: London is leading the way in the UK via the GLA London Plan.
	Heat networks	The Heat Networks Delivery Unit (HNDU) provides funding and support to public and private sector organisations to develop and deliver heat network projects in London. Future Heat Network Zoning Policy - under consultation. Expected by 2025. Under planning requirements local councils including the City of London Corporation can ensure developers connect to future heat networks if viable. The City of London Corporation are currently undertaking a Local Area Energy Plan that will create a strategy for further development under the future Zoning Policy.	There is an existing gas powered steam network covering Lower Manhattan. The system is over 100 years old. New buildings no longer connect to the scheme. Existing buildings decarbonising will require heating system upgrades to ensure they can connect to all electric lower temperature systems.	Heat networks are not widely used in the UK at present, but are being encouraged as a way to share heat and decarbonise. This may be an advantage where there is a low footprint to GIA ratio meaning all-electric heating plant cannot be accommodated on a rooftop. It is interesting to see the challenge faced in NY now with an aging steam network. We need to learn from this in London.
	Water efficiency	The London Plan includes policies that encourage water efficiency in new developments and major renovations. The City of London promotes the use of Sustainable Drainage Systems (SuDS) to manage stormwater runoff sustainably. The City of London Corporation has a Water Efficiency Action Plan, it focuses on reducing water consumption, enhancing water monitoring, and raising awareness among stakeholders. Low flow fittings are a requirement to achieve certain BREEAM credits.	The NYC Green Infrastructure Plan, sets out Stormwater Management requirements. LL84-2009 also requires reporting of water consumption.	Both City Councils have strategic plans for water management. Finding ways to incentivise existing buildings to play a part in these plans will be important.

	Topic	London	New York	Comparison
Carbon responsibility	Carbon emissions	The UK Climate Change Act 2008 is a comprehensive policy framework aimed at reducing carbon emissions. The Act sets a legally binding target for the UK to reduce its greenhouse gas emissions by at least 80% by 2050, compared to 1990 levels. GLA Climate Change commitments - The Mayor's London Environment Strategy declared an aspiration for a Zero Carbon City by 2050 (2018) The City of London Corporation Climate Action Strategy: CoLC is committed to achieving net zero in our Scopes 1 and 2 emissions by 2027. This includes everything we own and operate as an organisation. CoLC committed to achieving net zero in the Square Mile by 2040.	2019 Climate Mobilisation Act (including Local Law 97) C40 Cities led to NYC publishing a document announcing alignment with 1.5°C (with the Paris Agreement)	The City of London Corporation is committing to show leadership in this area . Achieving a 2040 net zero target in the Square Mile will need collaboration from building users, owners and operators. GHG emissions reporting is impacting on building occupiers and owners. This is likely to drive decarbonisation of buildings.
	Operational Carbon	The London Plan aims to reduce operational carbon emissions from buildings in the city. The two key policies, SI 5 and SI 6, require all new buildings to be zero-carbon by 2030 and all existing buildings to reduce carbon emissions by at least 40% by 2030. These policies are intended to promote energy efficiency and the use of low-carbon technologies in buildings. For new buildings there is a penalty requiring a carbon payment to offset remaining operational carbon for the first 30 years of operation to zero at a set carbon price. For existing buildings there is currently no methodology for incentivising energy/carbon reduction. The 'Be Seen' part of the London Plan requires new buildings to report energy usage publicly. Public buildings are already required to do this.	Local Law 84 of 2009 is aimed at reducing operational carbon emissions in buildings in New York City. The goal is to increase transparency around building energy usage to encourage building owners to invest in energy efficiency improvements. (Amended by LL133 of 2016) requires owners to measure and report energy and water use annually. It requires building owners to use the US EPA's online benchmarking tool, Energy Star Portfolio Manager to submit usage data to the city every year. LL95 of 2019 requires buildings to post the grades they receive for energy use and display at the building. LL33-2018 is also related to this, it covers the data disclosure but is amended by LL95) Local Law 97 is the main driver for reducing carbon in new and existing buildings. All-electric new buildings will comply, existing buildings require more effort and intervention. Local Law 154 of 2021 calls for the phasing out of fossil fuels in new construction starting in 2024. Buildings must be all-electric due to CO_2 limits set by the law, and gas powered plant and equipment, including cooking, are not permitted. New York State has just passed a similar law.	High level strategy exists in both locations. In London policy impacts on new buildings. In NY it impacts on existing buildings. The impact future policy will have on carbon emissions both of existing and to be developed building stock must be significant and hold real estate owners to account for the emissions for which they are responsible.
	Embodied Carbon	The London Plan's Policy SI 4: Circular Economy and Resource Efficiency, sets out requirements for the use of sustainable and low-carbon materials in building construction and renovation, and encourages the reuse and recycling of materials to reduce waste and carbon emissions. Additionally, Embodied Carbon Review by the UK Green Building Council, details best practices for measuring and reducing embodied carbon in building design and construction, and to develop industry standards and guidelines for embodied carbon reduction. No penalties or benchmarks.	NYSERDA has collaborated with Building Transparency, The Green Building Initiative (GBI) and Carbon Leadership Forum (CLF), to develop the Embodied Carbon in Construction Calculator (EC3). EC3 is a digital tool which provides a database of building materials and their associated embodied carbon emissions. Enabling designers to make informed decisions and select low-carbon materials during the design and construction phases.	This is an area where regulation does not impact behaviours at present. We are in a period of learning more and encouraging reporting to enable learning.
	Carbon tax	A carbon 'offset' payment is calculated based on emissions over zero through a 30-year period for new buildings and secured through S106 agreement. More information is in the Mayor's Sustainable Design and Construction SPD. Existing buildings are not subject to these requirements unless a major retrofit requires planning consent.	Local Law 97 sets emissions limits for existing buildings over a certain size and establishes penalties for non-compliance.	Both cities are following similar strategies, but NY is targeting existing buildings, London targeting new buildings. Opportunities to learn from each other.
In operation	Energy efficiency reporting	London Plan - Be Seen - regulations require yearly reporting of energy use in operation, secured through S106 agreement with penalties for not complying with planning targets.	Local Law 87 of 2019: in New York City mandates that large buildings (over 50,000 square feet) undergo energy audits and retro-commissioning activities every ten years. The energy audits are an assessment of the building's energy usage and efficiency. Retro-commissioning compliments the audit by optimising existing systems and identifies opportunities to reduce emissions.	
	MEES	June 2021 consultation by BEIS on Non-Domestic Private Rented Sector Minimum Energy Efficiency Standards Implementation of the EPC B Future Target. Non-compliant buildings are expected to require an exemption to allow continued leasing. Not yet passed into law, current requirements are EPC E.	Local Law 97 of 2019: set carbon emission limits for buildings based on their size and occupancy type, if buildings fail to meet their emissions limit during compliance periods, they will face a financial penalty.	Many existing Buildings need costly interventions to achieve these enhanced performance requirements. NY fines may not exceed cost of works. The London enhanced future target has not yet become regulatory. Clarity is required. Incentivising early compliance could drive change.
	Building safety	Building Safety Act 2022 - introduced post Grenfell tragedy.	Local Law 11: Façade upgrades and safety inspections, introduced after an incident involving a fatality due to falling façade.	Both these requirements have sadly been introduced following tragic fatalities. Ensuring that safety is equally covered in both jurisdictions would be a learning outcome that could prevent future incidents. This would benefit from further comparison.
	Reporting and disclosures	Energy and carbon reporting is regulatory for all UK quoted companies and large unquoted companies. It covers global energy use and greenhouse gas emissions. Reporting the emissions relating to occupied office area will be required under these regulations.	Reporting not regulatory.	

Topic	London	New York	Comparison
Drivers for change			
Sustainability accreditations	BREEAM [61] often a planning requirement with a target of Excellent or Outstanding, this is also used in marketing and attracts responsible tenants.	US Green Building Council (USGBC) developed the Leadership in Energy and Environmental Design (LEED) Certification LEED [62] is the prevailing measure for green buildings that has seen large growth in Manhattan. The certifiers, U.S. Green Building Council (USGBC) stated in 2021 that approximately 40% of Manhattan's total office space has achieved some level of LEED certification - over 15,793,000sq.m (170 million sq. ft), with the majority of which being certified since 2016. The LEED Certification has led to an increase in rental rates for old buildings in Manhattan and is seen as a premium to tenants. For example, existing buildings built between 1925 and 1949 that achieved LEED certifications brought in rental rates averaging over 13% higher than their non-certified counterparts. [63] During the past three years, LEED-certified assets had a 21.4% higher average market sales price per square foot than non-certified buildings. [64]	Higher performing buildings rent faster in both clusters. Applied mostly to commercial tall buildings.
Performance Ratings	EPC [65] - currently used to show building energy performance particularly for existing buildings. EPCs have historically moved the dial on reducing emissions but are not accurate for differentiating between high performing buildings. NABERS [66] - coming into use via Better Building Partnership these more accurately reflect emissions from buildings in use.	Performance ratings only starting to be used. No impact as yet.	
		CLCPA Climate Leadership and Community Protection Act - Provides incentives to companies and may result in substantial change. The incentives are not paid up front so are used as a bonus rather than funding.	There is no similar incentive in UK. Implementation not yet comprehensive in US so impact unclear.
Carbon reporting - voluntary	In the UK only large and listed companies need to report GHG and carbon emissions. BUT large corporations often commit to targets and report against them.	Large brands make ESG commitments, but reporting is not public or widespread.	For companies that do report on carbon - including globally operating enterprises - they often aspire to the most ambitious target for the areas in which they operate. This can dramatically affect sustainability in their building use, and if they are fund managers hence in the buildings they own or operate. This - if incentivised more - could be a source to influence and collaboratively fund change.
SBTi	A globally operating methodology for declaring and measuring a science-based target to combat climate change. This is a rapidly developing and reacting set of targets aligned to individual sectors. It is robust and quantifiable. Commitment means ommitment.		
CRREM	A global methodology for assessing real estate resilience to future climate change regulations, this is often used by real estate owners to evaluate the risk of losing asset value due to lack of compliance. CRREM pathways are available for sectors and regions and can be used to identify if an asset will 'strand' i.e., risk losing value due to non-compliance with the regulatory emissions reduction targets. CRREM often used as part of refinance package along with a pathway to show route to net zero with costing		
Decarbonisation pathway	See above - used often in ESG reporting or to validate refinance and green finance in the UK		
TCFD [67] reporting	Required in UK (and EU) when refinancing and in annual reporting for UK companies or UK subsidiaries of global entities.	The US is reportedly signing up for TCFD reporting.	
TCND reporting	A new initiative to ensure Nature is recognised as part of the reporting strategy for companies. This is hoped to drive more nature based investment.		
EU taxonomy	While not required in the UK by law, international companies often use this to ensure consistency across their portfolio. This covers climate adaptation, emissions reductions, sustainability and environmental credentials.		
Resilience	An area of growing importance - includes economic and climate, disaster resilience. E.g., UNDRR Real estate resilience tool. [68]		
Tenants	Tenants reaching the end of lease are beginning to influence landlords and agree sustainable change to buildings as part of a lease extension. Finding ways to allow co-funding in a collaborative way could unlock the decarbonisation future of many buildings. For tall buildings a number of leaseholders may need to reach an agreement to push for viability, but opportunities exist in a tall building to retrofit using swing space.		
Corporate ESG aspirations	Corporate aspirations (ESG) are pushing the envelope on change for better sustainability outcomes (e.g., embodied carbon, energy efficiency, water use, climate resilience, social value)		
Carbon Pricing	Carbon pricing curbs greenhouse gas emissions by placing a fee on emitting and/or offering an incentive for emitting less. The price signal created shifts consumption and investment patterns, making economic development compatible with climate protection. Some companies use internal carbon pricing to assist in robust carbon decision making. [69]		
Offset Strategy	Where emissions cannot reach zero through minimising impact etc., offsetting forms the final step to net zero. Using local offsetting strategies with additionality to invest in local schemes for the benefit of the environment and community can fund change.		

Maximising the contribution of Tall Buildings

Identifying the challenge

We have discussed the rationale for tall buildings, the sustainability challenges they present, the advantages they bring and the drivers for change. Now we look at how to maximise the contribution tall buildings can deliver on environmental and sustainability challenges. In this chapter we concentrate on the London cluster while applying learning from the Lower Manhattan experience.

In the past decade, policy changes have been effective in reducing energy consumption and carbon emissions in new building and major refurbishments. Continuing enforcement and monitoring are necessary to ensure compliance and to educate and influence others. Building owners need to be willing to invest in retrofitting and energy-efficient technologies to achieve the intended results. Investment and change are necessary to reduce the future emissions, the majority of which will be from the existing building stock[70]. It is estimated that 80% of buildings that will be operational in a net zero 2050 exist today. This means that looking hard at the existing tall buildings we have and maximising their contribution to net zero - as well as paying rigorous attention to the impact from new tall buildings.

Many of the policies and non-regulatory drivers discussed in the last chapter are true of the real estate market in both London and New York; there is an added value for more sustainable buildings. This can be seen in various ways including [64]:

– Improved marketing abilities and faster rental uptake

– Access to green finance

– Potential lease extension

– Residual building value.

As discussed throughout the report, there are some challenges that apply particularly to tall buildings:

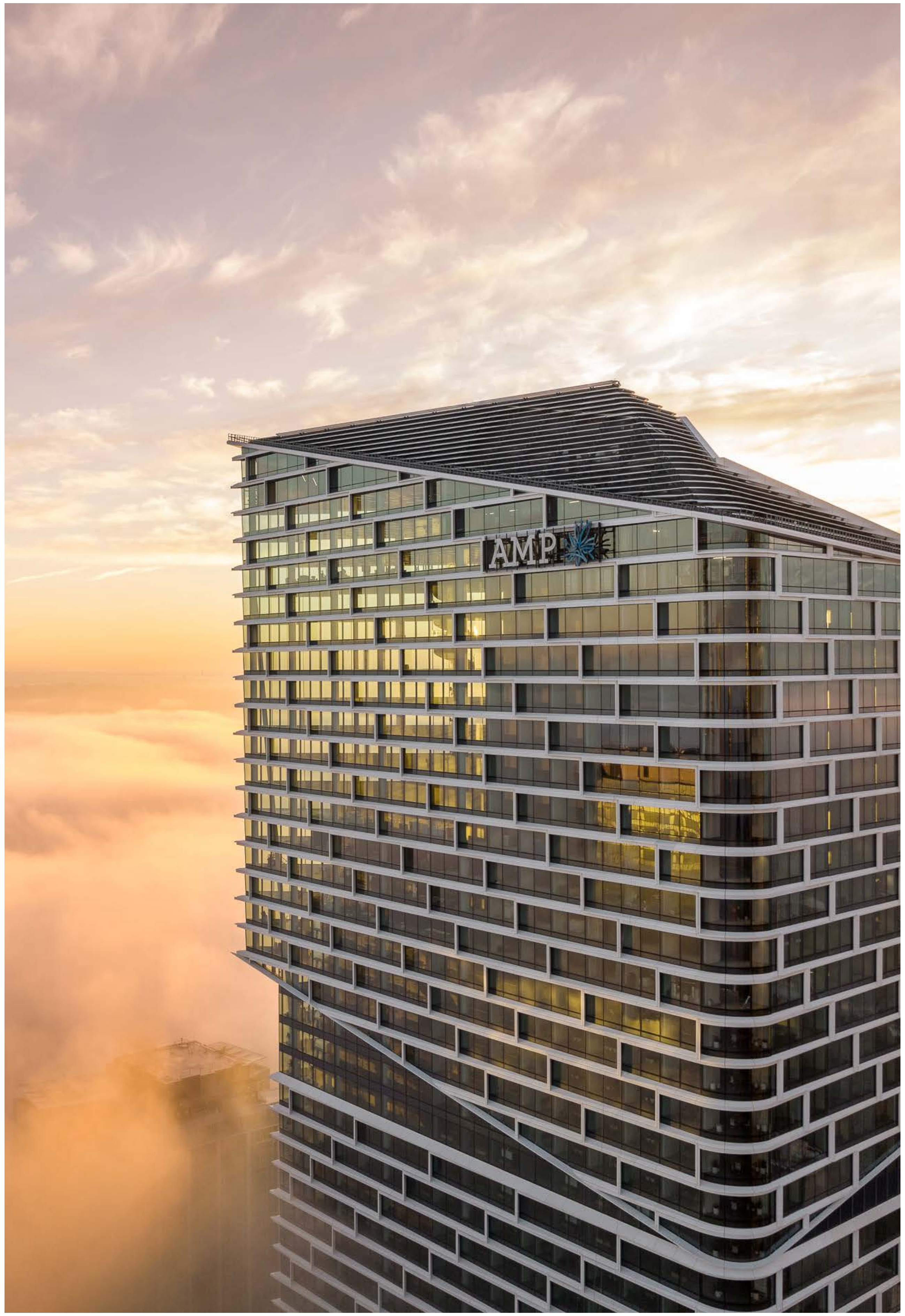
– The scale of the decarbonisation challenge. Tall buildings have multiple tenants, expanses of façade, and large centralised systems. It is disruptive to make changes to existing tall buildings.

– It is difficult to analyse accurately the holistic environmental contribution of tall buildings. As we previously noted, tall buildings are associated with increased density and agglomeration benefits, and their contribution as a district to the economy - but these benefits apply to their shorter neighbours too. Individual studies may be needed to accurately affect the contribution of each tall building.

– Space for all-electric heat generation - perhaps via ASHPs (air source heat pumps). Tall buildings have a vast GIA to footprint ratio. Finding sufficient space for all-electric rooftop plant can be a challenge but decarbonising fuel source is necessary. Heat networks are mentioned elsewhere in this report and provide one potential solution.

– Fabric performance. Regulatory requirements for improved fabric performance mean many older buildings will not achieve new regulations, requiring significant investment over the height of a tall building.

This chapter looks initially at how we can reduce carbon emissions before concentrating on three main areas where we can maximise the positive impact of tall buildings.



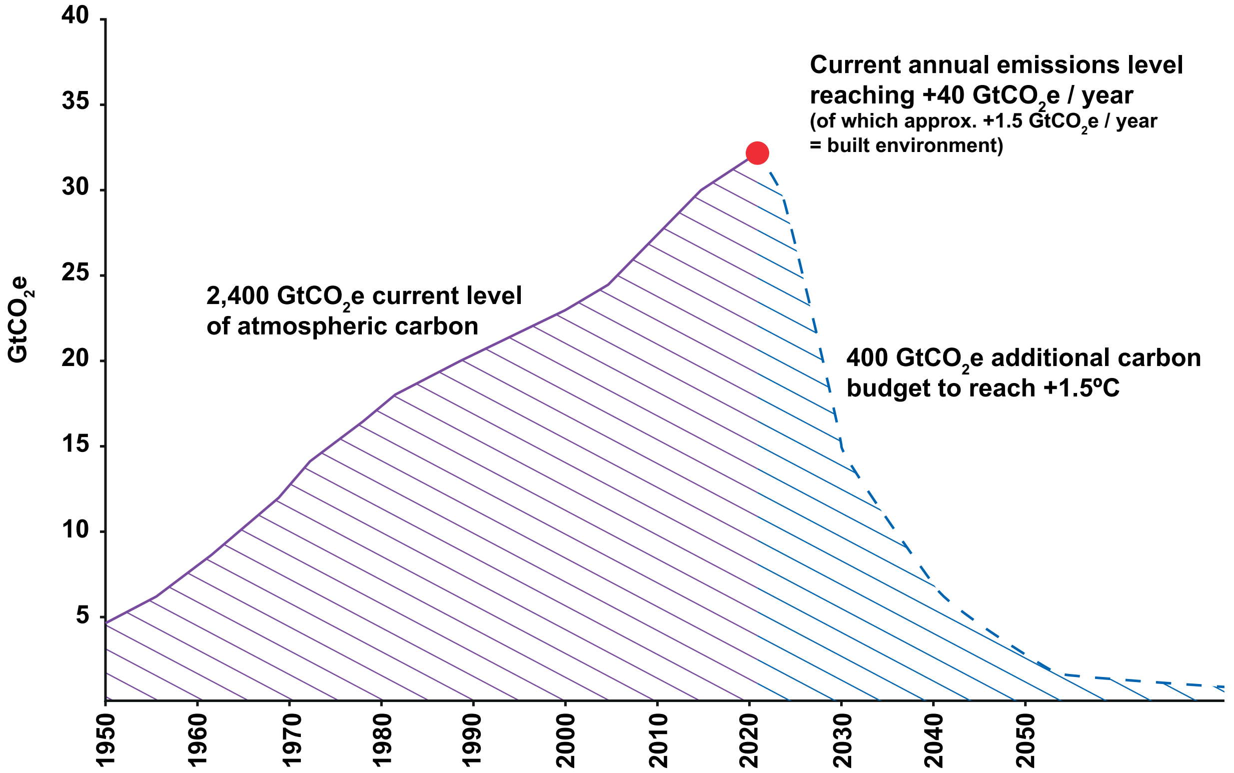
Quay Quarter Sydney
© Adam Mørk

Reducing construction carbon emissions

The built environment is responsible for almost 40% of global energy and process related carbon emissions[76] - approximatively 14 gigatons of carbon each year. Moreover, typically as few as six materials account for 70% of the construction-related embodied carbon

London	New York
In 2019, the City of London, scope 3 emissions (including embodied carbon of buildings) were responsible for 96% of the total greenhouse gas emissions.[79] Similarly, the scope 3 emissions for the Square Mile were as high as 50%.	In New York City (NYC), according to the Climate Mobilization Act of 2019, buildings are responsible for nearly 70% of the city's greenhouse gas emissions.[55]

To limit temperature rises to well below 2°C, in accordance with the Paris Agreement (2015), global emissions must effectively half by 2030 and reach Net Zero by 2050[80]. Effective carbon emission monitoring and tracking, taking action to reduce emissions, and investing to remove carbon from the atmosphere will be required to meet these targets. The first step on the roadmap to Net Zero will be data collection and pathway modelling.



Cumulative impact of atmospheric carbon since 1950, including future budgets. Source: WBCSD

London	New York
The Mayor's London Environment Strategy declared an aspiration for a Zero Carbon City by 2050. -and- The City of London Corporation have committed to achieving net zero in their Scopes 1 and 2 emissions by 2027, achieving net zero in the Square Mile by 2040, and achieving net zero in their value chain by 2040.[54] -and- In 2019, the Square Mile achieved a 55% reduction in Scope 1 and 2 emissions since 2008, assisted by their ambitious planning requirements which have led to over 20,000m² floor space achieving at least a BREEAM 'Excellent' rating since 2014.[79]	The NYC Mayor announced plans for Carbon Neutrality by 2050, aligning with the 1.5oC Paris Agreement limit to climate change[42]. -and - The Climate Mobilization Act is expected to: Reduce New York City's overall emissions 10% by 2030[41] -and- Local Law 97 of 2019 "is expected to reduce cumulative emissions from large buildings at least 40% citywide by 2030 through building retrofits."

As discussed in the policy and drivers section, corporate emissions reporting and corporate ESG targets are helping concentrate efforts on reducing carbon emissions. Companies that do report on carbon - including globally operating enterprises - often aspire to the most ambitious target for the areas in which they operate. Acting on their commitment can dramatically affect sustainability in their scope 1, 2 and 3 emissions - all of which can emanate from the built environment.

– Scope 1 emissions - includes emissions from sources controlled by the reporting company. Tenants in tall buildings may need to report their fuel use under scope 1.

– Scope 2 emissions - includes indirect emissions e.g., associated with generating fuel. Again, a tenant would need to report their scope 2 emissions.

– Scope 3 emissions are the result of activities from assets not owned or controlled by the reporting organization, but that the organization indirectly affects in its value chain. For a tall building the fund manager/ real estate investment trust or developer who owns the building will report the tenants' scope 1 and 2 emissions as their scope 3 emissions.

Carbon emissions through the life of a building

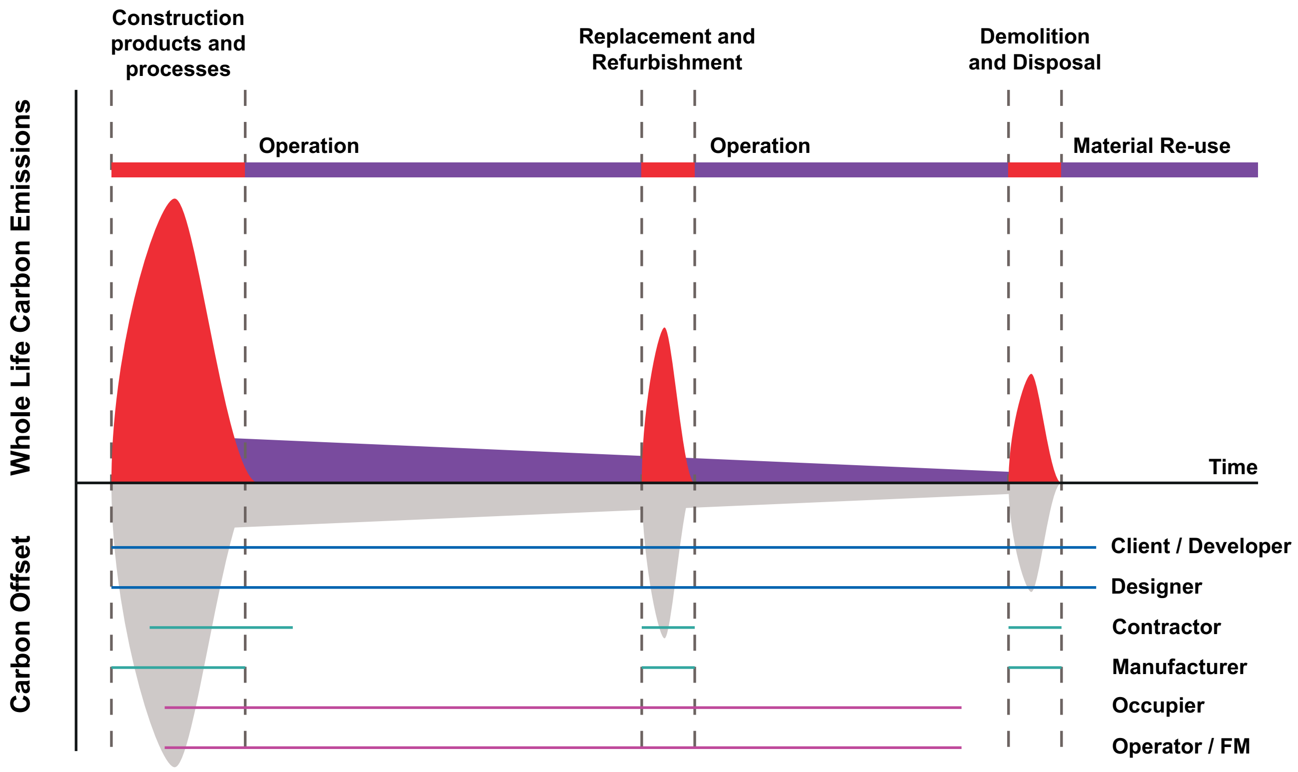
The construction industry is evolving, and it is no longer acceptable to consider the energy efficiency of the building as the only carbon emission metric. The whole life carbon approach acknowledges the carbon emissions that occur outside the site boundary, and includes the ongoing maintenance, replacement and refurbishment as well as the demolition of the building materials.

Emissions for a building throughout its life comprise:

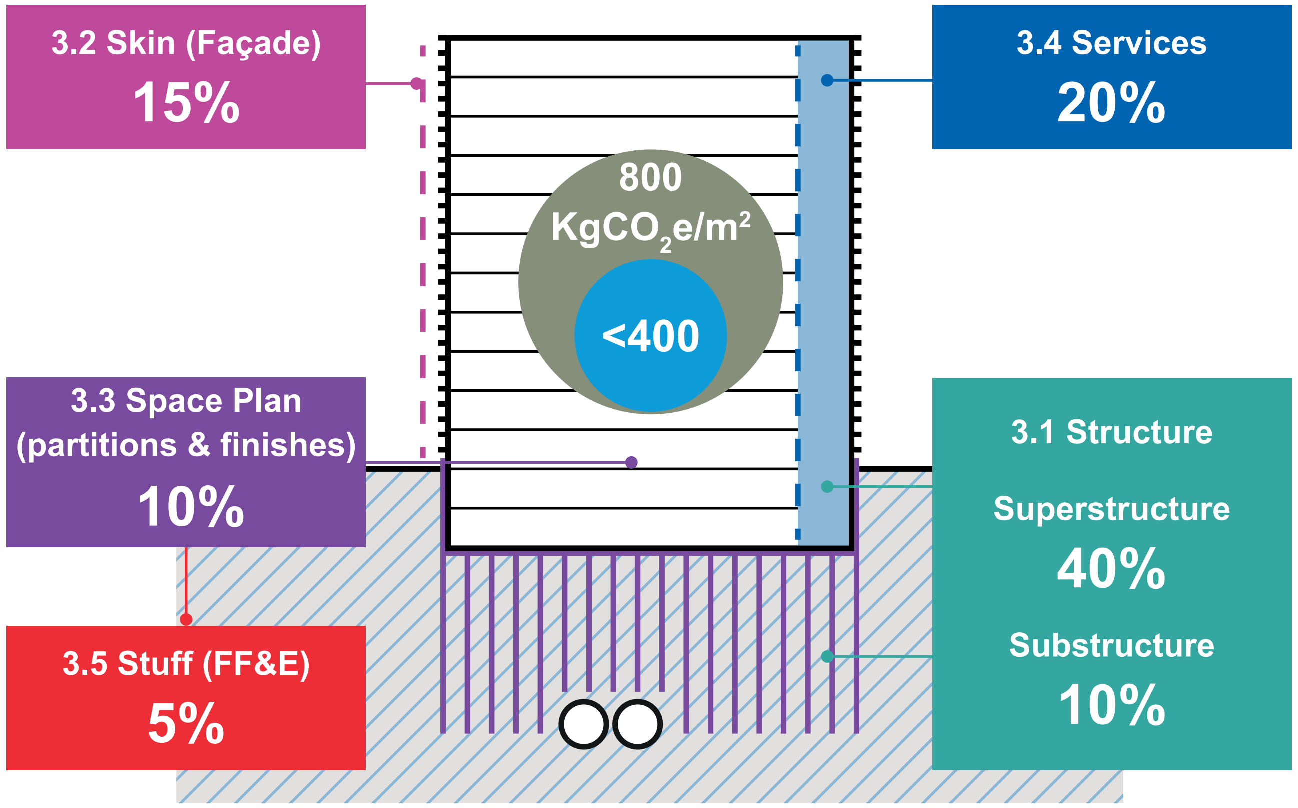
– embodied carbon - shown in red - at construction phase, maintenance and refurbishment - of which there may be many cycles, and deconstruction,

– operational carbon - shown in purple - associated with building energy use.

By reusing existing buildings, a substantial amount of the original embodied carbon is reused. But at the same time, the buildings that are created must be attractive to the market and form lasting assets with a considered risk of needing further (carbon intensive) interventions in the near to medium term.



Achieving a Net Zero Carbon Building: when carbon is emitted in the life of the building, and who can make an impact.



Achieving a Net Zero Carbon Building: on average, where the embodied carbon emissions are attributed to in the buildings. Source: WBCSD

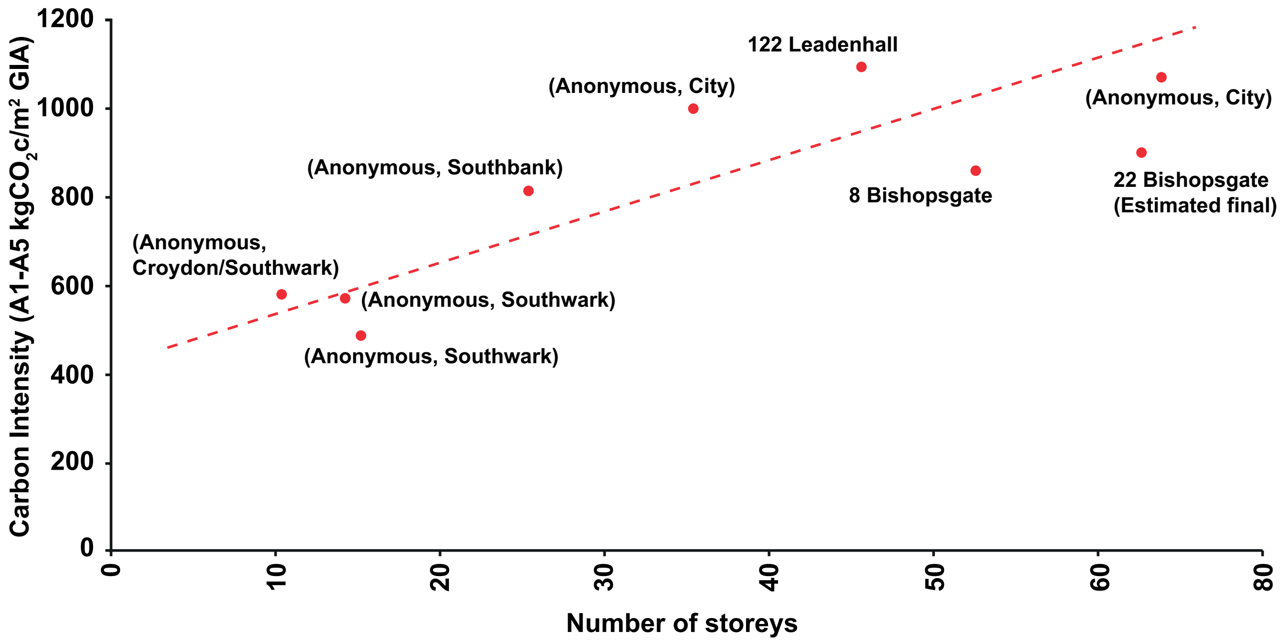
Embodied carbon

The graphic above[61] shows that a large proportion of the embodied carbon emissions for a tall building are present in the super structure of the building as well as the façade components, but also a significant amount is within the building services.

Gaining a greater understanding of where our embodied carbon emissions are, and how they compare within the context of the whole life of the building, helps us to pinpoint the areas of greatest potential to influence.

This is putting pressure on the new build market to significantly decarbonise their material use and construction processes that make up their embodied carbon emissions. Building designers are also using embodied carbon calculators to reduce embodied carbon throughout their decision making, and some policy requires embodied carbon emissions reporting. Policy makers in London are using this lever to increase the number of properties choosing to retrofit over building new.

Decarbonising built assets



The graph above shows how carbon intensity typically increases with the number of storeys; this information is causing designers and manufacturers to explore innovative materials and methods for tall building construction.

Operational Carbon

Tall buildings are also less energy efficient compared to smaller buildings. Researchers at UCL found, in 2017, that for a sample of 611 office buildings in England and Wales, electricity use was effectively two and a half times greater in high-rise office buildings of 20 or more storeys than in low-rise buildings of 6 storeys or less on an area intensity basis. The opportunity to reduce operational carbon in high rise buildings is higher: total carbon emissions from gas and electricity from high-rise buildings were twice as high as in low-rise[84].

Decarbonising built assets

In order to meet the WGBC net zero target, there is a need to reduce carbon emissions by around 60% to align with science based 1.5°C targets. Regulations and aspirations for buildings are getting stricter to reduce targets for carbon intensity and carbon emissions - both embodied and operational.

The risk to the value of a built asset by not complying with future climate regulations and aligning with sector expectations has been modelled by CRREM[81]. Assets performing worse than the sector decarbonisation pathway may be exposed to stranded asset risk. This could be brought on by a change in regulations, for example, increasing energy performance standards or imposed embodied carbon reporting and reduction targets.

As tall buildings are typically more carbon intensive in both these areas than shorter buildings, this could significantly impact on the tall building market across all sectors, with the Class A commercial property market at most risk due to high rent elasticity.[82]

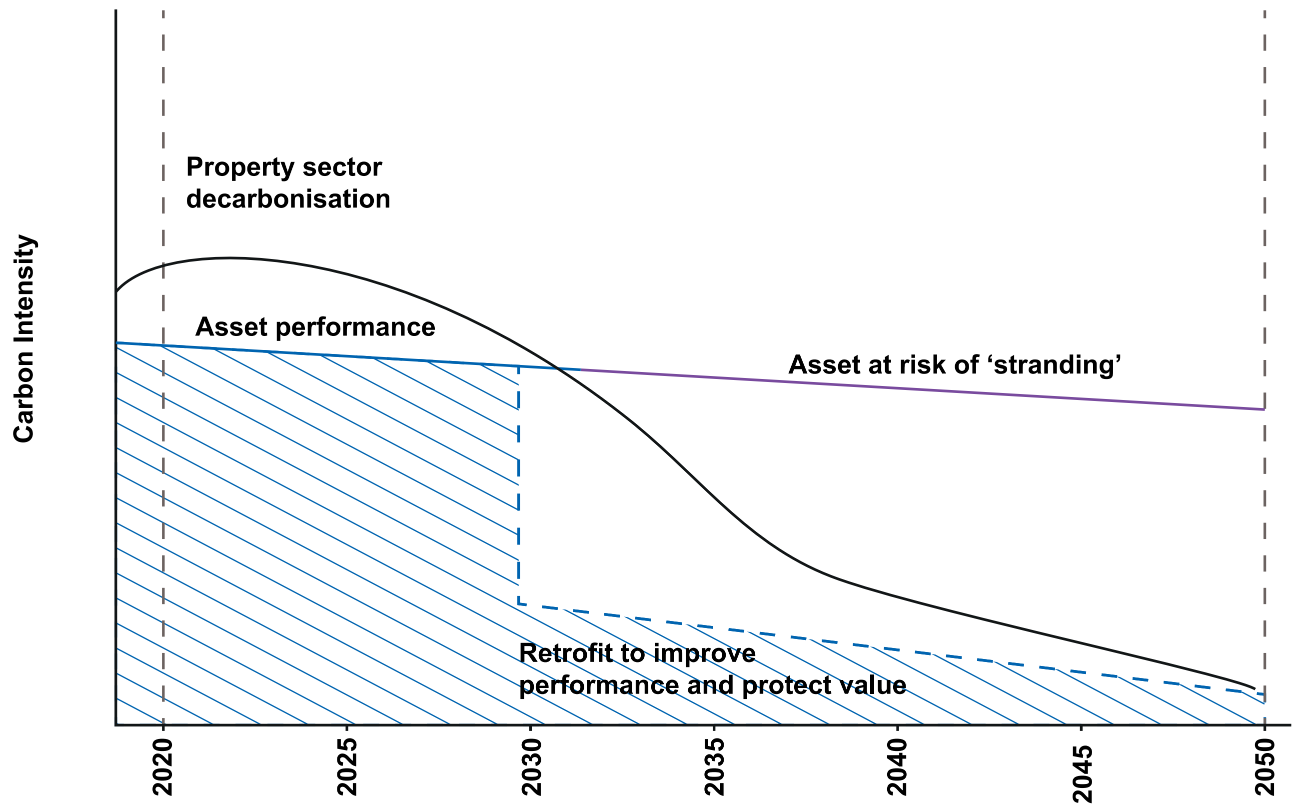


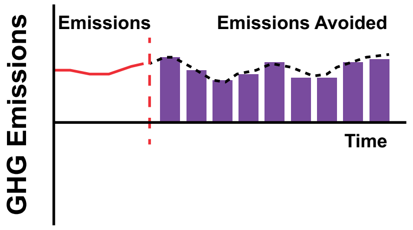
Diagram demonstrating asset stranding risk.

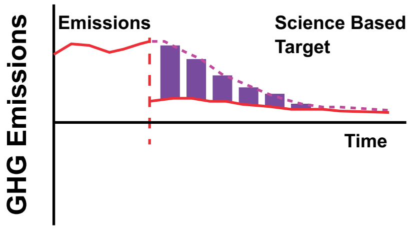
The scale of stranded asset risk is yet to be fully understood. In both cities, sustainability certification schemes have shown added value for commercial properties, and the number of properties on the market rated by energy performance verification schemes such as NABERS is increasing.
Other drivers for change, such as ESG aspirations, SBTi and landlord-tenant relationships, are discussed in more detail in the Policy and Drivers section.

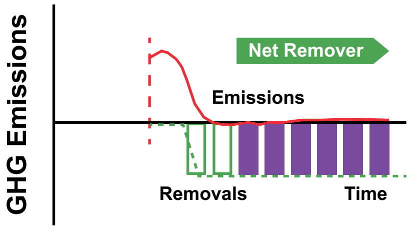
Other sector markets, such as residential or retail, will likely respond at a different rate, and other factors, such as affordability, might take priority for policy makers. Different CRREM pathways exist for different sectors and regions.

London	New York
The City is a key driver of the economy, generating over £85bn in economic output annually, or 4% of all UK GVA. Yet, the City only accounts for 0.001% of the UK's size.[2] Although only 1% of the City's 22,305 businesses are large, they account for over half of the City's employment. Despite being the smallest local authority area in the UK, the City has the second highest number of large firms. This means the City sees a high proportion of smaller commercial tenants, predominantly in the financial services and professional services sectors.	Lower Manhattan comprises less than 1% of the entire city's land area but generates almost 10% of the city's total economic output, as measured by Gross City Product, and is the location of over 10% of all New York City jobs.[3] Since 2001, over $20 billion of public and private investment has bolstered Lower Manhattan's transformation into a thriving, 24-hour live-work district. Hotel development has catalysed tremendous growth in tourism in Lower Manhattan: in 2016, nearly 15 million tourists visited the District, a 19% increase over the previous year.

Responsibly offsetting







Avoidance Offset Credits

Avoidance Credits are certified when an offset project has successfully prevented any Greenhouse Gas (GHG) emissions which most likely would have happened, had it not been for that action, in the base case scenario.

Reduction Offset Credits

Reduction Credits are certified when an offset project has successfully net reduced its own Greenhouse Gas (GHG) emissions beyond what is required by Science Based Targets when considering a whole life cycle GHG assessment.

Removal Offset Credits

Removal Credits are certified when an offset project has successfully Net removed Greenhouse Gas (GHG) emissions from the atmosphere when considering a whole life cycle GHG assessment.

What are the opportunities to responsibly offset residual emissions?

This report describes how the design, refurbishment, operation, and maintenance of tall buildings needs to be addressed to reduce their carbon emissions - both operationally and, for new buildings, in embodied carbon. However, having reduced emissions in line with limiting global temperature rise to 1.5°C, any residual GHG emissions should be responsibly removed from the atmosphere. This is the important balancing element of the equation to achieve Net Zero. The IPCC AR6[71] report recognises that reaching Net Zero primarily requires deep and rapid reductions in GHG emissions. However, some hard-to-abate residual GHG emissions (e.g., industrial processes) would need to be counterbalanced by deployment of GHG removal methods to achieve Net Zero.

At an individual building level, one of the opportunities to invest in removing the associated emissions which a project was unable to abate, comes from purchasing removal offset credits. Carbon offsets are certifiable and transferable units of emissions, termed credits, that can be purchased by an entity to balance their emission outputs through investment in additionality projects that remove, reduce or avoid emissions elsewhere. These credits are bought and then retired, to prevent them being sold on again. The Voluntary Carbon Market (VCM) is an un-regulated market where carbon credits are purchased by projects for voluntary use rather than to comply with legally binding emissions reduction obligations. There are different types of offsets available on the VCM, but these are typically broken down into three categories, avoidance, reduction and removal offsets.

Individual poor practices in the VCM have led to accusations of greenwashing and climate inaction[72]. To address this, the ICVCM[73] has introduced core carbon principles to complement existing ICROA[74] criteria. The Oxford Principles for Net Zero Aligned Carbon Offsetting[75] serve as a resource to help guide the implementation of voluntary project Net Zero commitments. While it may not be currently feasible to retire 100% removal offset portfolios at the required scale in 2023, the principles across these documents emphasises the opportunity to transition to this best practice.

There are two types of removal opportunities: nature based and technological. When considering offsets, it is important to ensure the permanence of the removed GHG as well as exploring co-benefits. Nature based solutions, like afforestation, can benefit soil quality, biodiversity, and local communities, but may have adverse effects on water, food production, and land rights based on implementation. Compared to storing carbon in rocks, nature-based storage is less durable due to potential reversibility from human or natural disturbances. However, more permanent solutions for carbon removal and storage using technology are currently costlier per tonne of CO_2 removed.

In an urban environment, there is limited opportunity to invest in schemes which remove greenhouse gas emissions. It is not practical to build large industrial direct air capture facilities or to plant sufficient woodland within the urban environment at the sufficient scale needed. However, there are additional opportunities a project could take within the VCM that benefits wider society.

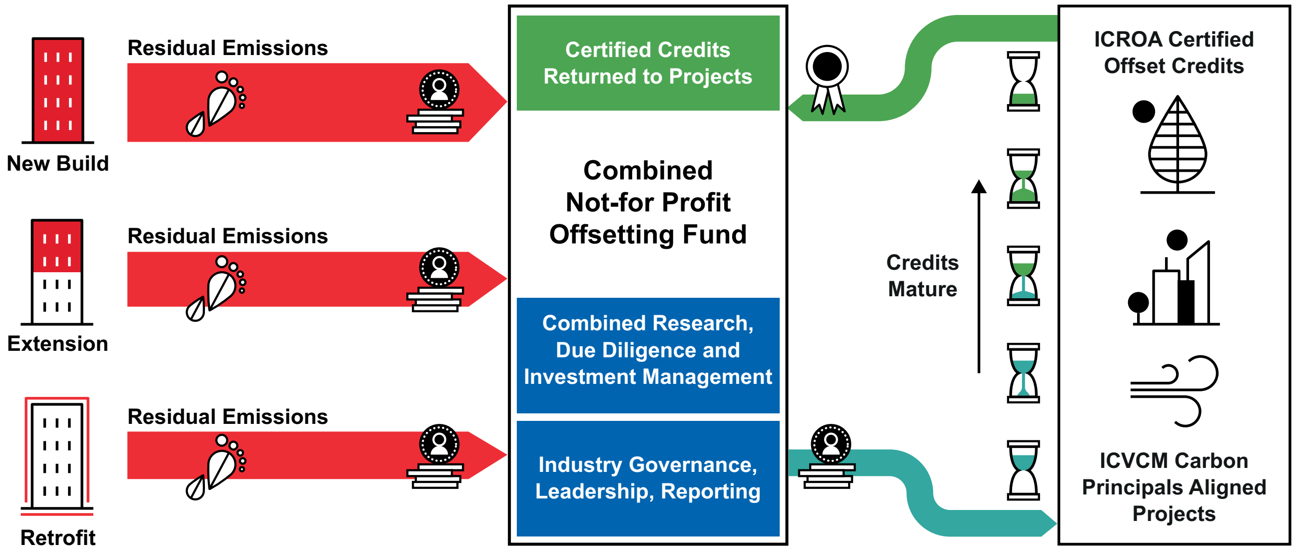
Example: Technology Removal	A solar-powered Direct Air Capture facility in Australia uses giant fans to capture atmospheric CO_2 by passing the air through a filter that absorbs CO_2. The captured CO_2 is then injected into deep geological reservoirs for permanent storage.
Example: Nature Based Removal	The ECO2 Rubber Forests project removes carbon from the atmosphere by reforesting degraded farmlands in Guatemala. To do so, it provides positive incentives for reforestation with sustainable and responsibly managed rubber tree forests providing direct benefits to local communities.

To provide market certainty for removal technology it is recommended that a minimum of 50% of any offsetting portfolio considers removal credits with the aspiration to transition towards 100% by 2050.

RETROFIT CREDITS, which is currently in a pilot stage in the UK, will provide a channel for investment in social housing by verifying the emission reductions and social value of housing retrofit projects and originating carbon credits backed by those emission reductions. It will centre the impact of these retrofit activities on residents and communities through the incorporation of social value metrics so that the funding unlocked through carbon credits doesn't just reduce carbon, but also improves lives. It is expected that other similar schemes will also be developed in the UK.

Similar to the removals discussed earlier in this section, there are not enough of these types of retrofit credits currently market available in the VCM. However, we know that there are significant volumes of poor-quality buildings which need to be retrofitted to meet global climate objectives.

Best practice retrofit and removal projects require significant capital investment and time before any credit can be sold and retired. Therefore, a growing movement is developing to encourage projects and organisations to explore the opportunity to invest collectively in best practice offset schemes.



An Introduction to Resilience

Cities are subject to a wide range of natural and man-made pressures that have the potential to cause significant disruption, at their worst leading to cascading social breakdown, economic decline or physical collapse. Historically, urban risk management has focussed on understanding the impact of specific hazards and taking appropriate measures to mitigate risk. In recent years the growing diversity of hazards, increasing complexity of cities, and uncertainty associated with climate change, globalisation and rapid urbanisation has made building urban resilience into a critical agenda.

Risk assessments and measures to reduce specific foreseeable risks will continue to play an important role in urban planning. In addition, cities need to ensure that their development strategies and investment decisions enhance, rather than undermine, a city's resilience. If governments, donors, investors, policymakers, and the private sector are to collectively support and foster more resilient cities, there needs to be a common understanding of what constitutes a resilient city and how it can be achieved.

City Resilience

City resilience describes the capacity of cities to function, so that the people living and working in cities - particularly the poor and vulnerable - survive and thrive no matter what stresses or shocks they encounter. Resilience focuses on enhancing the performance of a system in the face of multiple hazards, rather than preventing or mitigating the loss of assets due to specific events.

Energy Resilience

Resilience in an energy system can be defined as its ability to reduce the impact of shocks and stresses, including the capacity to anticipate, absorb, adapt to, and rapidly recover from such events and to transform where necessary. Resilience must consider social, technical, and organisational components.

– Shocks and stresses - what puts a system at risk?

– Ageing and deteriorating assets

– Increasingly interconnected and interdependent systems

– Extreme weather events and climate change

– New, disruptive technologies

– Natural hazards such as earthquakes and volcanoes

– Human error

– Geopolitical uncertainty

– Population growth

– Physical and cybersecurity threats

– Changing consumer expectations

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Qualities of resilient systems:

1. Reflective

Reflective systems are accepting of the inherent and ever-increasing uncertainty and change in today's world. They have mechanisms to continuously evolve and will modify standards or norms based on emerging evidence, rather than seeking permanent solutions based on the status quo. As a result, people and institutions examine and systematically learn from their past experiences and leverage this learning to inform future decision-making.

2. Robust

Robust systems include well-conceived, constructed, and managed physical assets, so that they can withstand the impacts of hazard events without significant damage or loss of function. Robust design anticipates potential failures in systems, making provision to ensure failure is predictable, safe, and not disproportionate to the cause. Over-reliance on a single asset, cascading failure and design thresholds that might lead to catastrophic collapse if exceeded are actively avoided.

3. Redundant

Redundancy refers to spare capacity purposely created within systems so that they can accommodate disruption, extreme pressures, or surges in demand. It includes diversity: the presence of multiple ways to achieve a given need or fulfil a particular function. Examples include distributed infrastructure networks and resource reserves. Redundancies should be intentional, cost-effective and prioritised at a city-wide scale, and should not be an externality of inefficient design.

4. Flexible

Flexibility implies that systems can change, evolve and adapt in response to changing circumstances. This may favour decentralised and modular approaches to infrastructure or ecosystem management. Flexibility can be achieved through the introduction of new knowledge and technologies, as needed. It also means considering and incorporating indigenous or traditional knowledge and practices in new ways.

5. Resourceful

Resourcefulness implies that people and institutions are able to rapidly find different ways to achieve their goals or meet their needs during a shock or when under stress. This may include investing in capacity to anticipate future conditions, set priorities, and respond, for example, by mobilising and coordinating wider human, financial, and physical resources. Resourcefulness is instrumental to a city's ability to restore functionality of critical systems, potentially under severely constrained conditions.

6. Inclusive

Inclusion emphasises the need for broad consultation and engagement of communities, including the most vulnerable groups. Addressing the shocks or stresses faced by one sector, location, or community in isolation of others is an anathema to the notion of resilience. An inclusive approach contributes to a sense of shared ownership or a joint vision to build city resilience.

7. Integrated

Integration and alignment between city systems promotes consistency in decision-making and ensures that all investments are mutually supportive to a common outcome. Integration is evident within and between resilient systems, and across different scales of their operation. Exchange of information between systems enables them to function collectively and respond rapidly through shorter feedback loops throughout the city.

Key Opportunities

Reducing carbon is only one aspect of sustainability but understanding the links and challenges between tall buildings and carbon help us prioritise how to maximise benefits.

We believe there are three main opportunities:

1. Increasing retrofit feasibility.
2. Taking a new approach to new build.
3. Creating a resilient city by maxmising collective influence.

Opportunity 1 - Increasing retrofit feasibility

Retrofit properties have been shown to emit considerably less embodied carbon emissions than new build, due to the avoidance of one cycle of demolition and construction. Increasing the feasibility of retrofit to enable a reduction in new build construction, whilst prioritising the building value and operational performance, will be the key to providing more sustainable pathways to Net Zero for the city and its built environment.

Continuing to provide high value office space, coupled with amenity, for the resident industries will boost productivity in the Square Mile, as high-quality stock will attract and help to retain high value-adding businesses. Moreover, allowing for flexible and adaptable working spaces will continue to help meet policymakers needs.

NYC governing institutions have identified that by maximising the contribution of existing commercial real estate assets the efficiency of its tall building cluster can be increased. In the UK, LETI[70] suggests a 2030 embodied carbon target (A1-A5) of 350kgCO_2e/m^2 for commercial offices (subject to change) which is also driving a shift towards the retrofit market.

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The attributes to introduce and focus on within the existing tall buildings include:

– Meeting carbon reduction targets - Both city mayors have communicated aspirational carbon emission reduction targets for their cities, although these are not yet a legal requirement. Substantial reductions in carbon emissions requires an uptake in the retrofit market due to the high embodied carbon content in building materials.

  – In NYC, the Local Law 97 of 2019 is expected to reduce cumulative emissions from large buildings at least 40% citywide by 2030 through building retrofits.

– Flexibility and adaptability - designing for future uses and for occupancy diversity enables organisations to take less space while creating amenity and other functions resulting in longevity of use, and a more effective use of space.

  – New York developers are converting existing buildings to different uses to respond to a changing economic and environmental landscape. Increasing the number of retrofit property repositioning projects helps to decarbonise the construction industry.

– Good quality building stock -. Much of existing building stock has considerable residual value, either as it currently operates, or with a level of refurbishment. This is also true for energy performance, as shown by the adoption of NABERS UK as an energy performance indicator.

  – Emerging energy performance frameworks in the London commercial sector focus on verified energy monitoring and reporting, as well as including energy conservation clauses in tenancy agreements.

– A balanced approach to heritage -Utilising the attributes of the existing buildings to optimise their function and contribution to the cluster, considering change of use and overall environmental impact.

  – An example of this would be naturally ventilating a heritage building with opening windows; this may not be viable for its original function (i.e. an art gallery), however changing use changes the design requirements (i.e. a community hub).

– Improving building databases - A barrier to improved decision making during the design phases is the lack of verifiable benchmark data for buildings. Through improved data collection, and joined up partnerships, metrics such as actual energy performance can be monitored and retrofit interventions assessed more accurately.

Quay Quarter Sydney
©Adam Mørk

Case study: Upcycling - Quay Quarter Tower[64]

Quay Quarter Tower is a landmark building in Sydney's Circular Quay offering new work, retail, and social experiences.

While the tower's excellence is evident to the naked eye, many hidden engineering gems are inside and outside the building, setting a new standard for sustainable building design. Arup's adaptive, retrofit design retained 65 per cent of the original building's existing floorplates and structure and 98 per cent of the original structural walls and core. This equates to a saving of approximately 12,000 tonnes of embodied carbon.

Originally built as the AMP Centre in the 1970s, AMP Capital had a vision to transform the traditional office space to be the centrepiece of a thriving cultural precinct integrating with the nearby Quay Quarter Lanes, heritage buildings and a bustling foreshore.

Working closely with Danish architect 3XN, it is the first major project designed by a Danish architect in Sydney since Jørn Utzon collaborated with Ove Arup on the Opera House in 1973.

12,000
tonnes of embodied carbon saved

120sq m
of floor space saved

98%
of the buildings original structure retained

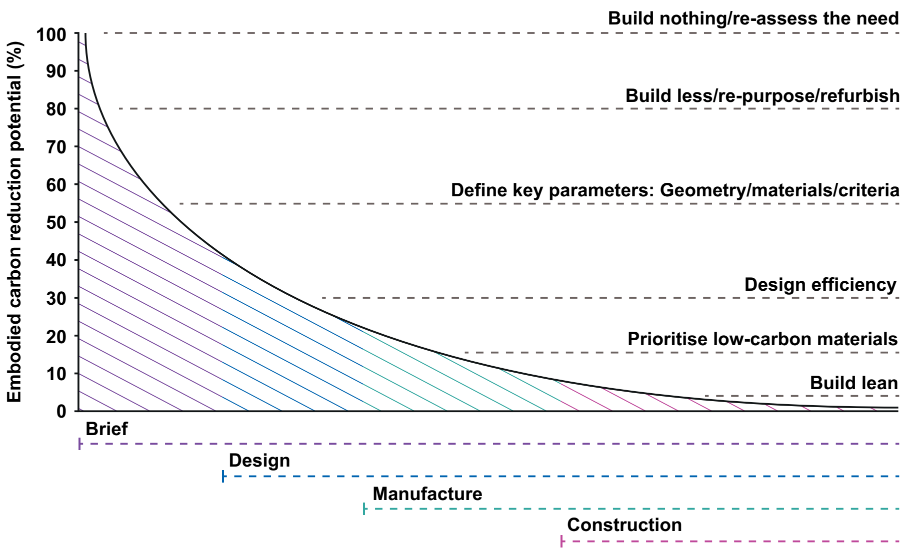
Opportunity 2 - Take a new approach to new tall buildings

The tall buildings that shape the skylines in London and New York have helped them develop an unshakable character and global identity, attracting people, capital and employers to their respective cities for both business and pleasure. New buildings offer the opportunity to provide high quality, healthy and vibrant spaces, increasing density and improving the amenity provision in local areas. However, the carbon cost of building new must be balanced and viewed alongside the benefits; are the cities using their significance to set an example of sustainable growth, and pioneer new technologies and approaches? Are new buildings providing net zero accommodation for responsible tenants? Does this affect value positively? How is embodied carbon viewed as part of this story?

New York and London are both striving to align with the Paris Agreement (2015) through carbon emission reduction targets and policy reform. There have been some technological advances and policy reforms that have achieved some reductions (see earlier sections), but barriers to decarbonisation at the rate required still remain.

It is widely accepted that construction needs to continue to support the expected population growth and improve the quality of living for future generations. Moreover, building something exceptional can help improve the lives of the people in the place the tall building occupies, either through job creation, responding to a local need, or creating homes and social spaces.

Moreover, Arup has found, through research based on the topic of circular economy in collaboration with the Ellen MacArthur Foundation, that real estate investors and construction clients are best placed to lead in the decarbonisation of the construction industry, in the hope that through positive action these stakeholders will provide an evidence base for policy makers. In other words, investment in sustainable innovation through better project decision making could start a chain reaction of industry innovation.



"The best building is the one you don't build" is a phrase commonly used by architects and engineers alike to assess the feasibility of schemes against wider sustainability credentials.

Some of the key benefits and opportunities for building new are:

- Managing complexity - Over-site development and mixed-use developments challenge the traditional functions of a building but contribute to the sense of place and the functional experience of the city. Redevelopment can also provide significant opportunities for resilience and universal design (i.e., improved accessibility) and improved social value through greater connectivity of spaces.
- Gaining from shared facilities - understanding the use profile and functions of existing buildings in a new development allows analysis of and proposals for: energy centres, heat sharing, green spaces etc.
- Understanding transport - Taking advantage of central and density of location to serve many more people and with sustainable transport modes than less dense and central locations.
  - Going vertical -The tipping points of vertical transportation drive floorplate and carbon efficiency, as well as how this impacts the connectivity. The optimisation of the distance, efficiency and viability leads to a defined optimum building height.
- Building something exceptional - offering better work-life balance by achieving greater diversity of context and accessibility to workspaces, culture, education, other services for people
- Adopting modern design and construction techniques - Embodied carbon in the built environment can be reduced significantly pioneering new and emerging technologies throughout the supply chain. For example, materials science is innovating to provide greener concrete solutions, and the adoption of digital software improvements has enabled greater research into design optimisation.
  - Criteria such as the Resilient Design for the Next Generation of Buildings (REDi[88]) can act as reference for users and developers to promote and add value to efficient and resilient tall building design.
  - Where ground conditions are favourable raft or piled raft solutions can be considered as a lower carbon alternative. Spreader walls can be used to redistribute vertical loads more uniformly across the base of the building.

  Innovative solutions involving post-tensioning of the raft and concrete cores have been implemented in recent years to reduced concrete volumes.
- Efficient Super-structure design - High strength materials, both for both steel and concrete elements, will result in lighter and slimmer elements, therefore helping in minimizing the foundations and overall sizes.
  - Each additional floor adds carbon, so light weight floor systems such as post-tensioned slabs, composite decking, and carefully engineered hybrid concrete -timber planks, are a key element to deliver a low carbon tall building.
  - Supplementary damping systems have the potential to allow significant reduction in a building's embodied carbon, as reducing dynamic response (movement) can reduce superstructure and foundations material requirements. Moreover, damping systems have proven to reduce structural and non-structural damage after large typhoons and seismic events thus improving building and community resilience under catastrophic events.
- Considering construction methodology and programme - Programme might require early strength gain in concrete core elements due to the construction and pre-fabrication where possible. Integration of temporary and permanent works design into a holistic approach at early stages would help in avoiding unnecessary carbon expenditures due to an inefficient construction methodology.
- Urban renewal opportunities - In circumstances where refurbishing the existing wouldn't solve many of the problems seen by the local communities such as poor fabric performance, safety issues and poor social connectivity, new build high rise offers the opportunity to increase density, opportunity for local people, efficiency of land use and ability to share services, whilst place-making, providing community amenity and better connectivity for all those in the local area.
  - Ebury Bridge Estate is an example in London, where problems with the existing building fabric, performance, safety issues of the layout, poor social connectivity and lighting were leading to an unsafe neighbourhood.

Innovative ways we are decarbonising the construction industry

From Principles to Practices[89] is a two-phase collaborative project led by Arup and the Ellen MacArthur Foundation that aims to translate the principles of a circular economy into everyday built environment practices by signposting the business case for Circular Economy.

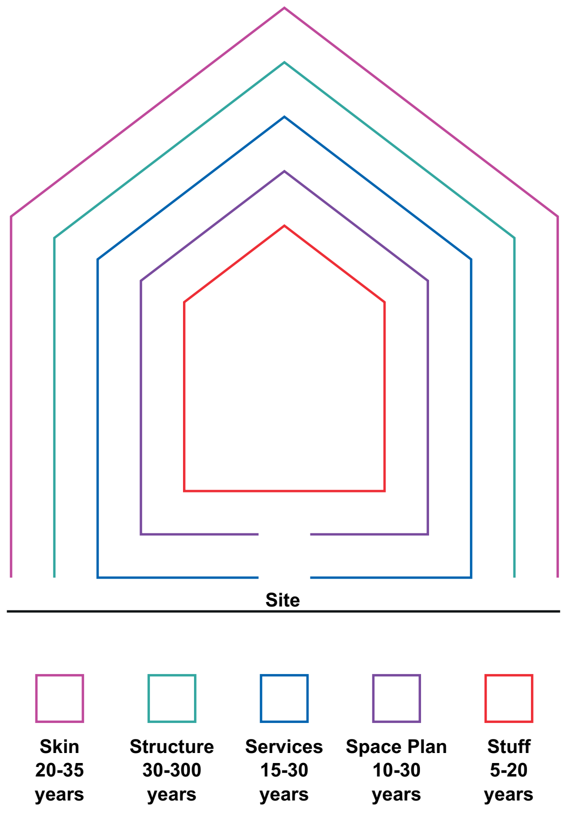
The first report titled *First Steps Towards a Circular Built Environment* released in July 2018, established the vision for a circular built environment and identified the key barriers, opportunities, and enablers of implementing circular economy practices. It also informed proposals for who needs to lead the change and what their first steps might be.

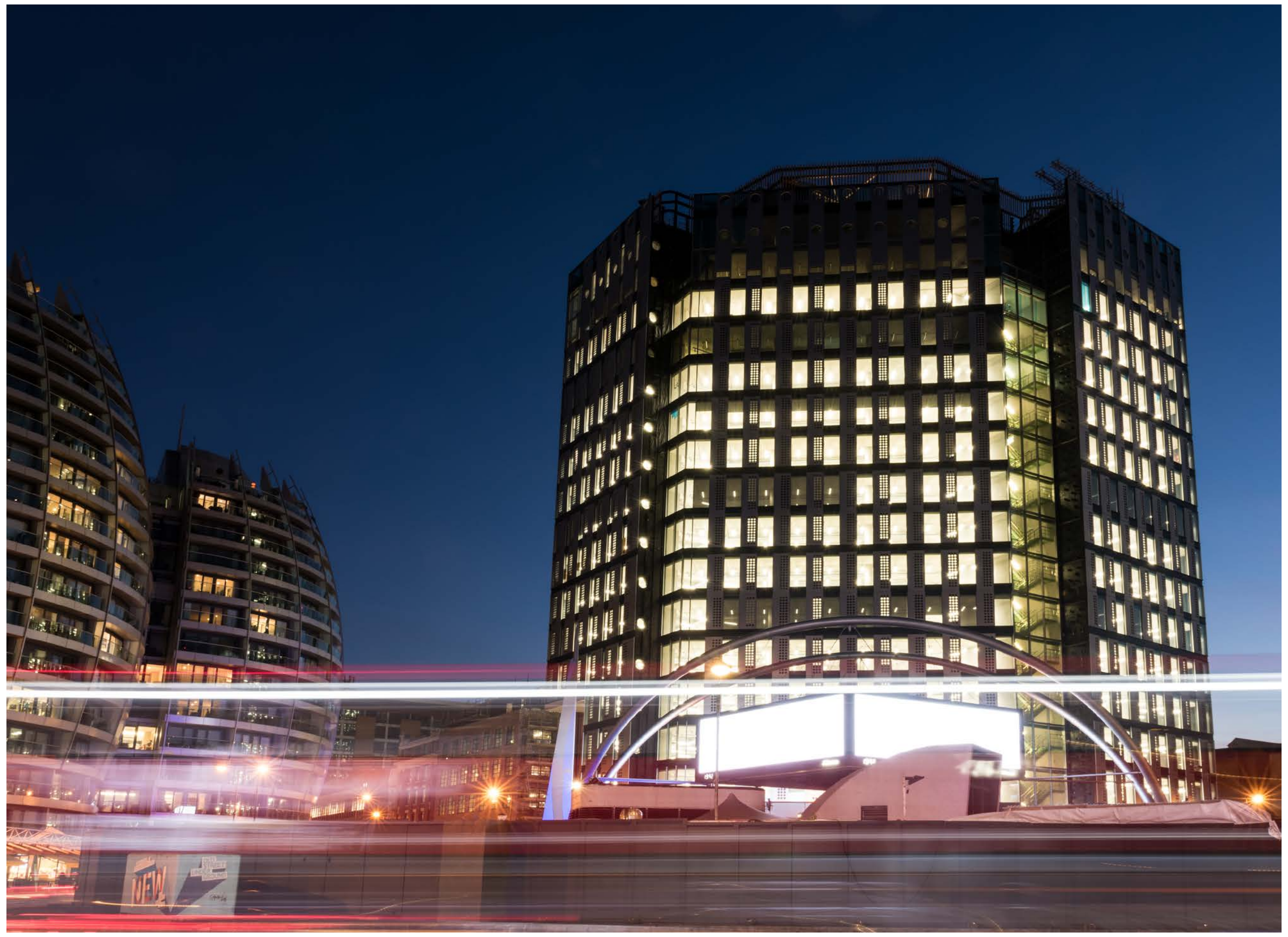
The second report, titled *Realising the Value of Circular Economy in Real Estate*, demonstrated the value and process of implementing circular economy principles in the built environment to real estate investors and construction clients.

During this study, Arup focused real estate investors and construction clients because they are best placed to lead the transition to a circular built environment, since they have the greatest capacity to influence decision-making, set direction and catalyse action throughout the value chain.

Policy makers were also identified as possible first movers, but during interviews they made it clear they needed an evidence base of the benefits of a circular economy to be developed by investors and construction clients.

Arup's research also revealed that value and the way in which it is created from real estate assets is set by investors and construction clients through investment requirements, tenure models and design briefs (developed within the confines of the policy environment in which they operate).





White Collar Factory, London
© Paul Carstairs

16
storey building

22,000m²
of floor space saved

150metre
rooftop running track and terrace

Case study: White Collar Factory[90]

White Collar Factory is a 16-storey, 22,000m² office building topped by a 150-metre rooftop running track and terrace in the heart of London's 'Tech City' district. Arup's innovative design has played a central role in establishing White Collar Factory as a model for a new type of office building - one that offers building users greater flexibility in the way they occupy and adapt floorplates, more choice over their working environment, and comfortable, productive spaces.

Arup's work on what became the White Collar Factory concept dates back to 2008, when we joined forces with developer Derwent London and architects Allford Hall Monaghan Morris to rethink new-build office design for London's commercial property market. The White Collar Factory approach combines the best of the past - particularly, industrial spaces that provided generous volumes - with new technology. The goal was to anticipate as-yet unexpressed needs from London's office tenants, rather than simply respond to established commercial office design trends. This exploration led us to focus on five principles: high ceilings, a thermal-mass structure, simple passive façade, flexible floorplates and 'smart' servicing.

Opportunity 3 - Creating a resilient city by maximising collective influence

Tall buildings and cities like London and Lower Manhattan cannot combat climate change alone. The only way to move into a more sustainable future in the built environment is to consider the wider impact of a building within its ecosystem of interconnected infrastructure and environmental systems. We also need to consider future change.

Reducing carbon is not the only environmental requirement for tall buildings and the city they inhabit.

Tall buildings are part of an ecosystem which extends outside the site boundaries of individual buildings. To take advantage of the agglomeration benefits, cities - and tall buildings - need to work together to maximise the shared benefits of the city, whilst minimising environmental impact.

In the context of the City of London tall building cluster, building on existing plans and initiatives, further consideration of the following areas could yield shared benefits from strategic and collaborative investment in the future:

1. Growth
2. Transport and travel
3. Biodiversity loss
4. Water management
5. Energy Management
6. Well-being and amenity
7. Adding Social Value

London	New York
In 2020, the City of London Corporation issued the "City of London Adaptive Pathways Study" which "established a series of actions that must be taken over time to ensure resilience to climate change, based on defined thresholds and trigger points in the future". The report suggests a series of pathways for improving climate risk resilience in the city.	In 2019, the NYCEDC joined forces with the Mayor's Office to produce the "Lower Manhattan Climate Resilience Study" which "builds on past efforts and leadership by the Lower Manhattan communities and the City after Hurricane Sandy and lays the path forward for the next phase of climate resilience planning for Lower Manhattan's future." The report considers both the 2050 and 2100 future scenarios. The outcome was a series of strategies included in the "Financial District and Seaport Climate Resilience Master Plan" and a series of projects such as the Two Bridges Coastal Resilience project, The Battery Coastal Resilience project, and the Battery Park City Resilience projects: all aimed at reducing the impacts of future storms.

Growth

With human population growing at an ever-faster rate, there is a global trend that sees 70% of people living in urban areas by 2050.[91]

There are 513,000 workers in the City of London, or 10% of London's total workforce. About 1 in 58 UK workers are employed in the City. The Square Mile's workforce is forecast to increase to 570,000 by 2030 and to over 620,000 by 2044. The residential population may also grow, with up to 3,000 more people estimated to be living in the Square Mile by 2044. Accommodating this growth, but also investing in the complex web of support systems that need to exist to sustain it, is vital for moving forwards.

As discussed earlier, the changing ways of working post-pandemic have resulted in reduced consistency of workers travelling into the city every day, but peak numbers are expected to return. There is increasing digitisation of working - requiring additional servers and electrical resilience. In addition, new industries: digital etc. - require different building requirements.

Whatever the building specification, growth is still expected.

Rank	City	Country	2035 GDP
#1	New York	United States	$2.5T
#2	Tokyo	Japan	$1.9T
#3	Los Angeles	United States	$1.5T
#4	London	United Kingdom	$1.3T
#5	Shanghai	China	$1.3T

Top 5 cities by predicted GDP for 2035[68]

Transport and travel

This growth will lead to more people travelling on the City's transport networks and streets, and more people walking and cycling, with increased demand for high quality public spaces. More residents, workers and visitors will also mean more deliveries and servicing of offices, homes, shops, pubs, cafés and restaurants.[93]

Strategic provision of additional active travel provision - space and facilities - is included in the City of London Corporation Transport Policy. Could shared facilities be accommodated within the footprint of more of the City's major buildings?

93%
of commuter travel to the City is by:

Public transport (84%)

Cycling (4%)

Walking (5%)

Biodiversity loss

Building the estimated additional floorplate required to accommodate the predicted increase in the number of workers laterally could risk significant biodiversity and habitat loss, endangering our protected species. Using tall buildings to provide higher density in the cluster area could leave space for active transport, biodiversity, and water management.

The world is already experiencing a catastrophic fall in biodiversity. Not only is this an environmental disaster, $44 trillion of economic value worldwide is moderately or highly dependent on nature and its related services.

Nature-based and derived solutions provide a host of compelling investment opportunities that could supercharge a positive growth trajectory for the environment and the economy going forward. The ratification of the Global Biodiversity Framework at COP15 in Montreal in December 2022 and the release of the Taskforce on Nature-Related Financial Disclosures (TNFD) beta versions provide a solid starting point and a boost for meaningful action.

Progress on multiple biodiversity impact assessment tools and environmental, social and governance (ESG) reporting standards enable better consideration of nature and biodiversity by financial institutions.

Water Management

Space for biodiversity can serve another purpose by helping manage water in cities[95]. Our cities aren't just concrete jungles. Every blade of grass, every tree, pond, lake and lump of soil together form vital infrastructure. As cities face increasing threats from climate change - including heavy rainfall and extreme heat events - they need to fully understand this natural infrastructure and how to enhance it. According to the Arup global sponge cities snapshot, London is 22% spongy. This is lower than Nairobi - as an example.

The City cluster is predominantly hard-landscaped, yet there are opportunities for greening the City helping the City of London to meet its biodiversity action plan[96] - which covers land owned privately.

Quay Quarter Tower
© Adam Mørk

Energy Management

The City of London is currently undertaking a Local Area Energy Plan that will help form a strategy for decarbonising the existing Citigen network but also support the move away from fossil fuels or buildings not connected to Citigen. Learning from the Lower Manhattan experience may be beneficial, though it is not expected new networks would be steam or high temperature.

The DESNZ Heat Network zoning policy is expected to be in place in 2025, at which time the City of London may have the power to require connection to a new heat network zone.

This will help tall buildings with limited floorplate to GIA decarbonise, overcoming the challenge of limited roof space as part of a resilient energy network for all.

Well-being and Amenity

Well-being and Amenity have been largely covered under active transport and biodiversity. Finding co-benefits shared for all will enhance the city for all.

Social Value

Corporations are committing to ESG strategies, they want to invest and be seen to invest in social benefits.

The City is home to 23,580 businesses, with nearly 99% of these being SMEs, but the large firms (1%) provide over 50% of the City's jobs and many lease space in the tall buildings.

Finding ways to leverage investment in the city to maximise shared benefits is an opportunity. Can a local offsetting strategy provide opportunities for funding some of these shared benefits?

The Skills for a Sustainable Skyline Taskforce, recently set up by the City of London is currently assessing how to meet the construction needs of central London with a focus on retrofit and net zero skills and trade shortages.[97]

Case study: Hudson Yards Eastern Rail Yards[98]

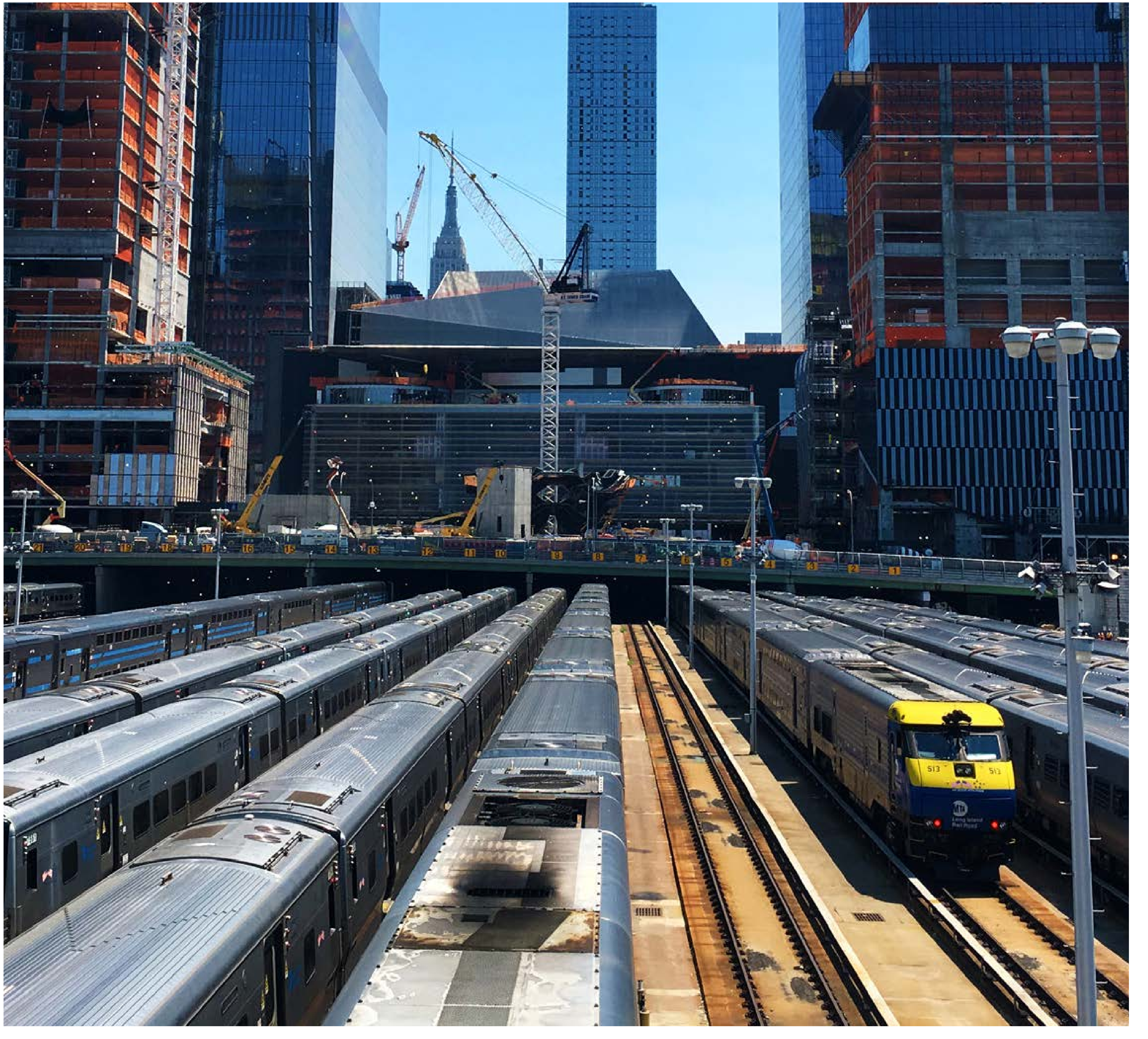
Hudson Yards is the largest private real estate development in the history of the United States and features 18 million square feet of residential, commercial, and retail space. To support a development of this scale in New York City, it was necessary to enclose the site's existing 30-track train storage yard with an overhead platform. Arup was commissioned to address the heat, engine emissions, and fire scenarios created by the trains running underneath this large platform.

Arup's interdisciplinary team provided fire /life safety consulting, engineering design, and construction administration and commissioning services for the tunnel ventilation system serving the newly enclosed train shed. The team developed egress strategies for various fire scenarios, including timed egress modelling, and tested, sized, and optimized corresponding ventilation strategies using CFD analysis.

18 **million**
square feet of residential, commercial and retail space

30 **track**
train storage below the development

Largest
real estate development in the United States



Hudson Yards, East Rail Yards Platform
© Arup

Next Steps

Next Steps

Tall building construction has historically been driven largely by commercial viability, location, and the benefits associated with focussed business clusters. But today, the climate emergency is increasingly having an impact on real estate investment and decisions to retrofit or rebuild.

Our new and existing tall buildings - along with all buildings - need to react to this sustainability challenge. The conclusions below set out three themes where actions will drive improvement. They are of particular relevance to the tall building cluster in the City of London.

1. Increase retrofit feasibility for existing tall buildings
Subject to long term commercial and engineering considerations, there is a need to make the most of our tall building stock within the City of London, ensuring it is safe and sustainable, while adapting to the changing needs of the City. Decarbonising existing buildings can help them hold their value when assessed against CRREM, optimising marketability and rental value.

2. Take a new approach to new tall buildings
Building on progress already achieved to date, developers and building owners within the City of London have an obligation to continue to reduce carbon emissions across the board, requiring rigorous consideration of new tall building decision making and, considering the whole life carbon and viability of buildings.

3. Create a resilient city by maximising collective influence.
Through the EC BID and City of London, the tall building cluster can come together to ensure resilience against future challenges whilst ensuring an adaptive and thriving commercial hub, further enhancing its position as a cornerstone of the UK economy. Stakeholders within the City of London will need to use their collective influence to ensure the provision of safe, green, and resilient city infrastructure, and to maximise the opportunities for shared benefits within the local area.

The actions opposite will help tall buildings rise to the net zero challenge as part of a thriving and resilient city cluster.

Suggested Actions

Area	Change	Action	Action by
Reducing operational carbon emissions in existing buildings	The MEES consultation document has not been passed into regulation. Clarity required to incentivise action.	Lobby Government for clarity in regulation	ECBID/ CoL/All
Decarbonising buildings	Incentivise early action	Investigate options - study required. Approach GLA	ECBID/ CoL/All
Target Setting	GLA 'Be Seen' requirements are written into planning policy. Data collected should be made available to other designer/owners/ energy providers to aid future change. Smart systems and shared data can contribute to the impact potential.	Lobby for wider availability of data.	All
Increasing Biodiversity / "sponginess"	Incentivise private landowners to offer land for nature. Additional incentive for funding the work required.	Investigate local offset or other incentive options - study required	ECBID/ CoL
Offsetting strategy options for other funding	Using local offsetting strategies with additionality to invest in local schemes for the benefit of the environment and community can fund change.	Investigate local offset or other incentive options - study required - what could a local offset fund be used for? Study required.	ECBID/ All/CoL
Embodied Carbon	In the UK there is currently no penalty for exceeding a target nor a requirement for a contribution towards embodied carbon - as there is for operational carbon.	Useful to understand what is likely to happen, when and the targets being looked at. Reporting happening now which will inform. Check with GLA.	ECBID/ CoL
Collaborative funding of decarbonisation at end of lease	Finding ways to allow Landlord/tenant co-funding in a collaborative way could unlock the decarbonisation future of many buildings.	Study required	ECBID
Safety legislation	New York's Local Law 11-1998 - Façade upgrades and safety inspections, introduced after an incident involving a fatality due to falling façade.	Building Safety Act to be comprehensively reviewed against Local Law 11-1998 and vice versa. Are all areas covered? Is any augmentation required for additional safety based on experience in either jurisdiction.	
Heritage Buildings	Clarity and robust advice required on how and when decarbonising heritage buildings is acceptable, and to what extent	Study and clarity required - currently subjective	GLA/CoL
Shared benefits	Can building owners and occupiers work together more closely to provide the amenity and benefits required? More bicycle spaces in one building than needed, more attenuation in the next door building in return?	Study required - is this useful, beneficial, enforceable over the long term?	All

Appendices

About EC BID

EC BID is a Business Improvement District working to promote and enhance a unique part of the City of London known as the Eastern City.

Representing a leading and innovative business community, the EC BID works collaboratively to deliver a range of programmes and transformative interventions that will develop this globally recognised economic district into an agile, dynamic and vibrant destination.

For more information on the work of the BID, please visit ecbid.co.uk.

About Arup

Arup is an independent firm of designers, planners, engineers, consultants and technical specialists offering a broad range of professional services. We aim to help our clients meet their business needs by adding value through technical excellence, efficient organisation and personal service.

We provide the engineering and related consultancy services necessary to every stage of the project, from inception to completion and after. These are available to clients singly or in combination, to suit the particular circumstance of the job.

Throughout the world we aim to provide a consistently excellent multi-disciplinary service, which also incorporates our concern for the environment. Arup is committed to sustainable design, to its increasing incorporation in our projects and to industry-wide sustainability initiatives.

Founded in 1946, Arup now has more than 18,000 people working in 94 offices in 34 countries and our projects have taken us to more than 130 countries.

Arup is a wholly independent organisation owned in trust for the benefit of its employees and their dependants.

With no shareholders or external investors, the firm is able to independently determine its own priorities and direction as a business.

Each of Arup's employees receives a share of the firm's operating profit each year.

A substantial proportion of the firm's income is devoted to improving its technical standards through the continuing professional development of its members and by developing new techniques of engineering design and management.

Arup Group's policy is set by its Group Board. This body reports to the firm's Trustees and to the firm itself, represented by the global college of directors and principals.

Arup operates as five Regions: Americas, Australasia, East Asia, Europe, and UK, India, Middle East and Africa (UKIMEA). Each Region is responsible for geographic strategy and management.

Each project is the responsibility of a Project Director who has access to specialist skills within the firm, whether those skills are in the project office or elsewhere.

We work in multi-disciplinary teams to ensure co-ordination between the disciplines. We operate formal quality management systems, routinely reviewing and auditing our work. We structure our project teams to achieve clear lines of responsibility and communication with the client and other consultants. By these measures, we add value to our clients' projects and achieve quality on which they can rely.

For further information about Arup, please visit arup.com.

Glossary of terms

Vertical Transportation
The different ways which people moved thought a building for example lifts or escalators.

Structural Bracing
Members which provide stability against lateral forces.

Structural Damping
Material to provide dissipation of energy to avoid resonance.

Static head
The pressure resulting from a column of liquid acting under gravity. [99]

GIA
Gross Internal Area - The total internal area of the building including anything inside it such as internal walls, excluding areas with ceiling height lower than 1.5m

GLA
Gross Leasable Area - The area of the building usable by tenants, including shares areas such as lifts.

GVA
Gross Value Added - The value generated by any unit engaged in the production of goods and services. [100]

Closed cavity façade
Completely enclosed double-skin façade that is triple glazed internally and single glazed externally for an increased insulation with operable blinds. Maximises daylight while controlling solar gain.. [10]

Façade
The outward facing skin of a building.

Occupancy diversity
The variation of occupants within a particular space with time

Stranding risk
Risk of assets dropping in value as they no longer comply with climate related regulation.

BREEAM
Building Research Establishment Environmental Assessment Method. The most recognised sustainability certification in the UK.

LEED
Leadership in Energy and Environmental Design. The most recognised sustainability certification in the UK.

SBTi
Science Based Targets Initiative.

CRREM
Climate Risk Real Estate Monitor.

EPC
Energy Performance Certificate.

NABERS
National Australian Built Environment Rating System.

ICROA
International Carbon Reduction and Offset Alliance

ICVCM
Integrity Council for the Voluntary Carbon Market

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For further information about the report, contact us.

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