Achieving net-zero buildings

An action plan for market transformation

World Business Council *for Sustainable Development*

Contents

Foreword

Climate change is no longer something in the future, to be debated whether it's real or not. From heatwaves in India to wildfires in Los Angeles, the climate crisis is unfolding all around us. So the need to drastically cut carbon emissions is clear, and broadly speaking the Built Environment is about a third of the problem.

The question is what to do about a sector that is so diverse, and at the same time critical to who we are and what we do – our homes, schools, hospitals, factories and offices.

As Built Environment professionals we deal with this challenge every day, one building or development at a time. But it's not enough for us to only focus on the projects that are in front of us. We need to use our knowledge of what works on the ground, building by building, to help shape policies and market incentives that will be effective in driving down Built Environment carbon emissions across the whole sector.

In this publication we are focusing on the carbon impact of buildings in operation. This is not a new topic, the science of energy efficiency in buildings is relatively developed, and the solutions to operational decarbonization are largely already in our hands. In this sense it is different to embodied carbon in construction, which is a relatively new area of study (and is addressed in other publications in this series). The challenge therefore is one of behaviors – how we push operational decarbonization far enough up the agenda to drive real action.

Our proposed 12-Step Action Plan is our blueprint for how to change those behaviors. It draws from the policies and industry initiatives that we, through our collective experience, have seen to be effective on the ground, and brings them together into what we believe to be a comprehensive and effective approach.

The action plan is underpinned by transparency – a clear understanding of the performance of individual buildings and how they compare to net-zero goals. Transparency is a powerful driver for change in itself, but in the action plan it is supplemented both by a performance floor – legislated minimum performance that gradually improves over time – and clear incentives for fully net-zero buildings. The incentives are critical to the transition – there is a strong sense that the investment market is ready and willing to invest in net-zero buildings, and if we can get the mechanisms right we can direct the flow of green finance towards the transformation of building to net-zero. The scale of investment that's needed brings a host of other benefits – driving growth, creating skilled jobs, making a significant contribution to the broader transition to a greener economy.

Confidence is a key factor in driving change, and that is where our case studies come in. These illustrate leading examples of the transition to net-zero for buildings and portfolios. The 16 case studies are drawn from different contexts and different locations around the world. They are not all perfectly net-zero buildings, but they each tell a part of the story of the journey to net-zero. And taken together the message is clear – the transition to net-zero buildings is already underway and not only is possible but is happening right now. Our challenge is how to dramatically accelerate the pace of change, and that is exactly what this publication sets out to help achieve.

We hope that you will find this publication an engaging read, but more than that, that it will inspire you to join the debate about how we can achieve the dramatic acceleration towards the net-zero property sector that is needed.

Stephen Hill, Associate Director, Arup

Roland Hunziker, Director, Built Environment, Industrial Transformation Pathway, WBCSD

Executive summary

In the run up to COP 29 We published "Achieving Net-zero buildings - key actions for market transformation" as a short summary for policy makers.

In this full report we develop the themes in that document in more detail, setting out the policy and market incentives we believe are needed to dramatically scale up the transition to net-zero buildings in operation.

Our 12-Step Action Plan is intended to be applicable at a national or regional level, but also at a corporate level in informing the approach to decarbonization for a property portfolio. In this report the action plan is supported by a series of case studies. These demonstrate that across operational buildings, and through refurbishments and new construction, the transition to net-zero buildings is achievable and indeed is underway. Our recommendations in this publication are intended to deliver the rapid acceleration in the pace of that transition that is needed to meet the challenge of the climate crisis that we face.

This publication is the 3rd in our series of collaborations between WBCSD and Arup, and expands on the themes presented in our November 2024 publication "Achieving Net-zero Buildings – Key Actions for Market Transformation."[1] It complements the previous reports in our series which explore routes to achieve the drastic reductions in embodied carbon emissions in the Built Environment that are an equally important part of our pathway to a net-zero property sector.[2]

In January 2025 the EU's Copernicus Climate Change Service confirmed that global temperatures exceeded 1.5°C above pre-industrial levels, in what was the hottest year on record.[3] Yet another in a long series of statistics that serve as a reminder of the urgency of acting to reduce carbon emissions. Given that the building sector globally is responsible for 37% of energy-related carbon emissions, and given that emissions from buildings grew by 1% between 2021 and 2022,[4] the transition to net-zero buildings is a critical part of our response to climate change.

It is widely accepted that industry has the technical solutions to deliver net-zero in the Built Environment. Organizations such as the IPCC, World Green Building Council and the International Energy Agency provide strategies, pathways, technology reviews and other resources supporting delivery of net-zero buildings. While these resources and many of the case studies given in this publication collectively convey the message that the technical solutions are available, the challenge lies in their widespread adoption and in the transition to net-zero at the scale and pace that is required.

This publication outlines how a successful transition to net-zero buildings needs a framework of clear, consistent incentives (the why) to complement the range of available technical solutions (the how).

Section 1 of this publication addresses the need to accelerate the pace of transition to net-zero buildings in operation. It defines a blueprint for the creation of an enabling environment for the transition to net-zero buildings in any jurisdiction (national or local), or for a corporation. It builds on our 2023 report "Net-Zero Operational Carbon Buildings – State of the Art"[5], by taking the best examples of policies and incentives from around the world to form a 12-Step Action Plan.

Section 2 of this report addresses the how through a series of case studies spanning portfolio and building approaches, for buildings in operation as well as refurbishments and new construction, from a range of markets around the world. The case studies demonstrate a range of routes and approaches to net-zero in different sectors and locations. And whilst these are not all fully net-zero buildings they are addressing the challenge of operational decarbonization in different ways. These case studies offer a sense of optimism, demonstrating that net-zero is possible and the transition is already underway in many locations.

Taking these remarkable case studies in the round, as well as the opportunity, we see some of the problems that we face as an industry. They are a long way from using the same language to talk about net-zero, and they do not all address all the aspects of a comprehensive net-zero definition. And these buildings are still the exception in many areas. So whilst the transition to net-zero has definitely started, it is moving at a snail's pace. And we are going to need to do better than slow and steady to win this race.

Drawing on the expertise of leading property sector practitioners, this report aims to illustrate to policy makers and industry leaders the key steps needed to enable the mass scale transition to net-zero buildings, and through the collection of case studies give confidence that this transition is not only possible, but has already started.

Executive summary
Section 1: The 12-Step Action Plan

Our proposed 12-Step Action Plan is based on the research carried out for our 2023 report "Net-Zero Operational Carbon Buildings - State of the Art"[5], where we looked at existing policy and market mechanisms for delivery of net-zero buildings in operation. The action plan takes the best examples of what has been shown to be effective in different locations around the world, in both global north and global south, and brings them together to create an holistic blueprint for how operational net-zero can be enabled through policy and market incentivization at a national or regional level.

Compliance to Performance
At the heart of the action plan is a key principle that should be underscored: validation of a net-zero operational strategy for buildings requires the adoption of a Performance Framework that seeks to influence the operational energy consumption of buildings in use directly as well as through design and construction. This is distinct from a code compliance framework, that seeks only to influence the design and construction process. The control of building energy efficiency through regulation in most countries follows a code or compliance-based approach.

Code compliance

Regulates specific aspects of a building's design and construction – façade thermal properties, energy efficiency of individual components. So-called "unregulated" or "plug" loads are excluded. Energy use of buildings in operation remains unregulated.

Performance Framework

Measures and sets targets for the total energy consumption of buildings in operation. A performance framework seeks to influence the operation of buildings as well as their design and construction.

Four objectives
In this document we define the 4 objectives that together aim to create an enabling environment to achieve the market transformation towards net-zero buildings. The principle that you can't change what you can't measure is fundamental to this. Hence the first two objectives are about creating an understanding of building performance.

The first objective – **definition** – ensures a consistent understanding of what a net-zero building is, with performance thresholds covering both efficiency and energy procurement tailored to regions and building types.

Transparency, whether voluntary or regulated through local or regional policies, provides a market understanding of how individual buildings perform against a net-zero emissions threshold. Studies show that transparency in itself is a powerful driver of change. In some markets, that understanding will lead to a higher valuation of net-zero buildings, which will act as a catalyst for investment.

Driving change across all areas of a market will require a mandatory minimum level of operational energy performance or **performance floor**. This will ensure that all buildings are at least on a pathway to achieving net-zero emissions in operation.

A key part of the enabling environment we are seeking to create is making it possible to invest in net-zero operational buildings. Achieving this will require clear **incentives** that will contribute to a higher valuation of a net-zero building.
To create effective incentives, leading sustainability certifications must adopt a clear, robust and internationally consistent definition that recognizes a fully net-zero building. The lack of clarity in the certification market is a significant constraint that is holding back market investment in the transition to net-zero emissions.

Executive summary
Section 1: The 12-Step Action Plan

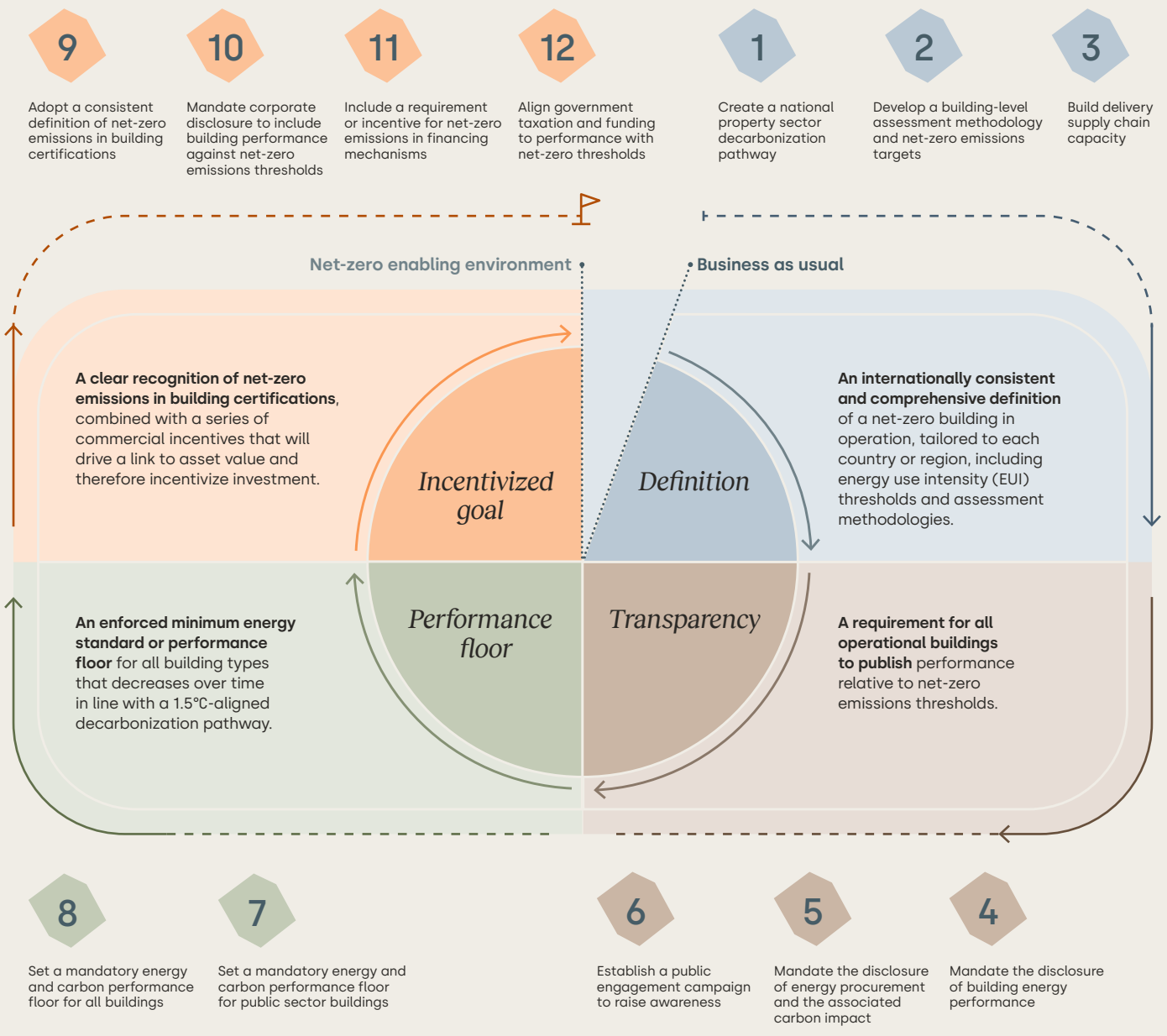
12-Step Action Plan
To achieve the 4 objectives, we propose a 12-Step Action Plan that will support the creation of an enabling environment for net-zero operational emissions in buildings. Precedents – examples of existing policies or industry initiatives that demonstrate an existing partial application of the proposed solution – inform each step in the action plan. The action plan aims to demonstrate how these individual jigsaw pieces can come together in a completed puzzle, forming a comprehensive approach to driving real change.

Key conclusions from our market analysis to support the action plan

1. The methodologies to define and assess net-zero buildings in operation already exist in some localities but their use is not yet widespread or consistent.
2. At least one country or region is partly implementing or has already implemented all the individual measures proposed as part of the 12-Step Action Plan.
3. The net-zero incentives are not yet consistently in place, with some localized examples, but a lack of global consistency on the definition of net-zero buildings remains a barrier to uptake.

Figure 1: Key actions for market transformation

12-Step Action Plan



Executive summary
Section 2: Case studies

The case studies presented - 16 in total across 4 themes - illustrate the ways in which portfolios and individual buildings are responding to the challenge of the net-zero transition. The first three themes illustrate how the transition to net-zero is being addressed at a building level in differing contexts - from operational buildings to refurbishments to new construction. Theme 4 addresses specific technologies that are important in enabling the transition at a building level.

Theme 1 *Optimization of building performance*

A key objective of the 12-Step Action Plan is a move from code compliance to a performance framework. Optimization of building performance is generally outside the scope of a code compliance framework, and as a result often does not get the attention it deserves. Under a performance framework, optimization, particularly of complex assets, will in many cases be the most cost-effective means of quickly improving performance and achieving decarbonization, whether to avoid non-compliance or to demonstrate out-performance against the market.

01. **Landsec portfolio optimization – London, UK**
Landsec's workplace optimization program demonstrates the effectiveness of a comprehensive portfolio-wide energy efficiency approach. It has delivered 2,500tCO_2 reduction across £10 billion UK portfolio, showing typically 10-20% reduction in landlords' energy and 20-30% reduction in tenants' energy at a building level.

02. **Global pharmaceutical company**
A global pharmaceutical company and their service provider is delivering a comprehensive program of operational readiness and energy performance management for a highly complex state-of-the-art global research and development facility. Use of data analytics techniques has directly led to lower energy usage, decreased maintenance tasks and the ability to effectively monitor and track progress.

03. **5 Hanover Square – London, UK**
A practical and actionable short- to medium-term decarbonization plan for a prime central London asset. Incorporating groundbreaking solutions, the plan will enhance the building's facilities and operational efficiency, combining cost-effectiveness, energy efficiency and respect for the building's historical significance, while reducing energy consumption and carbon emissions.

Theme 2 *Retrofit*

In the 12-Step Action Plan, the introduction of a mandatory energy performance floor will gradually expose under-performing buildings. Whilst optimization measures may be sufficient for some buildings to avoid non-compliance/ stranding, as standards tighten over time more substantial interventions will be required. Similarly as transparency drives demand, value of buildings not fully aligned with net-zero is anticipated to drop (brown discounting), which will further drive demand for retrofitting in order to achieve net-zero alignment.

04. **Susan Fennell Sportsplex – Ontario, Canada**
A zero-carbon retrofit is challenging to do in an existing facility, particularly where the facility needs to be open to the public. This particular facility is a great candidate for net-zero retrofit in that it already utilizes 41 water to air heat pumps throughout for space heating and cooling. The HVAC equipment was at the end of its life cycle so almost all the equipment needed to be replaced. There was ample space for a vertical, closed loop geothermal field in the parking area.

05. **40 Argyll Street – London, UK**
The refurbishment at 40 Argyll Street showcases the art of the possible when decarbonizing the office portion of a listed mixed-use building whilst keeping the retail tenants in occupation. The client now has an all-electric, prime office space to let with significantly enhanced value and in line with their overall net-zero ambitions.

06. **111 Bourke Street – Melbourne, Australia**
The proposed retrofit will take this already high performing asset to new levels and ahead of its competition. With a scope of work including full electrification and substantial energy efficiency improvements the project will deliver positive outcomes for the environment, the buildings' users and also the surrounding community.

07. **The Acre – London, UK**
Turning an existing iconic building into one of the healthiest and greenest developments in central London. The development retains 80% of the existing building whilst creating Covent Garden's largest speculative commercial office space with market-leading energy performance credentials. It provides spectacular roof terraces complemented by a new accessible "street" route through the city block.

Theme 3 *New build*

The emerging understanding of net-zero performance shows that new buildings need to go well beyond simply meeting current building codes and be designed to achieve net-zero performance outcomes in operation from day one. This forward-thinking approach is a significant shift from the conventional design-for-compliance mindset that has been prevalent for many years, but is essential to help avoid future carbon liabilities and support global climate targets.

08. **The Emma and Georgina Bloomberg Center – NY, USA**
The Emma and Georgina Bloomberg Center pioneers new standards of environmental sustainability and energy efficiency in its award-winning design. An all-electric building, it is among the largest academic buildings in the world designed for net-zero energy consumption. The building design uses solar arrays, a green roof, geothermal wells, smart building technology, and innovative insulation to meet its energy goals.

09. **AIRSIDE – Hong Kong**
AIRSIDE is an innovative commercial development that seeks to embrace all the needs of urban life, from shopping to culture, from work to wellness, in complete connection with nature. More than a district, a vision.

10. **Chiesi Farmaceutici Headquarters – Parma, Italy**
Designing a flexible, inspiring workplace to foster collaboration, enhancing common spaces that promote social interaction and improve wellbeing, while focusing on sustainability were the three key drivers behind Italian pharma group Chiesi Farmaceutici's new headquarters.

11. **The Henderson Building – Hong Kong**
The newly built iconic landmark in Hong Kong, The Henderson showcases its unparalleled potential to transform the Central metropolis into a vision that is both unique and enchanting, together with exemplary ESG credentials through a total of 10 green, healthy, smart and sustainable transportation accreditations, which all achieved the highest ratings.

Theme 4 *Technologies*

The preceding case studies demonstrate that net-zero buildings are deliverable with today's technologies. However, technological advancements do have an important role to play in bringing net-zero into the reach of more building types in more locations. The emergence of genuinely new technologies is important, but equally important is the percolation of existing technologies through different locations and market sectors, as manufacturers find ways to reduce upfront costs and embed more energy efficient technologies in lower price point equipment.

12. **Taikoo Li Sanlitun, Beijing of Swire Properties – Beijing, China**
Photovoltaics, Energy Storage, Direct Current and Flexible Power (PEDF) Systems use DC-generated renewable energy from photovoltaics directly in low voltage distribution, avoiding transformer losses. Combining with on-site electrical storage optimizes the energy and carbon savings that can be achieved through on-site generation.

13. **Arup Office – Manchester, UK**
As part of the refurbishment of Arup's Manchester (UK) office, existing fluorescent luminaires were upgraded to LED, achieving significant energy savings and substantially reduced embodied carbon impact compared to new luminaires. The award-winning project was completed with minimal disruption compared to a new installation.

14. **Dr. Oetker – Johannesburg, South Africa**
An ammonia refrigeration plant supplies cooling-as-a-service (CaaS) for the Dr. Oetker building's HVAC systems, process areas, process fluids, blast freezers, holding freezers and cold rooms, estimated to be 20% more efficient than a baseline installation with a further 21.5% saving realised through operational optimization. The project is innovative both in terms of the technology and the commercial service model.

15. **Elpro Park – Pune, India**
India's most intelligent air-conditioning system, the AI-powered chiller plant at 1 Elpro Business Park, runs on 100% solar energy and provides a surplus of clean energy that can power over 200 Indian households for a year. The system is installed, operated and maintained all under a cooling-as-a-service (CaaS) contract.

16. **Daikin R&D – Bangkok, Thailand**
This case study, part of the Cleaner Energy Future Initiative for ASEAN (CEFIA) demonstrates the benefit of energy recovery ventilation, along with optimized temperature and humidity control to reduce air-conditioning energy demand in hot and humid regions, such as Thailand. The test case shows it is possible to realize energy savings of 35-45% through an integrated system of air-conditioning and energy recovery ventilation.

Action Plan

01.

01. Introduction
The climate crisis and buildings

In 2022, the building sector globally was responsible for 37% of energy-related carbon emissions (or 21% of total greenhouse gas emissions),[6] of which 82% was from energy consumption of buildings in operation (direct and indirect).

In recognition of the importance of property sector decarbonization in the overall fight against climate change, at the 28th United Nations Climate Change Conference (COP28) 28 countries joined the Buildings Breakthrough,[7] aligning behind the shared goal to ensure:

Near-zero emissions and resilient buildings are the new normal by 2030.

And in March 2024, over 60 countries backed the Declaration de Chaillot[8], committing to the implementation of long-term property sector roadmaps, making building energy codes mandatory and leading public procurement, among other objectives, to accelerate and progress the decarbonization of buildings.

The intent is that these commitments lead to the development of local and national industry standards and legislation – the instruments that will drive transformation. But progress towards this is still very limited in most countries around the world. Globally, despite energy-efficiency improvements, evidence from the UN Environment programme shows that overall property sector emissions continue to rise, so there is an urgent need to accelerate action to drive the transition to net-zero emissions and deliver meaningful decarbonization across the sector.

Purpose of this document
Recognizing the urgent need for change, this document recommends a cohesive set of clear and specific steps to shift the market to deliver net-zero buildings at scale. This is supported by a series of case studies that demonstrate the transition to net-zero buildings in practice across a range of global markets and sectors. This is consistent with, and part of, the Built Environment Market Transformation Action Agenda.[9] Its Intervention 5 in particular (Standards Alignment) specifically speaks to this need. This is part of the broader industry objective to achieve net-zero whole-life emissions and has its place alongside work by WBCSD and others to address full life-cycle decarbonization.

This document builds on evidence from our 2023 publication "Net-zero Operational Carbon Buildings: State of the Art"[5], which points to a wide variation in net-zero emissions definitions in policies and certifications and a lack of widespread national policies requiring buildings to be truly net-zero. It identifies several leading examples of local policies and industry initiatives that have effectively driven change in their markets. Since then, ongoing research has highlighted further examples.

In this document, we advocate for a fundamental shift from a standards and code compliance approach to a clear framework focused on the real performance of buildings in operation.

Intended Audience
This document is intended to:

- → Provide national and regional policy-makers and industry leaders with a clear 12-Step Action Plan to embed operational net-zero in regional or national policy
- → Illustrate the role that NGOs, industry bodies and academia can play in implementing the 12-Step Action Plan
- → Provide the property sector, including owners, operators, developers and tenants, with a framework for the implementation of net-zero transition policies and plans within their own organizations
- → Provide policy-makers and the wider property sector with evidence of the transition to net-zero buildings in action, through a series of case studies.

The role of government
Our intention is for collaboration between policymakers and industry to deliver the action plan, whether at a regional or national scale. Experience from around the world highlights the key role that national and sub-national governments can play in driving the transition, specifically:

- → Mandating transparency of building energy performance in operation, which improves understanding and unlocks investment;
- → Through procurement, testing new and innovative approaches in the public sector;
- → Setting mandatory minimum energy performance standards, ensuring all buildings are at least on a journey to net-zero emissions.

Why only operational emissions?
There has been a significant shift in recent years from only focusing on energy efficiency as a means to decarbonize buildings to considering whole-life carbon emissions, including the embodied carbon impact of construction and refurbishment.

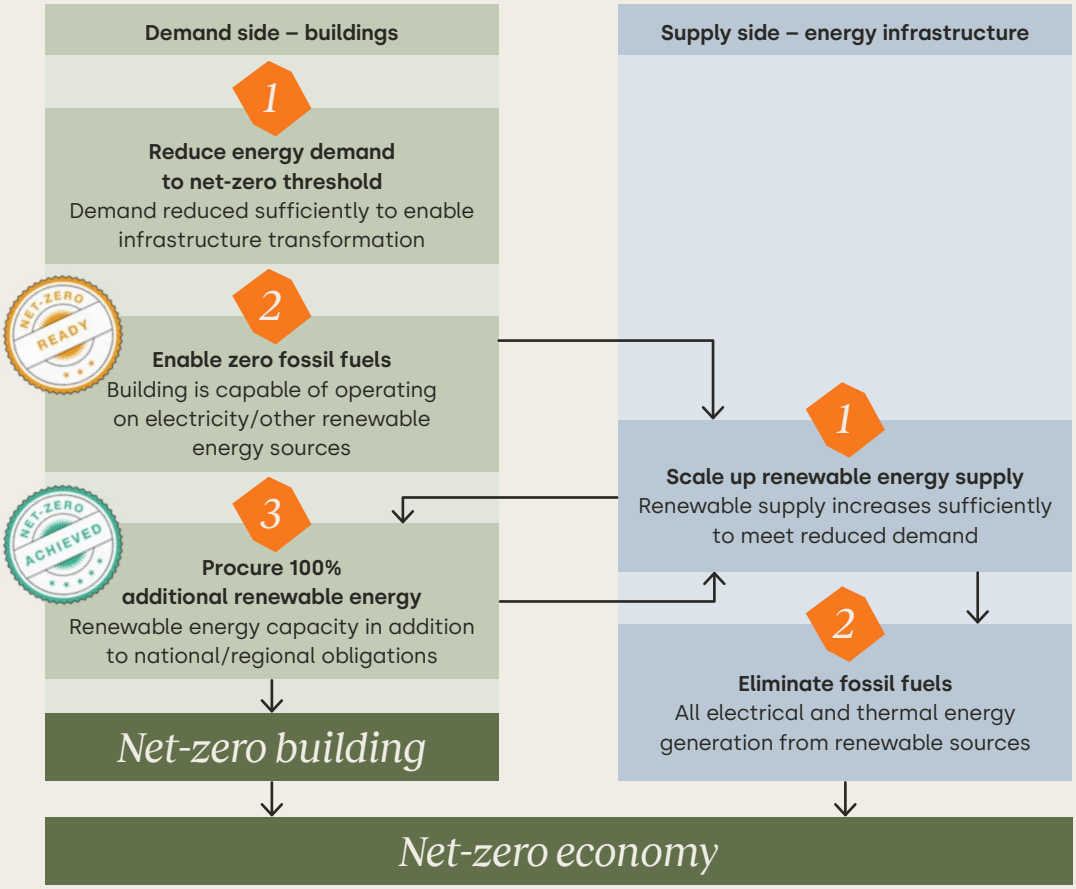
Operational and embodied emissions each require different policy measures to drive decarbonization. Decarbonizing embodied emissions requires regulation of construction, whilst for operational emissions we are seeking to regulate the energy use of buildings in operation. This document is focused on net-zero in operation.

Embodied decarbonization is addressed in WBCSD's Market Transformation agenda,[9] and from a more technical perspective in the Arup-WBCSD publication "Net-zero buildings – Halving construction emissions today."[2]

Net-zero operational definition
In our previous publication, "Net-Zero Operational Carbon Buildings, State of the Art,"[5] we included a clear definition of what a net-zero operational building is, recognising that the lack of clarity around this is one of the key elements holding the market back from a mass transition to net-zero.

The definition recognised the interconnection of buildings and the infrastructure that powers them, and proposed the concept of a Net-Zero Ready building, i.e. a building that has done everything necessary on site to be net-zero. The final step to Net-Zero Achieved requires the local availability and procurement of 100% renewable energy.

Figure 2: An integrated roadmap to a net-zero economy



01. Introduction
Four objectives

Four objectives
The proposed 12-Step Action Plan is focused on achieving 4 key objectives, with the aim of creating an enabling environment to achieve the market transformation towards net-zero buildings. This aims to achieve the definition, measurement, transparency and performance of net-zero buildings in operation. The principle that you can't change what you can't measure is fundamental to this. Hence the first two objectives are about creating an understanding of building performance.

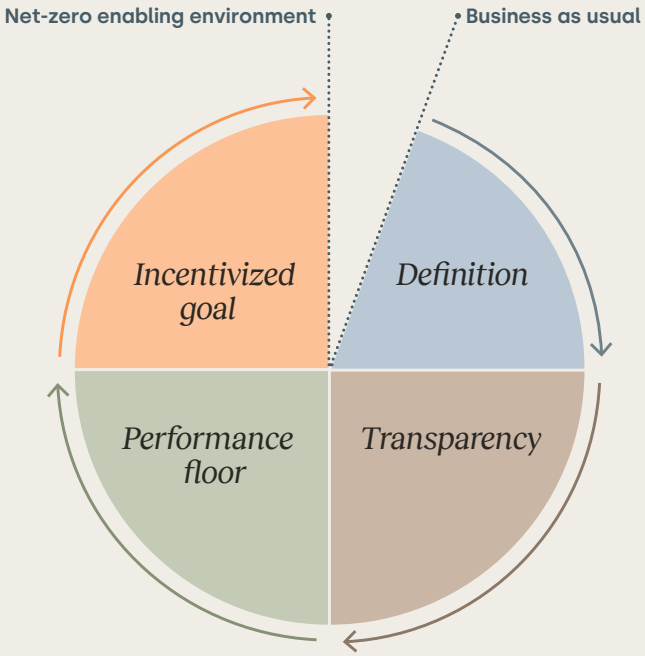
The first objective – definition – ensures a consistent understanding of what a net-zero building is, with performance thresholds covering both efficiency and energy procurement tailored to regions and building types.

Transparency, whether voluntary or regulated through local or regional policies, provides a market understanding of how individual buildings perform against a net-zero emissions threshold. Studies show that transparency is in itself a powerful driver of change. In some markets, that understanding will lead to a higher valuation of net-zero buildings, which will act as a catalyst for investment.

Driving change across all areas of a market will require a mandatory minimum level of operational energy performance or performance floor. This will ensure that all buildings are at least on a pathway to achieving net-zero emissions in operation.

A key part of the enabling environment we are seeking to create is making net-zero operational buildings an attractive investment proposition. Achieving this will require clear incentives that will contribute to a higher valuation of a net-zero building. To create effective incentives, leading sustainability certifications must adopt a clear, robust and internationally consistent definition that recognizes a fully net-zero building. The lack of clarity in the certification market is a significant constraint that is holding back market investment in the transition to net-zero emissions.

Figure 3: Four objectives



01. Introduction
12-Step Action Plan

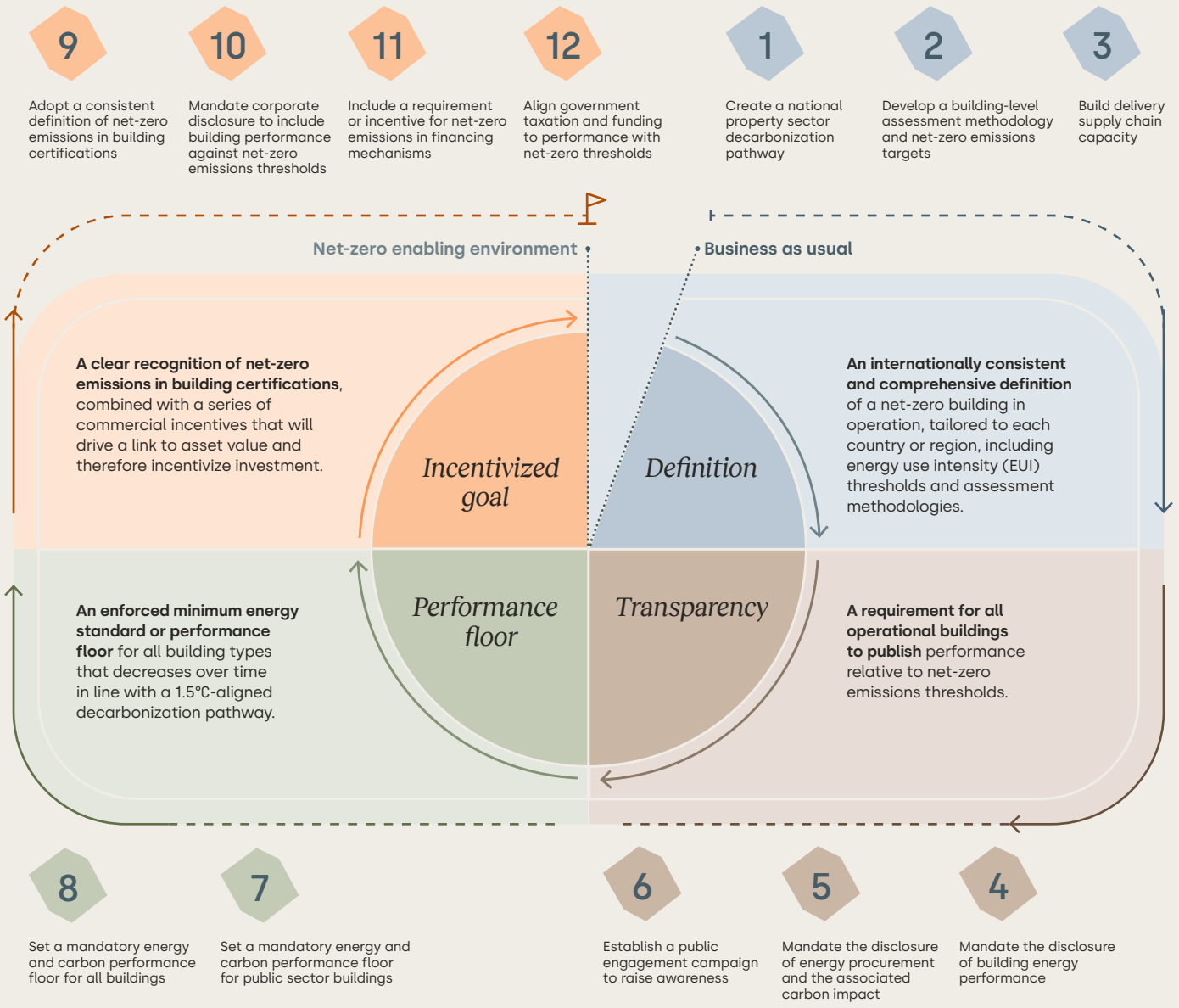
12-Step Action Plan
To achieve the 4 objectives, we propose a 12-Step Action Plan that will support the creation of an enabling environment for net-zero operational emissions in buildings. The 12-Step Action Plan is based on the research carried out for our previous publication, where we looked at existing policy and market mechanisms for delivery of net-zero. Precedents – examples of existing policies or industry initiatives that demonstrate an existing partial application of the proposed solution – inform each step in the action plan. The action plan aims to demonstrate how these individual jigsaw pieces can come together in a completed puzzle, forming a comprehensive approach to driving real change.

Key conclusions from our market analysis to support the action plan

1. The methodologies to define and assess net-zero buildings in operation already exist in some localities but their use is not yet widespread or consistent.
2. At least one country or region is partly implementing or has already implemented all the individual measures proposed as part of the 12-Step Action Plan.
3. The net-zero incentives are not yet consistently in place, although there are some localized examples, but a lack of global consistency on the definition of net-zero buildings remains a barrier to uptake.

Figure 4: Key actions for market transformation

12-Step Action Plan



01. Introduction
Scope and precedents

Scope

Our intention is for the action plan as a whole to be relevant to all countries; however we recognize that there are particular challenges within some countries in the global south around lack of regulation/enforcement and the need to attract investment in order to meet pressing social needs for housing and social infrastructure, which will need to drive a different approach to implementation. The incentivization aspect of the 12-Step Action Plan will be most directly applicable to the non-domestic property sector within global north economies.

The domestic property sector is different again. For housing and some aspects of social infrastructure there is a key issue of equity to be considered when pursuing net-zero transition and it is essential that the transition is managed in a way that does not negatively impact on particular lower income individuals and communities. Within the document we address some of the key challenges and possible approaches to applying the action plan in this sector.

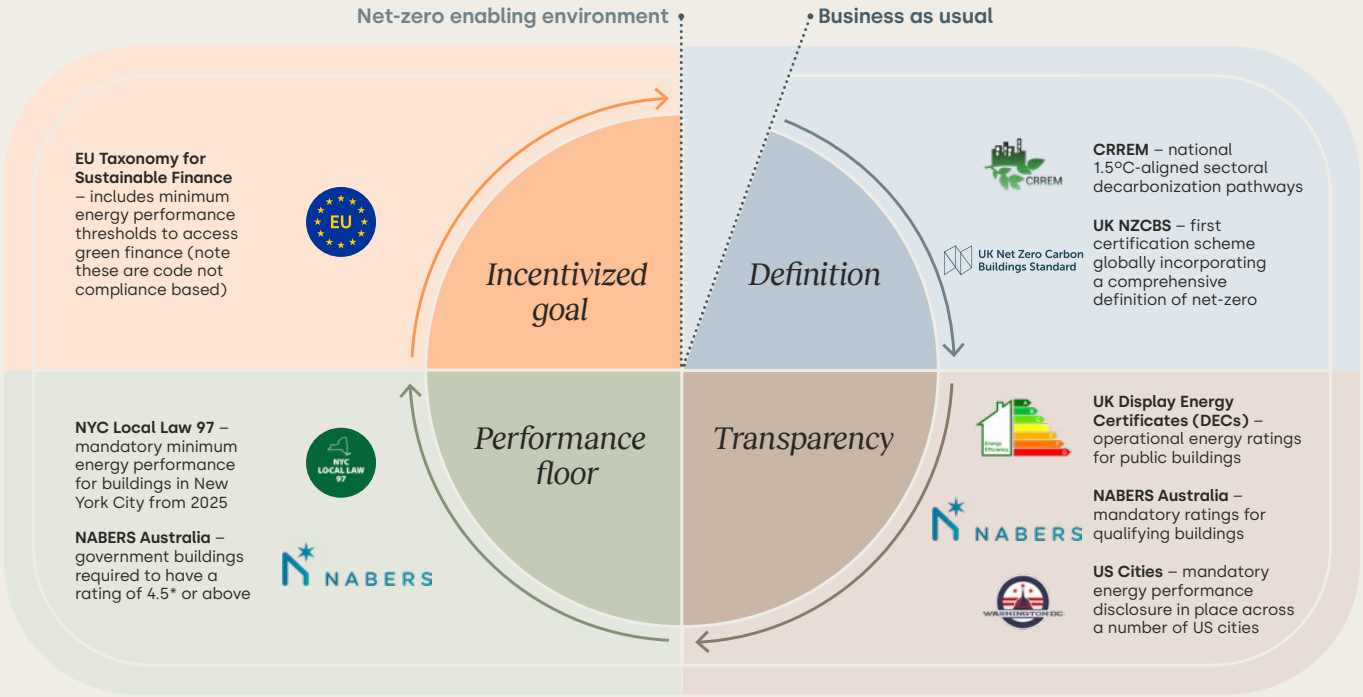
The action plan primarily seeks to influence the energy performance of buildings in operation; however, it does also address construction, both of new and existing buildings, recognising that decisions taken in construction are a key determinant of energy performance in operation.

Precedents

The 12-Step Action Plan is constructed on a foundation of real examples from around the world, as evidenced in our previous publication.[5] This demonstrates that the 12-Step Action Plan, far from being wishful thinking, is fully deliverable.

Figure 5 illustrates a number of key precedents from the global north. Whilst some aspects of the action plan are naturally more suited to global north economies, particularly in the area of incentivization, the action plan as a whole is very much intended to be applicable to all countries around the world.

Figure 5: 12-Step Action Plan precedents, global north

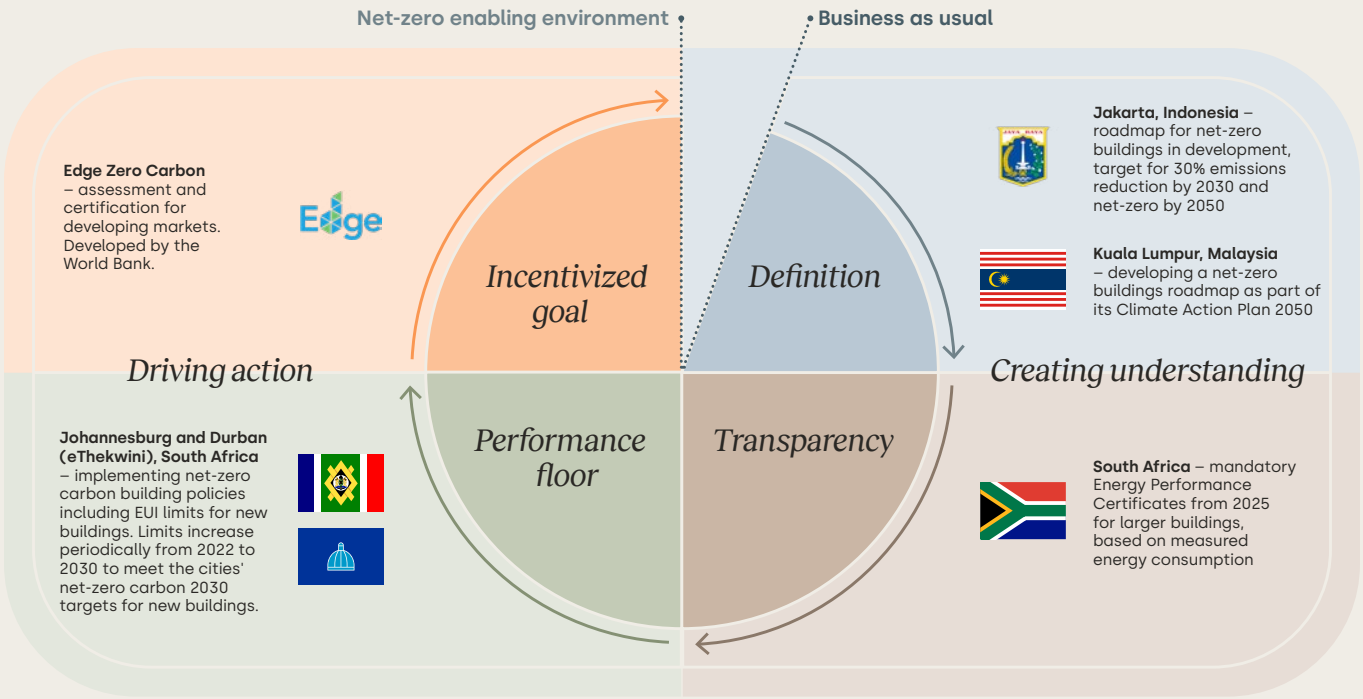


01. Introduction
Scope and precedents

Key challenges in global south economies include property markets that are less regulated than in the global north, whether due to the limits on the regulations themselves, or a lack of enforcement. Building capacity within government departments to deliver and enforce the 12-Step Action Plan is therefore a critical aspect of implementation.

There are a number of relevant precedents from the global south, including in Manila, Colombia, a number of cities in South Africa, and Jakarta. There is an emerging trend in global south economies in particular for major cities to move ahead of national regulation in this area. This can be an important first step, demonstrating the success of a policy in a smaller area to demonstrate the value and encourage national governments to roll it out more widely.

Figure 6: 12-Step Action Plan precedents, global south



01. Introduction
Ownership and timeline

Ownership

Implementation of the 12-Step Action Plan requires actions across government, industry and academia, as explored in the step-by-step action plan below. A coordinated approach between all stakeholders is essential to ensure that the overall action plan objectives are achieved. The mandatory aspects of the action plan – transparency and mandatory performance floor – can only be implemented by governments, whereas there is a greater degree of flexibility as to how the objectives around definition and incentivization are fulfilled. This suggests that the optimum outcome is likely to be achieved through close cooperation between government and industry.

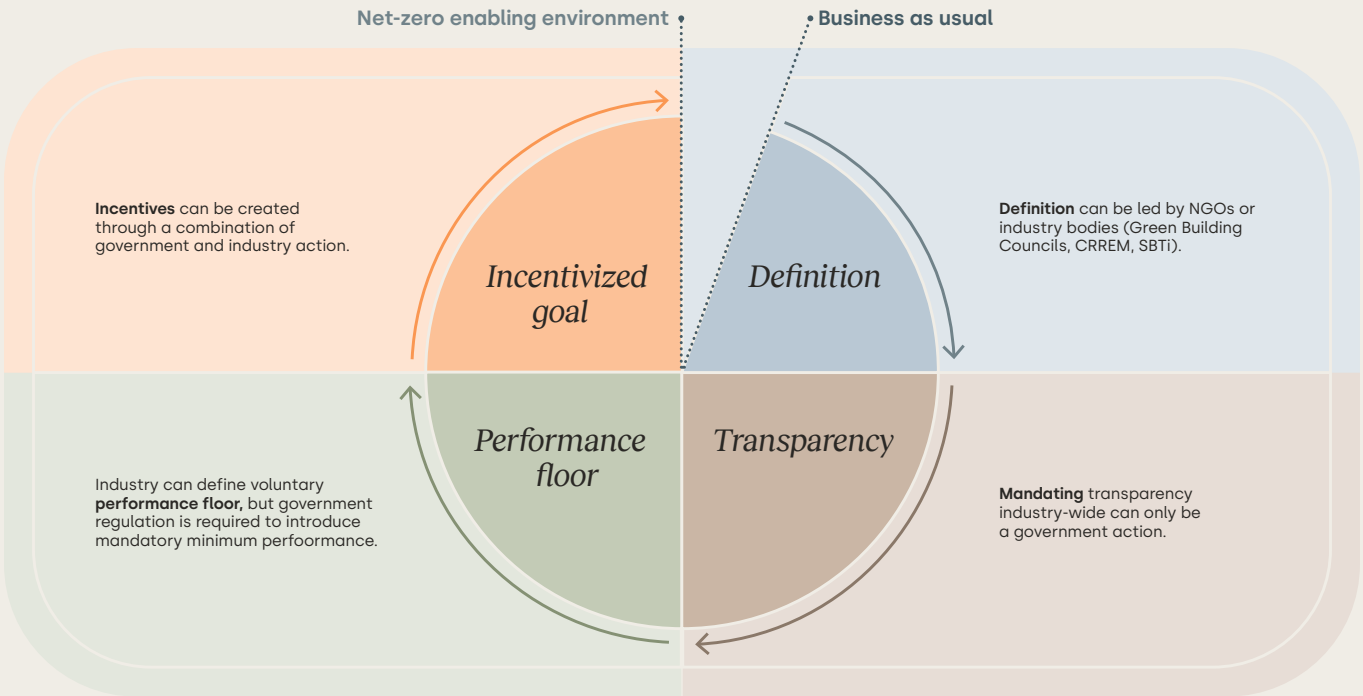
Timeline

With only 6 years to deliver on the 2030 Buildings breakthrough goal of halving emissions in the Built Environment, the timeline to implement the 12-Step Action Plan and start driving the transition to net-zero buildings on the ground is of critical importance. Feasible timelines will vary between countries, and will depend to a large extent on the existing situation, including both access to building data and the nature of the existing regulatory regime.

In many economies the need to build capacity within government in order to deliver on the action plan will be an important factor, as will the availability of building performance data.

Alongside the implementation of the 12-Step Action Plan, capacity building within the sector supply chain to deliver the transition on the ground once the action plan is in place is an important additional factor to consider. Ideally this capacity building should take place in parallel with the implementation of the 12-Step Action Plan in order to hit the ground running.

Figure 7: 12-Step Action Plan, leadership



01. Introduction
Compliance to performance

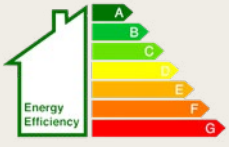
Case study: net-zero policy in the UK
Figure 8 below illustrates the current state of the policy transition to net-zero buildings in operation in the UK. Whilst the UK Government has consulted on a potential move to a national performance rating for larger commercial buildings, current policy remains as a compliance framework. Research by the Better Buildings Partnership in the UK (see Compliance to performance) demonstrates the limitations of this approach. In London, the Greater London Authority has introduced transparency requirements for major developments, including both estimated operational energy performance at design stage, and disclosure of actual annual operational performance for five years post completion. The commercial property market in the UK is increasingly transitioning to a performance framework, with NABERS now well established in the office market, and the UK Net Zero Carbon Building Standard undergoing pilot testing. As a result there is a gap opening up between prime markets that are pursuing performance outcomes, and the compliance-based approach adopted across the rest of the sector.

Compliance to performance
A key recommendation of the 12-Step Action Plan is the adoption of a Performance Framework that seeks to influence the operational energy consumption of buildings. This is distinct from a code compliance framework, that seeks only to influence the design and construction process. The control of building energy efficiency through regulation in most countries follows a code or compliance-based approach.

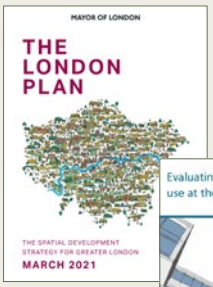
Code Compliance	Regulates specific aspects of a building's design and construction – façade thermal properties, energy efficiency of individual components. So-called "unregulated" or "plug" loads are excluded. Energy use of buildings in operation remains unregulated.
Performance Framework	Measures and sets targets for the total energy consumption of buildings in operation. A performance framework seeks to influence the operation of buildings as well as their design and construction.

Figure 8: Status of net-zero policy in the UK – public vs. private sector

National policy (compliance)



London policy (transparency)

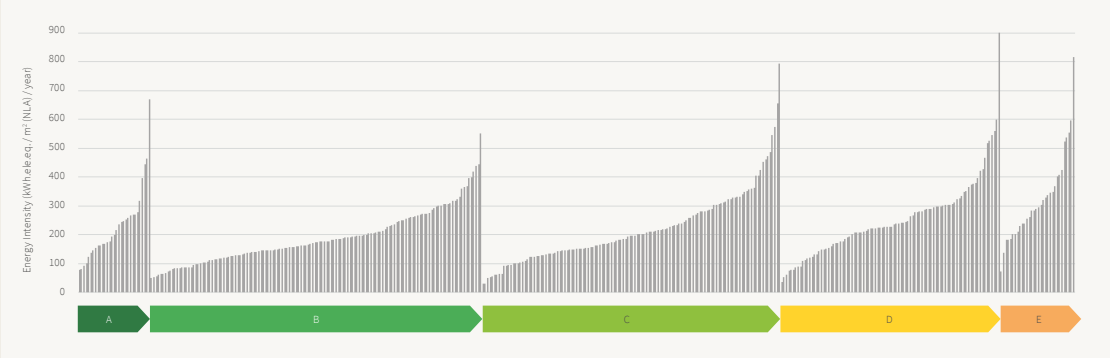


Market expectation (performance

01. Introduction
Compliance to performance

Whilst code compliance outcomes are sometimes expressed as an estimated energy or carbon performance, these do not typically encompass all the activities within a building (so-called "unregulated" or "plug" loads are excluded). Research in the UK by the Better Buildings Partnership demonstrated very little relationship between a building's level of code compliance (represented by its EPC rating) and its actual energy performance.

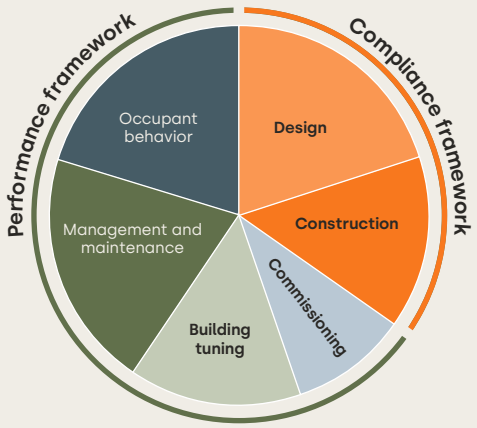
Figure 9: Office energy intensity compared to EPC Rating (BBP, 2024)[10]



Whilst a code compliance approach does have some impact on energy performance through the regulation of façade and equipment efficiencies, the issue is simply that code compliance only seeks to control some of the factors that influence the energy performance of buildings, as illustrated notionally in the graphic below.

A code compliance framework only regulates how a building and its main technical systems are designed and built. It does not regulate how that building is managed and used. A performance framework, by contrast, is focused on the actual in-use energy performance, and therefore includes consideration of all the factors identified in Figure 10.

Figure 10: Notional illustration of the factors that influence building energy performance and the scope of code compliance frameworks



01. Introduction
Decarbonization in housing and social infrastructure

EU Energy Performance of Buildings Directive
The EU Energy Performance of Buildings Directive (EPBD) incorporates many of the aspects of the proposed 12-Step Action Plan, including an internationally consistent methodology and a mandatory performance floor which increases over time. The Zero Energy Buildings (ZEB) standard, which applies from 2030 (2028 for public buildings) also requires the elimination of on-site fossil fuels.

However the EPBD remains a code compliance framework. Whilst outcomes are expressed in energy terms, the framework only covers regulated energy uses within buildings, and is assessed through a calculation methodology. Whilst the EPBD makes reference to the potential for validation through metered data, this is not mandatory, and calculated EPCs remain the implementation mechanism. The impact of the EPBD on real energy performance is likely therefore to be limited for the reasons discussed above, and there is no evidence to suggest that a Zero Energy Building as defined by the EPBD would be equivalent to a net-zero building.

CRREM
The Carbon Risk Real Estate Monitor (CRREM)[11] was initially developed with funding from the European Union's Horizon 2020 funding programme. It represents a whole building performance framework, which includes 1.5°C Paris-aligned energy performance targets.

NABERS
NABERS has been well established in Australia for a number of years, and is now operating in New Zealand and the UK. There are on-going discussions regarding its potential adoption in other countries, including Germany. NABERS[12] is a performance framework, the scope of which varies with the assessment type (whole building, landlord or tenant).

Low Carbon Building Initiative (LCBI)
In use across Europe, LCBI includes an assessment of operational carbon alongside embodied carbon and biogenic sequestration. Whilst primarily a construction methodology, the highest 3-star rating is obtained through evaluation of measured data. Energy performance thresholds are aligned with CRREM thresholds for each country. LCBI is therefore able to function as a performance framework when used with measured data.

Decarbonization in housing and social infrastructure
There are aspects of the 12-Step Action Plan, particularly around incentivization, that are primarily applicable to the commercial property market. Whilst energy and carbon are starting to influence commercial investors in the residential sector, energy performance is by no means a material consideration for the vast majority of householders, of whatever tenure. In addition, there is a material risk that by placing an obligation to upgrade on individual householders or landlords as part of a perfomance floor, lower-income householders in particular may be negatively impacted, and this could contribute to existing problems over unaffordability of housing that are already prevalent in many areas. The same principle applies to aspects of social infrastructure, particularly in the charitable sector, where organizations may have very limited access to funds for buildings upgrade.

This challenge needs to be set against the very clear and well-documented health and social benefits of decarbonizing housing regarding both reduction in fuel poverty and typically also improvements in comfort and living conditions.

The delivery of mass housing retrofit is an important policy area in itself, and in the UK (for example), there is an active consortium of public and private sector developing the approach to retrofit at scale.[13] An important principle is to consider housing, particularly social housing, as social infrastructure that is critical to the delivery of health and productivity outcomes for the economy. Bringing together these important social outcomes with the environmental benefit of decarbonization provides a strong case for large-scale investment, both public and private.

02. A 12-Step Action Plan
Steps 1-3: Definition

This defines a 1.5°C-aligned decarbonization pathway for the property sector in a country or region, consistent with the local context and planned energy system decarbonization. This leads on to a methodology for the evaluation of the performance of an individual building, with targets for individual buildings per typology and asset class.

At this stage it is important to start building up capacity, both in governing organizations (whether government or industry bodies) and across the sector to enable implementation of the action plan across the value chain.

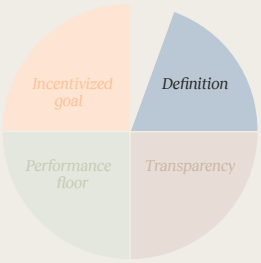


Figure 11: Definition, steps 1-3: actions and global precedents

Step		*Detail*	*Value*	*Precedents*
1	**Create a national property sector decarbonization pathway**	Sets a whole sector decarbonization pathway (differentiated by building type) that aligns with the 1.5°C pathway and is consistent with national/regional policies and context. Carbon Risk Real Estate Monitor (CRREM) v2 pathways provide a starting point where available but there will ultimately be a need for more detailed country-specific pathways.	Defines a clear objective for the national or regional property sector, demonstrating alignment with the Paris Agreement.	**Jakarta, Indonesia, and Kuala Lumpur, Malaysia:** Developing city-wide net-zero buildings roadmaps. **Science Based Targets initiative (SBTi)-CRREM:** National 1.5°C-aligned sectoral decarbonization pathways and EUI targets for the EU and leading global economies.[11]
2	**Develop a building-level assessment methodology and net-zero emissions targets**	Develop a methodology to assess the real energy performance of a building, along with targets aligned with the sector pathway. Set targets based on an understanding of the performance of existing buildings, for which the availability and quality of building performance data is a key enabler.	Translates the sector pathway into targets for individual buildings by asset class. Provides a robust means for evaluating and communicating the performance of an individual building in relation to net-zero emissions.	**UK:** Comprehensive 1.5°C-aligned sectoral decarbonization pathway developed to support the Net Zero Carbon Building Standard.[14] **The National Australian Built Environment Rating System (NABERS) (Australia, New Zealand, UK):** Defines a robust methodology for evaluating building energy performance.[15]
3	**Build delivery supply chain capacity**	Develop capacity and skills in governing organizations for oversight and in the sector supply chain to deliver the transition in practice.	Ensures that there is sufficient capacity in delivery and regulatory oversight to deliver the roadmap in practice and at the same time creates high-quality green jobs.	**US:** Buildings Technology Office (BTO) supporting the development of an "American building efficiency workforce as part of the clean energy economy".[16]

National decarbonization pathway
This requires a detailed understanding both of the property sector itself, and the energy infrastructure that serves it. The CRREM methodology has defined these pathways for a number of major countries around the world, and these were updated in 2023. These offer a good starting point for countries developing policy in this area, and have the significant advantage of global consistency. However, they are necessarily at a high level, and ultimately a more detailed analysis will be required at country level to navigate the journey to a net-zero property sector. This is underway in the UK for example, where the Net Zero Carbon Building Standard has been working to map out exactly this pathway as part of a comprehensive national standard.

Global equity
There is a broader question of global equity when setting national decarbonization pathways. Should nations in the global north, that over time have contributed more to global warming, set pathways to decarbonize more rapidly than those in the global south? This would recognise that global south economies have contributed less in the past and have to balance the environmental imperative of acting to stem climate change with the social imperative for development to alleviate poverty and improve living conditions.

02. A 12-Step Action Plan
Steps 1-3: Definition

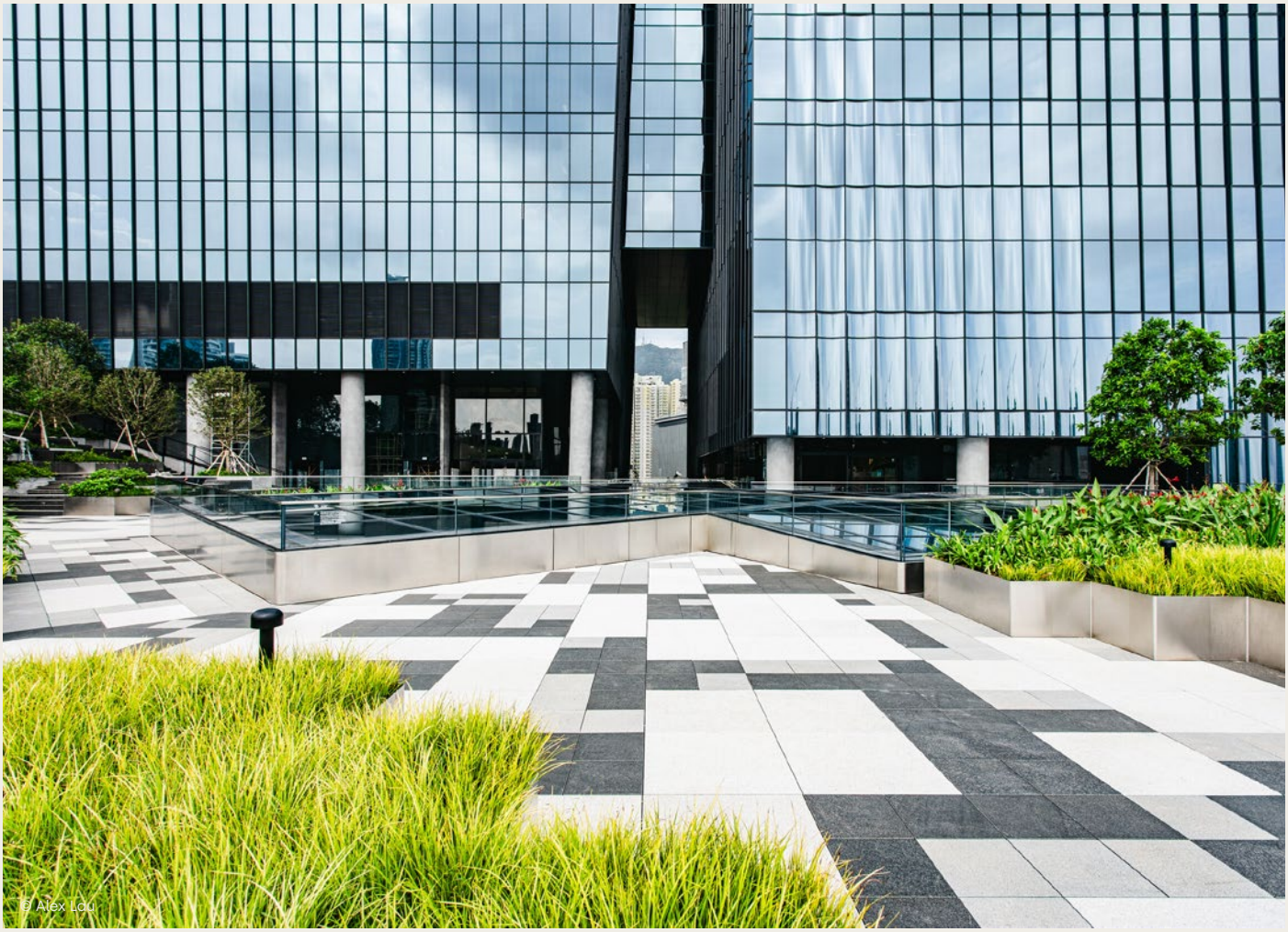
Building methodology
The building level calculation methodology will need to address both the robust estimation of energy performance in design and construction, and the measurement of performance in operation. The most robust example of this is the NABERS methodology, which is well established in Australia (also operating in New Zealand and the UK) as both a design-stage and operational assessment methodology. There are other examples of a robust design stage method, including notably ASHRAE 90.1, which is the basis of LEED energy assessments.

The approach in global south markets will need to be appropriate to the skills and capacity within those markets, which relied heavily on analysis to predict performance at design stage. The EDGE[17] certification scheme was developed by the International Finance Corporation (IFC), part of the World Bank. It defines a more elemental certification process, less reliant on analysis, but still focused on real operational performance. EDGE reflects both the budgetary constraints and availability of supply chain skills in global south markets.

Key considerations for the development of a methodology include:

- → Division between responsible parties (landlord/tenant)
- → Normalization for utilization/productivity output to avoid perverse incentives
- → Availability/quality of data required to make the assessments
- → Cost of implementation (red tape), and therefore the impact of enforcing mandatory assessments
- → Skills and capacity within the market to deliver assessments at the required scale

All current and emerging energy efficiency methodologies use EUI – energy use intensity per floor area, calculated on an annual basis. This clearly needs to remain as the base metric for consistency. However, as policies and incentives mature it will be important to consider additional metrics which more accurately reflect our overall objectives.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02. A 12-Step Action Plan
Steps 1-3: Definition

Energy vs. carbon

The ultimate goal of the 12-Step Action Plan is to minimise the carbon emissions associated with buildings in operation. However, carbon performance combines two issues – how much energy a building uses, and where that energy is sourced from. The approach proposed divides these two issues, with separate targets for energy efficiency (Energy Use Intensity) and renewable energy procurement.

However, the relationship between energy and carbon varies from day to day and season to season. The nature of this variation is different between countries and regions based on the local generating mix. Where fossil fuel generation dominates, the fluctuations tend to be relatively modest. However, as countries around the world transition to more intermittent renewable energy sources, such as wind and solar, grid carbon intensities become much more variable, and as a result static annual average grid carbon factors are increasingly a gross simplification of a complex and dynamic reality. In some countries, including the UK, hour-by-hour data on grid carbon intensity is readily available, either nationally or regionally.

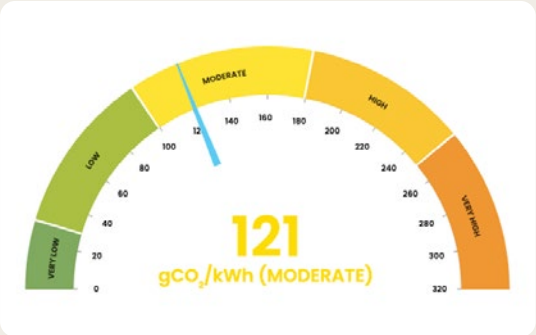
As the proportion of intermittent generation increases, the role of energy storage becomes more important – the more storage available the more effectively renewable generation capacity can be utilized. Buildings have an important role to play here, alongside infrastructure scale storage. Buildings can contribute through provision of actual storage capacity (thermal or electrical), and by active demand management, shedding non-essential loads during peak times. In many markets there are already mechanisms to manage load shedding for large consumers, both commercial and industrial as a means of managing grid capacity at peak times. Currently, however, this is considered separately to energy and carbon efficiency, which is considered on an annual average basis. Current energy and carbon reporting practices take no account of time of use, and don't allow a mechanism to show any performance benefit from the inclusion of on-site energy storage, in whatever form.

Ultimately a net-zero aligned policy landscape will need to influence not just how much energy is used, but when it is used, creating clear incentives to shift demand away from peak periods. This implies a more sophisticated reporting metric than annual average EUI, with hourly timestep carbon intensity being the ultimate goal. This is a significant increase in complexity, however, and comes with risks as a result. It also makes building performance reporting more volatile, putting it literally at the mercy of the elements.

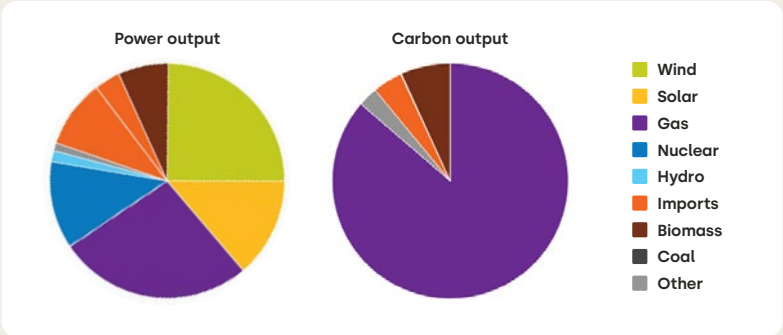
Our recommendation in the short term is that annual average EUI remains the central metric, but that additional factors are considered in a comprehensive definition of net-zero, such as the ratio of peak demand to annual average, and the quantum of on-site energy storage.

Figure 12: UK Grid Carbon Intensity Data[18]

Current carbon intensity



Current generation mix and carbon emissions



02. A 12-Step Action Plan
Steps 1-3: Definition

Setting performance targets
Defining the performance threshold for net-zero can be complex, and needs to be done right if any associated policies are going to be effective. In New York there are around 80 separate targets for building sub-classes, and those targets are adjusted further under certain circumstances, for buildings operating 24/7 for example.

Some key issues to consider are:

- → Creating a level playing field between typologies and usage patterns. Where sufficient data exists, allocation of energy budgets between typologies can simply be on the basis of the differences in average performance. But for a truly equitable policy, other considerations around social benefit may need to be considered – should the net-zero target for a hospital be proportionally as difficult as an office or factory, for example?
- → One long-term target or a pathway? Most current examples define the starting point as the current market average performance, and set a downward pathway from that point to a defined net-zero target year.
- → Matching top down (what's needed) with bottom up (what's possible), and how to address the gap between the two (if there is one). Simply setting unrealistic targets ignores the gap, but doesn't make it go away.

Build delivery capacity
Once the national pathway and assessment methodology are in place, the next critical step is to develop the capacity necessary both within government and in the supply chain to deliver the action plan on the ground.

In many economies, the regulatory challenge will be the transition from a code compliance to a performance-based approach. Where a comprehensive building code regulation already exists, the ideal solution would be to re-purpose that existing regulatory framework, rather than adding additional layers of requirements. So in this situation the challenge is likely to be one of skills rather than capacity per se. The shift of mindset from compliance to performance is significant and should certainly not be underestimated.

In global south economies that may have less developed building codes and/or enforcement capability, the additional challenge will be building capacity to develop and effectively implement the 12-Step Action Plan.

Alongside the implementation of the 12-Step Action Plan, capacity building within the sector supply chain to deliver the transition on the ground once the action plan is in place is an important additional factor to consider. Ideally this capacity building should take place in parallel with the implementation of the 12-Step Action Plan in order to hit the ground running.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02. A 12-Step Action Plan
Steps 4-6: Transparency

Transparency of performance can be a powerful agent for change. While mandatory building energy codes for construction are relatively commonplace, a performance framework for buildings in operation only exists in a few jurisdictions globally. The shift in focus to real energy performance is a big step and will require the support of a comprehensive public and industry engagement campaign.

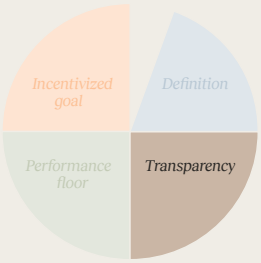


Figure 13: Transparency, steps 4-6: actions and global precedents

Step		*Detail*	*Value*	*Precedents*
4	**Mandate disclosure of energy performance against net-zero thresholds**	Require all operational buildings to calculate and disclose their energy performance relative to defined net-zero targets and publish the outcome.	Creates transparency in building energy efficiency, which allows the market to factor energy performance into commercial decisions.	**South Africa:** Mandatory Energy Performance Certificates from 2025 for larger buildings, based on measured energy consumption.[19] **UK:** Display Energy Certificates (DECs) – operational energy ratings for public buildings. **Australia:** Mandatory NABERS ratings for qualifying buildings.
5	**Mandate disclosure of the carbon impact of energy procurement**	Require all operational buildings to disclose energy sourcing, including both on-site generation (fossil and renewable) and the carbon impact of the purchase.	Adding transparency about energy sources and procurement adds further clarity on building alignment with net-zero emissions.	**US:** Mandatory energy emissions performance disclosure in place across a number of US cities, including New York City, Washington, DC and Seattle.
6	**Establish a public engagement campaign to raise awareness**	Raises awareness and, in the longer term, helps in gaining the acceptance of a minimum energy performance floor approach.	Public awareness of and support for the action plan is critical for its success.	**New York City:** Local Law 97 involves an extensive public engagement campaign to support the launch and subsequent expansion.

Energy procurement
The source of energy is as important as energy efficiency in terms of achieving net-zero. A building that is meeting the efficiency threshold and either 100% electric (excluding emergency power) or powered by a combination of electricity and another renewable energy source where available, but using a typical electricity tariff would be defined as Net-zero Ready. Adding a 100% renewable energy supply would enable that building to be fully Net-zero in Operation.

The availability of renewable energy and/or other renewable energy sources at a grid level varies significantly between jurisdictions. In many developed markets, 100% renewable energy is available either through 100% renewable tariffs or direct from generators through Power Purchase Agreements, thereby demonstrating additionality beyond national renewable commitments.

However, even in the most developed markets specific purchasing arrangements and green tariffs are not available in certain geographies and Renewable Energy Certificate (REC) based tariffs remain the only option. In general RECs represent a re-allocation of government-required renewable generation and so do not result in additional capacity on the grid. However, where available, green-e certified RECs are retired on behalf of the purchaser and thus cannot be used by another entity for renewable generation compliance requirements, so they can represent additionality and would be considered equivalent to a 100% renewable tariff.

For buildings in countries with a nationalised grid and without the option of purchasing fully renewable power, other options will need to be considered, including carbon offsetting on the international market to a recognized standard.

Awareness raising
A key finding of the process of implementing Local Law 97 in New York was the critical importance of awareness raising. Implementing an operational performance floor is a fundamental change – introducing regulation where none existed previously – and therefore communicating effectively with industry is vital. Priorities initially will focus on making individuals and building owners aware, moving then on to making the case for acceptance.

02. A 12-Step Action Plan
Steps 7-8: Performance floor

Performance transparency can be an important driver of change but is not effective across all regions and sectors, in particular in markets where competition is less of a driver and the market is less mature.

Action 7 proposes the introduction of an energy and carbon mandatory performance floor in the public sector as this offers an opportunity for a limited trial and for the government to raise both awareness and broader confidence in deliverability with the wider market before sector-wide roll out (Action 8).

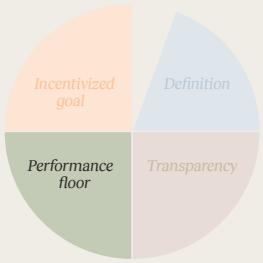


Figure 14: Performance floor, steps 7-8: actions and global precedents

Step		*Detail*	*Value*	*Precedents*
7	**Set a mandatory energy and carbon performance floor for the public sector**	Mandate a performance floor for both new and existing government buildings as a first step in driving market transformation.	Implementing a performance floor for the public sector allows for a smaller scale trial and additional opportunities to raise public and industry awareness prior to a full roll-out.	**Australia:** Mandatory minimum NABERS rating of 4.5* for government buildings. **EU:** Zero Energy Buildings (ZEB) standard comes into force for public buildings ahead of private assets (note that limits are still code based and not performance based).
8	**Set a mandatory energy and carbon performance floor for all buildings**	Extend the performance floor to all buildings and sectors. Put appropriate support in place to avoid any adverse social equity impacts, particularly in the housing sector.	Implementing a performance floor will ensure that the least-efficient buildings achieve a minimum level of energy efficiency and are on a trajectory to achieving net-zero alignment. This will deliver economic benefits to building users through reductions in operating costs along with the carbon benefit.	**New York City Local Law 97:** Mandatory minimum energy performance from 2025 with increasing standards to 2040. **Johannesburg and Durban (eThekwini), South Africa:** Implementing net-zero carbon building policies, including EUI limits for new buildings.

Timeline to introduction

A mandatory performance floor is a big step with far-reaching implications for the market. Setting an appropriate performance floor will require a robust evidence base of real performance in order to accurately assess the market impact. Prior to mandating performance transparency this may not exist, or data may be patchy and unreliable. Following the implementation of transparency, the market will also take time to increase its understanding of performance, and this understanding will be required in order for the proposed performance floor to gain broad acceptance.

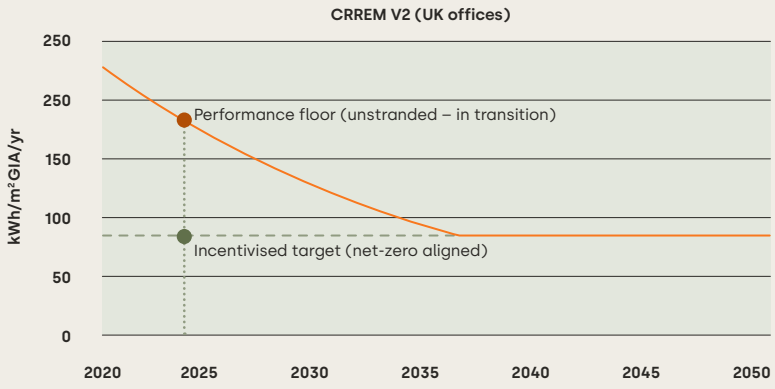
As an example, in New York City's Local Law 97 (see case study) mandatory disclosure was introduced in 2019 with preceding regulations (Local Law 84 and 133) dating back to 2009. Minimum performance only comes into effect in 2025.

02. A 12-Step Action Plan
Steps 7-8: Performance floor

Performance floor vs. net-zero target
Figure 15 demonstrates the principle of a performance floor – proposing a target aligned with the national decarbonization pathway. The target is initially aligned therefore with the average performance for the sector, but decreases over time. The net-zero target for the sector by contrast is fixed, as illustrated below using the UK CRREM trajectory as an example. Having an ultimate net-zero target that does not vary over time would appear to be an important part of hardening the definition of what a net-zero building is.

An important aspect of a performance floor therefore for operational buildings is that the limit will decrease over time, meaning that buildings will need to continue to find ways to improve performance in order to remain compliant.

Figure 15: The principle of a performance floor



Case study - New York City Local Law 97
Local Law 97 came into effect in New York City in 2019, introducing a requirement for mandatory annual operational carbon emission reporting for all buildings over 25,000 square feet in size. It updated and expanded preceding requirements of Local laws 84 and 133, dating back to 2009. The declared goal is to reduce carbon emissions of New York's largest buildings by 40% by 2030 and achieve net-zero by 2050.

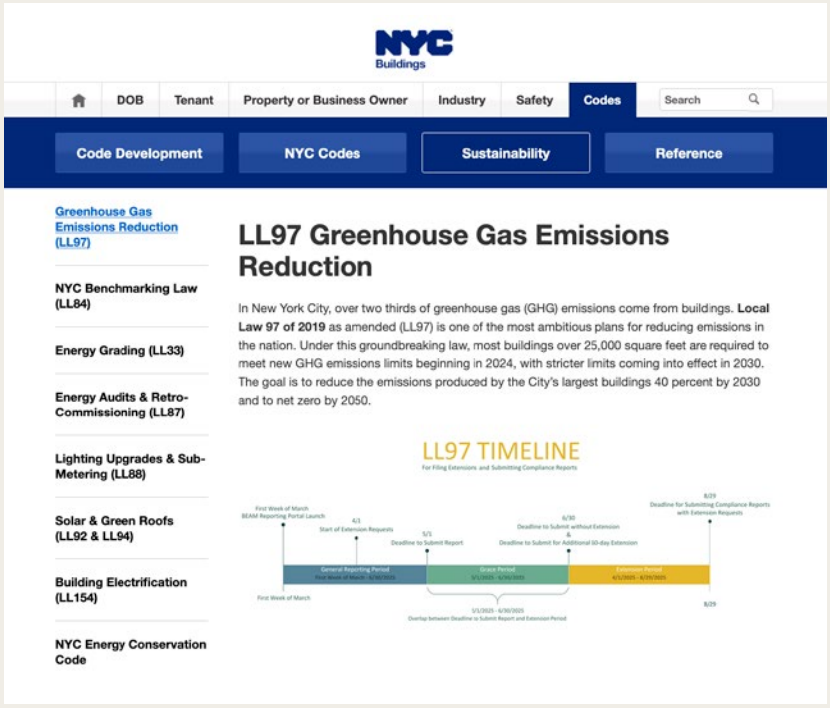
Carbon emission limits come into force from 2025, with 80 different limits set for different asset sub-classes, and adjustment for non-standard use patterns and other specific circumstances. Limits reduce over time, in line with the overall objective to achieve a 40% reduction by 2030.

Buildings that are unable to achieve the targets will from 2025 be required to pay a penalty set at $268/tonne for emissions above the threshold. At this level it is anticipated that the penalty will provide a relatively strong incentive to act to reduce emissions, rather than just becoming another form of taxation.

There is an additional requirement in NYC (Local Law 33) for buildings over 25,000 sq ft to display their energy efficiency and water grades in a visible location.

In practice New York City and other cities implementing building performance standards have found that outreach and making sure all building owners know about requirements is one of the biggest challenges. This demonstrates that alongside these market incentives there also needs to be significant communication, outreach and support.

Figure 16: New York City, Local Law 97



02. A 12-Step Action Plan
Steps 9-12: Incentivized goal

With a performance floor in place, the minimum level of performance of operational buildings in the market should start to improve. In parallel, it is important to have a strong set of incentives in place to achieve the long-term objective of full net-zero emissions alignment. The incentives proposed in actions 9 to 12 all depend on action 9. Without a clear and robust net-zero building badge or certification for buildings in operation, there is no clear basis for incentivization through disclosure, financing or taxation.

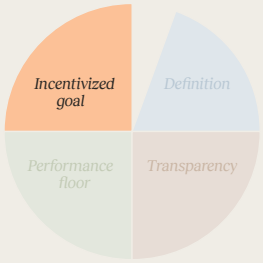


Figure 17: Incentivized goal, steps 9-12: actions and global precedents

Step		*Detail*	*Value*	*Precedents*
9	**Adopt a consistent definition of net-zero emissions in building certifications**	Adopt a clear, internationally consistent definition of net-zero emissions in building certifications at construction and operation stages. This will allow investors to differentiate and thus attribute value to assets aligned with net-zero emissions.	There is strong evidence that markets will respond to clear certifications and that this drives a value differential between buildings that do and do not meet the defined standard.[20]	**UK:** The Net Zero Carbon Building Standard is the first certification scheme globally incorporating a comprehensive definition of net-zero. **Global:** Edge Zero Carbon is an assessment and certification for developing markets. Developed by the World Bank.[18] **Australia:** Evidence of a value premium for NABERS-rated buildings, as well as the effectiveness in improving performance.
10	**Mandate corporate disclosure to include building performance against net-zero thresholds**	Defining disclosure requirements to include the proportion of owned/leased buildings meeting a net-zero emissions target (voluntary or mandatory).	It is likely that corporations would respond to the risk of *naming and shaming*, taking action to avoid association with a portfolio that does not align with net-zero emissions.	**UK:** The first G20 country to introduce mandatory disclosure against Task Force on Climate-related Financial Disclosures (TCFD) standards.[21]
11	**Include a requirement or incentive for net-zero emissions in financing mechanisms**	Setting net-zero alignment as a requirement, whether in an overall green finance taxonomy, government loan scheme or domestic mortgage.	The ability to access an improved finance rate for a building aligned with net-zero emissions would have a direct positive impact on a development's bottom line. This would provide a clear commercial incentive to achieve alignment.	**EU:** The Taxonomy for Sustainable Finance includes mandatory minimum energy performance, with public sector thresholds ahead of private assets (note that limits are generally code-based and not performance-based).
12	**Align government taxation and funding with performance against net-zero thresholds**	Offering differential building taxation rates for buildings aligned with net-zero emissions, whether commercial or domestic, or setting net-zero alignment requirements for government funding.	Provides a direct commercial benefit for buildings that achieve net-zero performance by reducing operating costs and providing access to lower cost finance.	**London, UK:** The Mayor's Energy Efficiency Fund includes threshold performance requirements to access funding (note that thresholds are code not performance based).[22]

02. A 12-Step Action Plan
Global consistency: certifications

The concept of carbon stranding demonstrates that the market will respond positively to a clear definition of a building's performance relative to a net-zero target. Carbon stranding is starting to be picked up by investors and is now part of GRESB for example, using the CRREM methodology.

However, CRREM is one assessment method in what is a crowded global market for sustainability certifications. Key global players, including BREEAM, LEED and Green Star, do not currently align explicitly with net-zero as we explored in our previous publication. Pressure in the investor market for this to change is growing.

LOTUF (Leaders of the Urban Future)[23] was launched in 2022 as a timebound, investor-led project to help accelerate the decarbonization of institutionally-owned real estate. Its 2024 White Paper[20] sets out clearly the dysfunctionality of the current real-estate market in terms of its response to the climate crisis and sets out some clear actions to improve transparency and incentivise change. A key finding is that none of the leading sustainability certifications evaluated are fully aligned with a comprehensive definition of net-zero. This is a critical intervention, coming as it does from a key group of international property investors, illustrating the strength of demand within the investor market.

In the UK the Net Zero Carbon Building Standard is in pilot testing. In the analysis presented in the LOTUF White Paper, it is the only standard of those reviewed to encompass a comprehensive definition of net-zero (including both operational and embodied carbon emissions). The process that has been gone through to get to the pilot launch in summer 2024 demonstrates the challenges of developing a comprehensive standard of this nature, and no doubt there will be lessons from this for other sectors and countries, but it is essential if we are to achieve the Buildings Breakthrough that this is done beyond the UK, and in a way that generates international consistency.

It is crucial now that key players in the certification sector come together to adopt a consistent and comprehensive approach to net-zero. Not all countries will be able to follow the UK's example in generating a country-specific rating scheme, so international certifications such as LEED and BREEAM have a critical role to play in generating the transparency that we need.

Embedding net-zero incentives

There is growing pressure from organizations including the International Investors Group for Climate Change (IIGCC) for net-zero transition to be investible across all sectors,[24] with clear goals and outcomes that can mobilise private finance.

Once we have a clear and consistent definition and measurement of a net-zero building, supported by a robust certification that is well recognised in the market, then evidence suggests that the market will respond by generating demand for net-zero assets.

Corporate climate disclosures are gathering pace around the world, with some countries mandating disclosure, and many companies following voluntary schemes. Including within this disclosure the proportion of buildings that achieve the net-zero building standard would be an easy way of increasing transparency and incentivising action.

There are a total of 28 green finance taxonomies around the world, with the EU Taxonomy on sustainable finance being the most well known. This does include minimum energy performance requirements, but currently relies on a compliance approach to govern energy efficiency linked to EU regulations. In time this could be extended to incorporate a net-zero buildings requirement. And this requirement could also be introduced to other unregulated green finance taxonomies.

Finance levers are not necessarily limited to large scale corporate finance. In the domestic sector, with a clear definition in place, net-zero aligned homes could qualify for a lower mortgage rate. This could be enforced through legislation, but it may start to happen naturally if net-zero homes start to be perceived as having stronger long-term value.

Corporate disclosures and green finance would have an impact on the corporate market, but to reach the whole market requires the last action, number 12. This is to introduce differential building taxations for net-zero buildings. In the UK, this means business rates for commercial property and council tax for domestic, and similar regimes operate in many other countries. Introducing reduced taxation rates for buildings that align with net-zero, and increasing for those that don't would create a fiscally neutral market incentive that would feed through to asset value over time. As with the performance floor, the gap in tax rate between net-zero and other buildings can start small and widen over time to give the market time to adjust. This final step is the one that would reach down into the lower reaches of the market, ensuring that even small property owners and businesses are incentivized to align with net-zero.

02. A 12-Step Action Plan
Policy and incentives: precedents

The policy and incentives action plan is constructed on a foundation of real examples from around the world, demonstrating that the action plan, far from being wishful thinking, is fully deliverable.

1	**Define a national property sector decarbonization trajectory**	The Carbon Risk Real Estate Monitor (CRREM)[11] decarbonization trajectories define 1.5°C aligned trajectories for key use classes in the main global markets. Jakarta, Indonesia, is developing a roadmap for net-zero buildings in development, working towards a target for 30% emissions reduction by 2030 and net-zero by 2050. Kuala Lumpur, Malaysia, is developing a net-zero buildings roadmap as part of its Climate Action Plan 2050.	CRREM
2	**Develop a building level methodology to assess the performance of buildings against the sector trajectory**	ASHRAE 90.1 provides a robust methodology for assessing building performance at design stage. NABERS in Australia, New Zealand and now the UK, provides both a design stage and operational performance assessment method. The EDGE Certification includes a more basic energy performance methodology that may be appropriate for global south countries. New York City's Local Law 97 defines threshold emissions for a total of 80 asset sub-classes. The UK Net Zero Carbon Building Standard will shortly release targets for all main asset classes.	ASHRAE NYC Local Law 97 NABERS Edge UK Net Zero Carbon Buildings Standard
3	**Build delivery capacity both within government and supply chain**	The supply chain sustainability school in the UK is one of many organizations around the world focused on skills and training for the green transition of the Built Environment. Holcim Sustainable Construction Academy is a free and open learning resource that covers decarbonization across the whole-life cycle. Developed by Holcim together with experts from academia and industry it is "on a mission to decarbonize building, and enable circular, low-carbon, energy-efficient, and regenerative buildings and cities".[25]	Supply Chain Sustainability School Holcim Academy
4	**Mandate disclosure of energy performance against net-zero thresholds**	In the UK, public sector buildings have to publish their DEC Rating, which is based on real energy performance. In Australia, NABERS ratings are mandatory for some asset classes over a minimum size. A number of US Cities have mandatory energy performance disclosure requirements, including Washington DC, Chicago, Los Angeles, San Francisco, Seattle. South Africa is introducing mandatory Energy Performance Certificates from 2025 for larger buildings, based on measured energy consumption.	NABERS
5	**Mandate disclosure of carbon impact of energy procurement**	Whilst voluntary, the UK Net Zero Carbon Building Standard will set threshold requirements for renewable energy procurement. LEED Zero requires 100% renewable energy procurement in addition to a LEED certification.	UK Net Zero Carbon Buildings Standard LEED Zero
6	**A public engagement campaign to raise awareness and gain support for mandatory minimum energy performance requirements**	Raising public awareness and generating support has been cited as the biggest challenge in the implementation of Local Law 97 in New York. Building on previous disclosure regulations, the mandatory minimum performance requirements come into force in 2025.	NYC Local Law 97

02. A 12-Step Action Plan
Policy and incentives: precedents

7	**Public buildings: implement a regulatory framework for building energy performance incorporating mandatory minimums**	In Australia, all government buildings are required to have a NABERS rating of at least 4.5*. In the EU, public buildings are required to achieve Zero Energy Building (ZEB) status 2 years ahead of the deadline for all buildings (2030).	NABERS EU
8	**Extend the above framework to all buildings, in place of any energy-related code compliance framework**	In New York under Local Law 97 from 2025 any buildings not meeting the mandatory energy performance thresholds will have to pay a carbon offset tax, set at $267/tonne. Similar schemes are in place across a number of north American cities including Washington DC, Seattle, Boston and Vancouver. Johannesburg and Durban (eThekwini) in South Africa are both implementing net-zero carbon building policies including EUI limits for new buildings. Limits decrease periodically from 2022 to 2030 to meet the cities' net-zero carbon 2030 targets for new buildings.	NYC LOCAL LAW 97
9	**Create a market incentive through a recognised net-zero building certification**	Whilst there are a broad range of building sustainability certifications that to some extent reference net-zero, as explored in our previous publication,[5] there are none available currently that reflect a comprehensive net-zero definition. The UK Net Zero Carbon Building Standard, due for pilot launch in late 2024 will be the first such certification globally.[14]	UK Net Zero Carbon Buildings Standard
10	**Mandate corporate disclosure to include the performance of buildings against net-zero**	The UK was the first G20 country to mandate large corporations to disclose carbon impacts in line with the Task Force for Climate Related Financial Disclosure (TCFD). This does not currently include disclosure around net-zero buildings.	TCFD
11	**Include a qualifying requirement or rate incentive for net-zero alignment within financing mechanisms**	Green Finance is currently an unregulated market in many jurisdictions. In the EU, the EU Taxonomy addresses building energy efficiency but through the lens of compliance rather than performance.	EU
12	**Align government taxation/ funding to performance against net-zero thresholds**	In New York, Local Law 97 is set up as a performance floor, but as the penalty for non-compliance is a carbon tax, it does in reality operate as a differential taxation system against net-zero performance.	NYC LOCAL LAW 97

The key conclusions from the above analysis are:

1. The methodologies to define and assess net-zero buildings in operation are already in existence.
2. All the policy levers proposed as part of the 12-Step Action Plan have already been or are being implemented in at least one country or region.
3. The net-zero incentives are not yet in place, with a lack of global consistency around the definition of net-zero buildings remaining a barrier.

02. A 12-Step Action Plan
The policy imperative

Taking action to tackle the climate crisis is of course an imperative, but for policy-makers this has to be balanced against other policy priorities. In this section we explore the key broader benefits that would flow from the implementation of our proposed 12-Step Action Plan. Alongside those benefits we assess the key risks and how these can be most effectively mitigated.

Opportunities

Operating cost savings

Delivering energy efficiency improvements reduces operating costs for building owners, operators and tenants in both commercial and residential markets.

- → "In developed economies, lower energy intensity helps to enhance competitiveness through lower total energy cost while attenuating environmental risks." (WEF, 2024)
- → "For consumers, the energy savings brought about by doubling efficiency progress would result in significant savings in energy bills. Today's energy bills in advanced economies could be lowered by a third." (IEA, 2023)
- → The UK's independent review of net-zero found that "Making homes lower carbon by improving energy efficiency – and so reducing energy demand – and installing low carbon heating can provide many benefits. For households, it can cut bills, improve health and wellbeing, and increase the value of homes." (p.238)

Investment in buildings

There is a strong sense that there is untapped demand in the property market to invest to create net-zero aligned buildings. The 12-Step Action Plan creates transparency and a clear black and white definition of what a net-zero building is. We anticipate that this will create an enabling environment for investment in net-zero buildings, leading to a "race to the top" for the commercial property sector in more affluent markets, unlocking additional private investment in real estate development and refurbishment. We anticipate that this would manifest initially within prime real estate markets, but with a trickle-down over time to other market sectors.

In Australia, first voluntary and latterly mandatory NABERS ratings for commercial buildings have had a significant market impact. It is clear that buildings with higher NABERS ratings attract higher asset values, with differentials up to 18% according to Knight Frank research[26] not only because of the implied energy efficiency, but because the market considers them to be higher quality buildings overall, i.e. the market is using NABERS ratings as a proxy for quality.

This additional investment translates into growth in the construction sector, which will need to be supported with skills training to ensure that there is sufficient capacity in the supply chain to deliver. Assuming this capacity can be created however, then that growth will deliver new green construction jobs, as well as contributing to overall economic growth. In an international property market, there may be a "first mover advantage" with early adopting countries or regions able to attract more international investment into the property sector.

- → The energy efficiency-related measures needed to achieve the doubling target (COP 28 target to double the rate of global energy efficiency improvement) would result in the creation of around 4.5 million jobs in 2030 compared to today, with more workers needed to help retrofit buildings, install energy-saving technologies and manufacture more efficient vehicles. (IEA, 2023)
- → The UK's independent review of net-zero recognises that "Increasing the energy efficiency of appliances and buildings is also a key driver of economic growth, estimated to support up to 175,000 jobs and add £6 billion in Gross Value Added (GVA) to the [UK] economy by 2030" (p.238)
- → PWC finds that retrofitting homes in the UK could sustain more than 500,000 jobs. (PWC)

02. A 12-Step Action Plan
The policy imperative

Market attractiveness

A significant proportion of major corporates have or are considering implementing net-zero targets and roadmaps within their organizations. And whilst the impact of this trend on corporate property portfolios is not yet clear, the expectation is that organizations will increasingly seek to align the performance of their buildings with their corporate objectives. So it is reasonable to expect that, all other things being equal, a jurisdiction that adopts the 12-Step Action Plan would create a more attractive market for international tenants and investors, who would be able to invest with confidence in net-zero aligned property.

The benefits that flow from this mainly relate to the growth in demand for, and therefore supply of, net-zero commercial buildings. A net-zero aligned property sector would be a pull factor for corporates making decisions about where to headquarter and where to take space (acknowledging that net-zero alignment is one of many factors at play here), and attracting businesses to the location would drive other economic and employment benefits for the region in question. We would expect that net-zero alignment would also impact property values, with aligned property attracting a premium over assets of a similar nature in other locations. Initially we would expect this to impact major corporates in prime commercial locations, but over time we would anticipate seeing a trickle-down effect through smaller businesses and other market sectors.

Investment in renewables

Many countries have already set national net-zero targets. One of the challenges implied by such a target is a transition to 100% renewable electricity generation infrastructure. Investment in net-zero buildings can contribute to this in a number of ways, ultimately reducing the infrastructure cost associated with the transition:

1. Wasting less energy, as well as incorporating energy storage that reduces peak demand, results in a smaller energy system that requires less physical infrastructure. A transition to net-zero buildings would therefore also provide substantial cost savings to industry and governments (IEA, 2023);
2. By incorporating on-site renewable energy, effectively privately financing a proportion of the overall required capacity;
3. By shifting demand through energy storage and active demand management, so reducing the quantum of both infrastructure renewable generation and energy storage capacity required;
4. In developing countries, taking action to manage energy demand as well as focusing on the supply can improve access to secure energy, improving the ability to attract investment while offering the opportunity to avoid low-efficiency legacy systems seen in developed economies (WEF, 2024).

Aside from the buildings themselves, the need for a net-zero building to procure 100% renewable electricity can also be a mechanism for funding additional renewable energy generation capacity in that locality, effectively providing a conduit for private financing.

The proportional impact of buildings on infrastructure transition will vary between markets. The impact is likely to be significantly larger in global south economies where electricity networks are less well developed and major developments are required to be more self-sufficient in energy terms.

Risks and mitigations
Nothing is risk free of course, and there are risks associated with the adoption of the 12-Step Action Plan. Key risks we have identified include the following:

Increase in cost of doing business
The impact for building owners and developers on the cost of developing and managing property will be a key concern in many markets, particularly where demand for space and rental income is lower. In leading markets such as London and New York progress is already underway as case studies in this document demonstrate. For other regional cities, there will be a valid concern over a negative impact on competitiveness.

The regional competitiveness issue can be mitigated by moving to adopt the action plan nationwide. The overall impact on the cost of doing business can be mitigated by modifying existing mechanisms, rather than creating new ones. For development projects, in most economies there is already a building code and/or permitting process that could be aligned to net-zero. For operational buildings there is a bigger challenge as the operation of buildings is subject to less regulation. However, property taxes and utility billing provide two opportunities for intervention via modification of existing mechanisms.

In many global south markets the more limited regulation of the property market results in a bigger gap to close to implement the action plan. As mentioned in the methodology section above, the EDGE certification offers a methodology for evaluation that was developed by the World Bank specifically for global south countries and reflects a level of skills and complexity appropriate to those economies, and therefore in our view offers a useful blueprint approach.

Regional brown discounting
The need for investment in existing properties to achieve net-zero alignment risks favouring prime markets over more marginal regional locations. With prime locations able to produce net-zero aligned property, implementation of the 12-Step Action Plan may accelerate "brown discounting" in regional locations.

This negative impact can be mitigated by actively introducing measures that incentivise net-zero transition in specific, more marginal locations. Policy examples include differential property taxation or local loan or grant schemes. Another interesting potential is to mobilise carbon offset funding, by setting up local net-zero retrofit funds. With appropriate governance (for example aligning the fund obtaining Gold Standard[27] or ICROA[28] accreditation), a carbon offset fund would be able to attract net-zero transition funding from corporate investors and target that specifically at areas where a self-funded transition to net-zero is not feasible.

In the UK, Arup has worked with BusinessLDN to develop a Blueprint for a Business-led UK Collective Offsetting Fund[29] that explores this issue in more detail.

Risk of Inaction
As well as considering the risks around implementation of the 12-Step Action Plan, it is also important to consider the risks of not doing so. National or regional markets that adopt the action plan will gradually increase the supply of net-zero aligned property. In markets that do not move to adopt the action plan, such buildings, to the extent that they exist at all, will not be able to demonstrate their net-zero credentials to an international market. This on-going lack of transparency risks leading to the devaluation of buildings in that market when compared to international competitors. Whilst international competition is only relevant to the top slice of the prime market, and there are many other factors at play, it is possible that inaction would lead to some devaluation of property compared to international competitors in markets that have adopted the 12-Step Action Plan.

Case studies

02.

02. Case studies
Introduction

This section seeks to demonstrate that across the world the transition to net-zero buildings is already underway. The number of truly net-zero buildings in the world is still vanishingly small and it will be seen that in none of these cases is the building comprehensively aligned with net-zero. However each demonstrates a piece of the puzzle, and when put together a clear picture emerges of a viable route to net-zero for buildings of different shapes and sizes, geographies and sectors.

The differing metrics used to express performance speak to the lack of consistent definition which is the focus of international collaborative efforts currently underway for Priority Action B1 of the Building Breakthrough Agenda. Underlying all the case studies is an objective to achieve significant decarbonization, in line with a sectoral 1.5C trajectory. In most cases there is an underlying desire by the investor or property owner to "do the right thing" and contribute sectoral decarbonization, overlaid with commercial concerns such as securing long-term asset value, and achieving market recognition in order to attract tenants. All of which is evidence that, whilst still patchy, we are starting to see striving for net-zero become a commercial as well as an environmental objective.

By limiting energy demand from the outset, and adopting energy-efficient designs, renewable energy sources and sustainable construction materials, net-zero carbon buildings not only reduce environmental impact but bring a range of broader benefits, including lower energy costs and improvements to occupant health and productivity. The lessons from these case studies are key to meeting international climate goals, but also creating resilient cities in a broader sense, and fostering a sustainable future for generations to come.

The goal of assembling these case studies is twofold:

1. **To build confidence among policymakers**
   These case studies provide concrete examples that demonstrate the feasibility of decarbonizing buildings on the ground in a variety of contexts, giving policymakers the assurance that these initiatives are practical and achievable.
2. **To provide evidence for portfolio managers**
   These examples serve as proof that decarbonization is a realistic objective at a building or portfolio scale, showcasing the viability of such efforts on a range of scales and supporting property owners and managers in implementing their own net-zero transformation programmes.

By drawing on examples, these studies highlight the different ways that innovation plays out under different market situations. The case studies demonstrate in some cases a genuinely new approach, and in others the application of more tried-and-tested technologies from established markets in new or less common contexts, particularly in global south economies. This approach illustrates how established solutions can be adapted and introduced into different markets effectively.

02. Case studies
Introduction

The following 16 case studies are split in four themes as follows: Themes 1-3 show how this transition is manifesting in new buildings, in renovations and in the management of operational assets. Whilst themes 1-3 demonstrate the viability of achieving net-zero with existing technologies, technological innovation undoubtedly has a role to play in driving the transition and this is explored in theme 4.

Theme 1 *Optimization of building performance*

A key objective of the 12-Step Action Plan is a move from code compliance to a performance framework. Optimization of building performance is generally outside the scope of a code compliance framework, and as a result often does not get the attention it deserves.

Under a performance framework, optimization, particularly of complex assets, will in many cases be the most cost-effective means of quickly improving performance and achieving decarbonization, whether to avoid non-compliance or to demonstrate out-performance against the market.

Optimizing existing building systems prior to undertaking more expensive upgrades is an essential first step to decarbonization, and for good reason. In addition to the immediate energy cost and carbon emission benefits, tuning up existing systems ensures major refurbishments are informed by an understanding of real energy demand, so avoiding oversizing and reducing overall refurbishment costs.

The context here is that how efficiently buildings are actually performing is only recently beginning to matter commercially: energy was cheap, carbon wasn't reported, certification was mainly based code compliance. With that being the case it should perhaps not be surprising that when the performance of existing systems is investigated, more often than not significant opportunities to optimize systems are found.

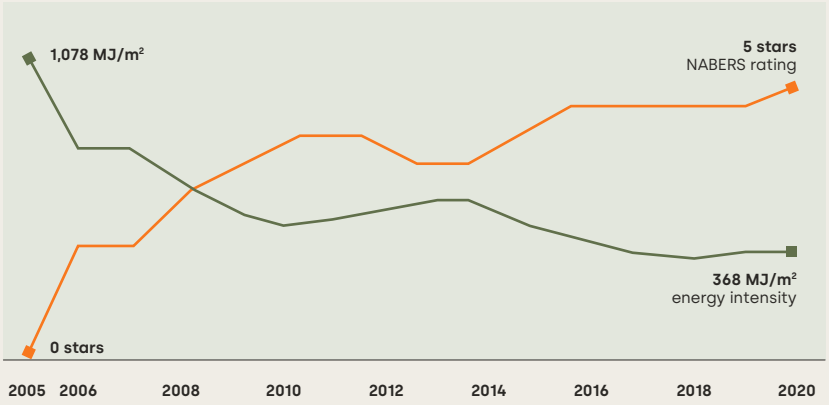
In Australia, where the NABERS rating based on actual energy efficiency has been established for 20 years, the following graph of the actual energy efficiency of 264-268 George Street is given by NABERS as a representative path buildings there have taken. The graph shows the quick, greatest (cheapest) reduction was achieved through the initial optimization of existing systems.

However, the greatest benefits are perhaps less obvious:

- → **Extending plant life**
  Optimizing building systems goes hand in hand with their being subject to reduced wear. This has the potential to push back, by several years, capital replacement costs that are frequently in £100,000s.
- → **Reducing replacement costs**
  Frequently, the actual demands of a building, once optimized, are significantly less than original design maximums, allowing smaller replacement equipment to be specified (which can deliver further improvements in energy efficiency).
- → **Reduced decarbonization costs**
  Similarly, the data from an optimized building can inform significant reductions in capital costs of more significant decarbonization measures. In addition to improved sizing, the insight can identify if some equipment actually needs replacing at all.

The case studies on the following pages illustrate examples of where optimization of operational assets has been key to maximizing efficiency and minimizing carbon emissions.

Figure 18: NABERS in Australia – Improvement in energy performance over time (Australia Square, 264-268 George St, Sydney)



02. Case studies: Optimization of building performance
Landsec portfolio optimization, London, UK

Portfolio optimization

Landsec's workplace optimization program demonstrates the effectiveness of a comprehensive portfolio-wide energy efficiency approach. It has delivered 2,500tCO_2 reduction across £10 billion UK portfolio, showing typically 10-20% reduction in landlord energy and 20-30% reduction in tenants energy at a building level.

Project overview

Landsec is a UK Real Estate Investment Trust that owns 22.8 million sq ft (as at 31 March 2024) of real estate valued at circa £10 billion. In an effort to cut carbon emissions and costs while improving the experience for its office occupiers, Landsec has invested in two parallel programmes, firstly improving the performance of landlord systems through optimizing its Building Management Systems (BMS), and secondly helping occupiers reduce their energy demand through delivering a series of occupier energy audits across its office portfolio. As a result, Landsec expect to report an impressive 2,500 tCO_2e reduction in emissions which supports positive progress towards achieving net-zero by 2040.

→ **BMS optimization**
At the start of 2022, Landsec's Workplace Engineering Team identified key buildings where the Building Management Systems were working outside of optimal parameters. Supported by their supply chain, Landsec identified and implemented solutions aimed at improving the control strategy of the BMS to ensure that systems run in line with actual building demands.

→ **Occupier energy**
Audits with approximately 40-50% of its office buildings' energy consumption coming directly from occupiers, collaboration is a key element of Landsec's efforts to decrease energy consumption in tenanted spaces. Since 2021, Landsec has engaged with 38 of its highest consuming occupiers, conducting energy audits and workshops to identify key actions to be taken by each occupier to reduce total consumption.

Our £135m net zero transition investment plan

Overview

70% CO_2

Our science-based target requires a **70% reduction in carbon emissions by 2030** against a 2013/14 baseline aligning both energy and carbon intensity with best practice CRREM pathways.

55% CO_2

In March 2021 we achieved a **55% reduction in carbon emissions** against our 2013/14 baseline.

£135m

Our new **£135m net zero transition investment plan** will help us achieve our science-based target by 2030 – aligned to the 1.5°C global warming pathway.

24,000

Overall the programme will see **24,000 tonnes of carbon emissions removed from Landsec's operations** – this is equivalent to over 35,000 return flights from London to New York.

02. Case studies: Optimization of building performance
Landsec portfolio optimization, London, UK

Key energy efficiency measures

BMS optimization

- BMS controls recommendation reports were produced for each asset within the programme. These were produced by building performance specialists and contained a series of software strategy improvement changes as well as some hardware upgrades that would optimize the performance of each building's HVAC equipment. These were passed to the site operations team for each asset to implement and report progress.
- As of 2023, Landsec is seeing savings of up to 10% on electricity and up to 20% on gas for buildings that have been optimized.

Occupier energy audits

- On average, the audits have identified energy reduction potential of 20-30% per customer.
- Identified opportunities include improved lighting control, revised computer room cooling, consistent on floor temperature control.

"Investing in energy reduction projects that have multi-faceted benefits to both business, occupiers and the environment is key for any organization achieving net-zero. Landsec's BMS optimization project that commenced in 2022 is a prime example of this, where the results are very encouraging."

Lawrence Hall, Sustainability Programme Manager, Landsec

Key stats

2,500tCO_2e
Expected overall reduction in emissions

10% electricity
Landlord savings

20% gas
Landlord savings

20-30%
Tenant savings

£135m
Part of a £135m net-zero transition investment plan

£1m/year
Total annual savings anticipated

£10-40k
Annual savings per building reported

Project team

Landsec Asset Management (Client);
Arup (Building Performance Consultant).

02. Case studies: Optimization of building performance
Global pharmaceutical company, Cambridge, UK

Pharmaceutical facility performance management

A global pharmaceutical company and their service provider is delivering a comprehensive program of operational readiness and energy performance management for a highly complex state-of-the-art global research and development facility. Use of data analytics techniques has directly led to lower energy usage, decreased maintenance tasks and the ability to effectively monitor and track progress.

Project overview

The state-of-the-art global research and development (R&D) facility was completed in 2023. The 19,000m² of laboratories and supporting facilities incorporates over 2,200 research scientists.

Laboratory facilities are inherently energy intensive, particularly with respect to HVAC provision. At its peak, the facility can provide 220m³/s of treated outside air to labs and support spaces. Heating and cooling is provided from an adjacent energy centre, which contains the UK's largest ground source heat pump system, consisting of 174 boreholes that are each 200m deep.

To support the efficient operation of the facility an energy management approach was implemented prior to handover, as part of a broader operational readiness program. It was developed in collaboration between the facility owner, asset management provider and building performance specialists. The aim was to ensure maximum 'time for science' (maximizing operational resilience of key systems) whilst minimizing environmental impact.

The complexity of the systems, combined with demanding reliability and efficiency targets required new ways of working, bringing manufacturing sector asset-management practices into building management, including elements of both condition-based and performance-based management. In this approach, energy management and maintenance are guided by data, focusing on identifying performance issues and deploying resources to resolve them on a flexible basis, a far cry from the standard schedule/alarm-based approach typically employed in building maintenance.

02. Case studies: Optimization of building performance
Global pharmaceutical company, Cambridge, UK

The strategy focused on the comprehensive management of data from >100,000 BMS and metering data points using specialist BMS analytical software. This platform also allowed for live extraction of data via an API. This data was used to produce several bespoke digital representations of key systems. These were developed collaboratively between the asset management team and building performance consultants.

A key outcome was to find a better way to monitor, visualize and act upon the vast amount of BMS data generated from such a large R&D facility. The purpose of this digital representation of key assets and systems was to provide advanced analytical capabilities to highlight optimization opportunities, allow for effective conditions-based maintenance (reducing routine workload for facilities-management colleagues) and allow KPIs to be monitored, visualized and improved. It now provides a digital representation of the performance of 2,647 assets.

The comprehensive approach to management of data is the foundation that supports the overall performance management approach, which includes regular progress reporting by the service provider against clearly defined performance metrics. The approach also allows for performance incentivization of the service provider on the basis of the performance achieved, which is a key part of a performance-based maintenance approach.

Key energy efficiency measures

- → Ground source heat pump;
- → Condition-based maintenance approach;
- → Advanced data analytics for monitoring and tracking performance;
- → Incentivization of efficient performance through governance structures.

"I have had my eyes opened with the introduction of advanced BMS analytics solutions at this facility. I have consistently been impressed with the insight into our assets it provides".

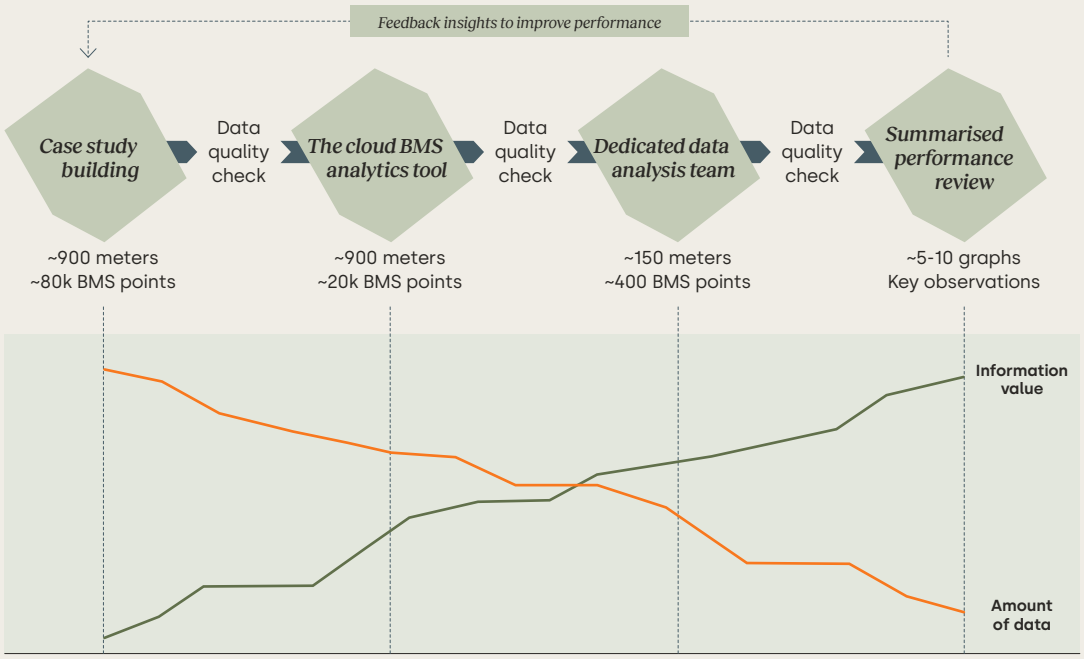
Asset Management Team Account Director

Key stats

Project team

Confidential (Client);
CBRE (Asset Management);
Arup (Building Performance).

Figure 19: Monitoring KPIs using data analytics



"The skill of data storytelling is removing the noise and focusing people's attention on the key insights."

02. Case studies: Optimization of building performance
5 Hanover Square, London, UK

Office building decarbonization roadmap

A practical and actionable short to medium term decarbonization plan for a prime central London asset. Incorporating groundbreaking solutions, the plan will enhance the building's facilities and operational efficiency, combining cost-effectiveness, energy efficiency, and respect for the building's historical significance, while reducing energy consumption and carbon emissions.

Project overview

5 Hanover Square is a landmark mixed-use development offering 63,500 sq ft of Grade A office accommodation, ground floor gallery space and five residential apartments in a prime West End location. The site was acquired by Mitsui Fudosan in 2008 and the redevelopment was completed in 2012. The change in market expectations for building performance since completion has prompted Mitsui Fudosan and its supply chain to develop a decarbonization action plan aligned with a net-zero carbon pathway produced for the building.

The study focused on identifying interventions actionable while the building remains in operation, taking these ideas from feasibility studies to actionable concepts. This process involved detailing the implementation methods, associated costs, and optimal timelines for each intervention.

Alongside physical interventions, analysis of the operation of the existing MEP services and associated controls and monitoring (BMS and EMS) systems identified a number of performance enhancements to improve operational efficiency and integrate advanced controls for better energy management. More substantial interventions included the elimination of on-site fossil fuels through a switch to heat pumps, the implementation of demand-controlled ventilation optimizing air supply based on occupancy, reducing energy consumption and maintaining air quality, and the evaluation of EPC upgrade options and energy use intensity benchmarking.

Building on the findings of the Net-Zero Pathways report, the project team appraised how specific energy/carbon saving interventions could be delivered. These included:

Key numbers and figures

- **Demand-controlled ventilation**
  New variable volume flow dampers installed within landlord areas to control airflow to tenant areas in response to new CO_2 sensors. This will reduce overall airflow rates at times of lower demand and reduce energy consumption. An added benefit to occupants would be improved comfort. At times of low occupancy, buildings can often feel cold through over-supply of tempered air. Reducing this supply at times of low demand will reduce this issue.
- **Phased heat electrification**
  A phased replacement of gas boilers and air cooled chillers. These would gradually electrify and decarbonize the heating and hot water systems within the building. We combined the output from a period of winter monitoring and adjusting the existing flow and return temperatures to validate the capacity of the heating system to work at lower temperatures which allow the new heat pumps to operate at optimal efficiency.


© Arup

Theme 2 *Retrofit*

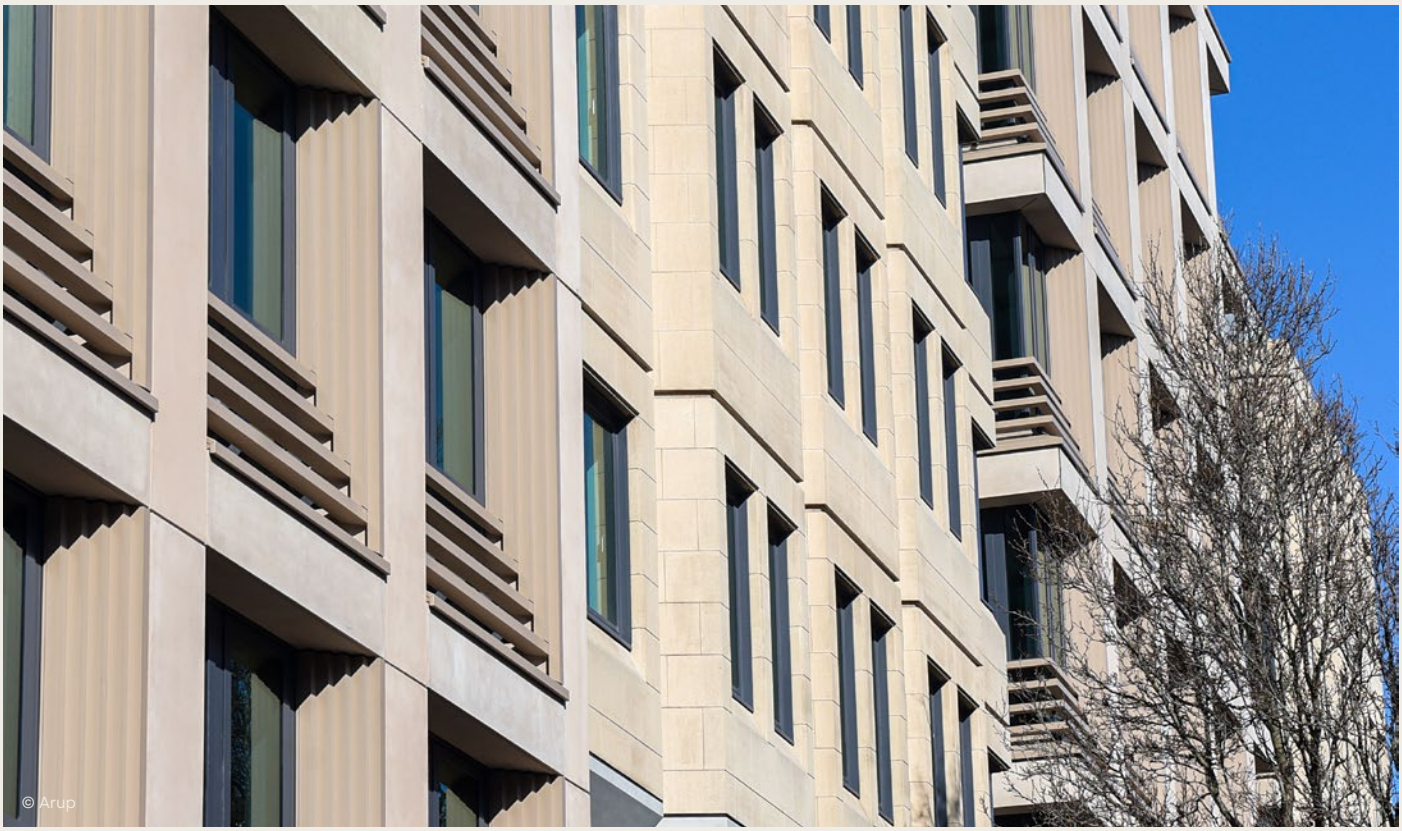
In the 12-Step Action Plan, the introduction of a mandatory energy perfomance floor will gradually expose under-performing buildings. Whilst optimization measures may be sufficient for some buildings to avoid non-compliance/stranding, as standards tighten over time more substantial interventions will be required.

Similarly as transparency drives demand, value of buildings not fully aligned with net-zero is anticipated to drop (brown discounting), which will further drive demand for retrofitting in order to achieve net-zero alignment.

In the global north, an estimated 80% of the buildings that will exist in 2050 already stand today, and so retrofitting existing structures is crucial to achieving global net-zero carbon goals. The net-zero retrofit agenda focuses on upgrading these buildings to align with the broader objective of eliminating fossil fuel use and significantly improving energy efficiency. Retrofitting not only reduces operational carbon emissions, which are generated during a building's use, but also addresses embodied carbon, which is tied to the materials and construction processes involved in the building's lifecycle. A holistic approach, incorporating Whole-life Cycle Assessment (WLCA), is essential to minimize both operational and embodied carbon impacts.

In many countries, leading industry developers are increasingly driving this shift as they aim to align their portfolios with net-zero targets. While retrofitting for net-zero can require significant investment, some markets are seeing success in transforming buildings with little to no additional funding, demonstrating that commercially sustainable transitions are achievable with the right strategies.

Addressing the existing building stock is a key component of global efforts to limit climate change and create a sustainable future. The following case studies demonstrate how various aspects of net-zero can be achieved whilst retrofitting buildings.



02. Case studies: Retrofit
Susan Fennell Sportsplex, Ontario, Canada

Leisure complex retrofit

A zero-carbon retrofit is challenging to do in an existing facility, particularly where the facility needs to be open to the public. This particular facility is a great candidate for net-zero retrofit in that it already utilizes 41 water to air heat pumps throughout for space heating and cooling. The HVAC equipment was at the end of its life cycle so almost all the equipment needed to be replaced. There was ample space for a vertical, closed loop geothermal field in the parking area.

Project overview

The Susan Fennell Sportsplex, in Brampton, Ontario, Canada, was built in 2 phases around 1996. This facility of around 1,612m² is a public building operating 17 hours a day, 7 days a week, currently undergoing retrofit. When complete it will have: four ice hockey rinks, an Olympic size swimming pool, a fitness centre, community meeting rooms and a library. Its completion is expected in 2025.

As part of Brampton's commitment to reduce the impacts of climate change and achieve its net-zero goal by 2050, Susan Fennell Sportsplex was selected as the city's first zero carbon facility.

Johnson controls were the retrofit system designer and installer, HVAC Original Equipment Manufacturer and finance provider.

Targeting reduction of heating and cooling energy consumption, the chosen energy saving solution was HVAC optimization, including heat pump retrofit, digital solutions and control as well as the installation of solar thermal.

100% GHG reduction, including 91% efficiency reduction from a 2010 baseline and a residual 9% reduction from carbon offsets provided by partner 3Degrees. This included a 99% reduction in on-site natural gas consumption.

The project was supported by $15.7M from Green and Inclusive Community Buildings (GICB) program, $10M from the Federation of Canadian Municipalities (FCM) Green Municipal Fund (GMF) like this: $2.5M grant, $7.5M loan.

An energy savings performance contract is in place and the project is financed in part through guaranteed utility savings of approximately $195,000 per year.

02. Case studies: Retrofit
Susan Fennell Sportsplex, Ontario, Canada

Project dates
Feasibility January to April 2022, Design and Procurement May 2022 to June 2023 (this included city negotiation periods, re-designs, and scope changes), September 2023 contract signing, April 1, 2024 construction mobilization, April 1, 2025 transition to rinks 1 & 2/community centre (requirement to keep 2 of 4 rinks operational during construction). Substantial completion September 2025.

Lessons learned
Given the bulk of the work is retrofit work, there are many interfaces that create challenges to installation. The project team had to weigh the level of effort and cost to vet the design on site with a qualified subcontractor vs the risk and cost associated with interference costs that cannot be passed along to the customer. The team were cautious of design scope deferred to post-contract signing/build stage, ensuring the project was carrying appropriate design contingencies. Electrical capacities for the building, and major feeders required verification during design to verify the available capacity for complete electrification of the building and need for any upgrades. Hydronic piping can add considerable weight that needs to be supported from new or existing structures and requires structural investigations during design.

Key energy efficiency measures
- → Rooftop solar PV;
- → Ground source heat loop;
- → Digital solutions and controls;
- → Solar thermal heating pool;
- → New, first-of-their-kind indoor CO_2 ice rink chiller replacements;
- → LED retrofits;
- → Various HVAC upgrades.

© Johnson Controls

Key stats

91%
Operational energy reduction
on a 2010 baseline

100%
Overall carbon emission savings
on a 2010 baseline, including purchased offsets

$25,000,000
Investment

$195,000
Cost savings

Performance-based contract
Performance-based contract through guaranteed utility savings

02. Case studies: Retrofit
40 Argyll Street, London, UK

Office refurbishment

The refurbishment at 40 Argyll Street showcases the art of the possible when decarbonizing the office portion of a listed mixed-use building whilst keeping the retail tenants in occupation. The client now has an all-electric, prime office space to let with significantly enhanced value and in line with their overall net-zero ambitions.

Project overview

Situated in the West End of London, 40 Argyll Street is a historically significant Grade II listed building. Initially constructed as the renowned Dickens & Jones department store in 1921, the building underwent an extensive redevelopment in 2007-08 transitioning from a large department store to mixed use office and retail. Spanning five floors with 25,935m² GIA, the building offers a diverse range of functions. The retail spaces occupy the basement, ground floor and level 1, while levels 2-4 provide office spaces, and level 5 serves as a public restaurant area.

This new project, designed by architects AHMM and engineers Arup, addresses the decarbonization of the office spaces, to improve energy performance and align with latest market expectations. The office areas of the building include a large central atrium that provides the interior with natural light, flexible office areas with high ceilings and a 500mm full access raised floor, which provides flexibility for conditioning and services. The refurbishment includes full replacement of office area fit-out, plus targeted upgrades to central plant, in particular the removal of gas boilers in favour of all electric heat pumps for both space heating and domestic hot water.

The refurbishment at 40 Argyll Street is aiming to achieve net-zero aligned performance, and the project team undertook extensive modeling of both operational performance (following NABERS UK guidelines) and embodied carbon impacts. The project is aiming to achieve operational energy targets in line with a NABERS UK 4.5* rating, and the NABERS energy modelling was influential in guiding both equipment selections and the approach to control of HVAC, vertical transportation and lighting systems in particular in pursuit of this aim.

The challenge was to achieve this level of performance working within the constraints of the existing building. Thermal performance was constrained by the existing façade, which having been upgraded in 2008 was not part of the scope of this project. In addition, carrying out the refurbishment without disrupting existing retail and restaurant tenants, and working with limited space in existing risers and an already congested roof all posed significant challenges. There were existing electrical supply and distribution constraints in addition. Nevertheless, the project is on track to deliver high energy efficiency improvements for an existing listed building of this type, with completion scheduled for 2026.

02. Case studies: Retrofit
40 Argyll Street, London, UK

Key energy efficiency measures

- → Tuning of the HVAC controls;
- → Introducing a smaller ASHP for efficient operation at low part loads;
- → Introducing an optimized start to AHUs and downflow units;
- → Refining operational temperature set points;
- → Enabling mixed-mode ventilation.

Key stats

Excellent
BREEAM, fit-out

4.5*
NABERS UK target

Platinum
WiredScore

53.2kWh
Operational energy (kWh/m²/year)

200kg CO_2e
Embodied carbon (kg CO_2e/m² GIA/year)

Project team

Capital Real Estate Partners (Client);
AHMM (Architect);
Arup (Engineer & Sustainability Consultant);
Blackburn (Project Manager).

02. Case studies: Retrofit
111 Bourke Street, Melbourne, Australia

Office retrofit

The proposed retrofit will take this already high performing asset to new levels and ahead of its competition. With a scope of work including full electrification and substantial energy efficiency improvements the project will deliver positive outcomes for the environment, the buildings users and also the surrounding community.

Project overview

The Southern Cross West Tower, located at 111 Bourke Street, is an A-Grade office building of approximately 45,000sqm of GFA that was built in 2008 to a legacy Green Star standard. The building features gas boilers, high performance chillers, VAV ventilation systems and a decommissioned blackwater treatment system.

The project will fully refurbish this commercial building which is part of the Southern Cross precinct to enhance the existing offering in order to attract tenants to lease the space. The project will also include retrofits and refurbishments to ground floor retail space, communal areas and external laneway space.

The tower's single anchor tenant, Australia Post, were vacating the building providing a unique opportunity to undertake a deep retrofit to modernize services and systems within the building with energy efficiency and circular economy principles at the front of mind.

The building has been performing highly in recent years, partly as a result of lower occupancy levels post-Covid and has previously performed consistently with typical good practice in the city of Melbourne. In line with Charter Hall's ESG strategy, the redevelopment is pursuing highly sustainable outcomes which focus on low embodied and operational carbon through electrification and high-performance operation.

The enhanced ESG credentials of the building were also a key factor in the strategy to attract new tenants to lease the space. The tender design on the project has been completed and includes complete electrification of heating, domestic hot water and cooking services in the building, an upgraded building management and controls system along with enhanced control strategies for greater energy efficiency and indoor environment quality, an LED lighting retrofit to all lettable areas, a destination-controls upgrade of lifts and building technology upgrades to enable smart building operation. Aside from the engineering upgrades, the building is also investing heavily in the activation of publicly accessible spaces including a covered laneway and its lobby.


© Cox Architecture

02. Case studies: Retrofit
111 Bourke Street, Melbourne, Australia

Key energy efficiency measures

- Building envelope audit and strategy to improve air tightness;
- LED lighting upgrade;
- Electrification of heating gas-boilers with heat pumps (COP 3.5+);
- Electrification of domestic hot water gas system with heat pumps (COP 3.5+);
- Electrification of the retail F&B tenants, gas cooktops on the ground floor;
- BMS upgrade including upgrades to controllers and control strategies for all MEP plant;
- Extensive rooftop PV as array on the rooftop (70 kW);
- To achieve Climate Active Carbon Neutral;
- Procurement of renewable energy for base building (100%);
- Targeting a 6-star Green Star rating under the new Buildings v1 tool;
- 5.5 Star NABERS Energy Rating;
- EV chargers in basement for cars with a load management system (5% with 10% future);
- Building technology upgrade including retrofitting of an integrated communications network.

Key stats

6*
Green Star, operational energy

5.5*
NABERS, energy

5*
NABERS, indoor environment

Platinum
WELL Standard

Project team

Charter Hall and Brookfield Properties (Client);
Cox Architects (Architect);
Arup (Engineering Consultant).

02. Case studies: Retrofit
The Acre, London, UK

Office refurbishment and extension

Turning an existing iconic building into one of the healthiest and greenest developments in central London. The development retains 80% of the existing building whilst creating Covent Garden's largest speculative commercial office space with market-leading energy performance credentials. It provides spectacular roof terraces complemented by a new accessible "street" route through the city block.

Project overview

Originally built in the 1970s, 90 Long Acre is a 240,000 ft² landmark building in Covent Garden, London. The refurbishment, designed by architects Gensler and multidisciplinary engineers Arup, retains 80% of the existing structure, whilst adding significant additional floor space. The façade and all internal systems and finishes are replaced, revitalising the existing office areas, upgrading the building's performance and providing new public space and retail opportunities at ground level.

'Infill' extensions make the building's thermal envelope more effective, reducing heating and cooling loads. Other passive improvements include internal insulation fitted to existing façades and high-performance new façades. A new, all-electric heating and cooling system uses high-efficiency heat pumps that reclaim heat for hot water.
90 Long Acre will be fitted with a smart data platform that allows real time energy analysis and predictive maintenance of the plant, along with live monitoring of window operations to manage the interaction of natural and mechanical ventilation systems. This will give the property team and occupiers valuable insights and empower them to manage the building for efficiency and wellbeing.

02. Case studies: Retrofit
The Acre, London, UK

Key energy efficiency measures

- All electric scheme proposed with heat pumps for CHW/LTHW generation;
- Openable windows with mixed-mode ventilation, with natural ventilation meeting the perimeter cooling load when conditions are favourable;
- Low glazing g-value to reduce solar gain in the offices to enable a greater benefit from the mixed-mode ventilation system;
- Low energy, highly efficient Artus fan-coil units with low specific fan powers and variable speed fans to reduce the auxiliary electrical load. In addition, avoiding the need for secondary ductwork simplifies commissioning and reduces embodied carbon associated with materials.

Key stats

Outstanding
BREEAM

3 star
Fitwel

*4.5**
NABERS target

Platinum
WELL Standard

145.8kWh
Operational energy (kWh/m²/GIA/year)

70%
Operational energy use reduction

Project team

Northwood (Investor);
Gensler (Architect);
Arup (Multidisc. Engineer and Sust. Consultant);
Platform (Development Manager).

Theme 3 *New build*

In global south economies, construction rates associated with rapid development mean that alignment of new buildings with net-zero is a high priority in terms of securing the transition to net-zero. Across the world, new buildings offer the best opportunity to deliver true net-zero outcomes, generally having far fewer constraints than existing buildings, and achievement of net-zero on day 1 is considerably more cost-effective than complex retrofits down the line.

For new buildings especially it is essential, however, to consider a balanced whole-life carbon approach, accounting for both operational carbon (emissions during the building's use) and embodied carbon (emissions from construction materials and processes) across the lifecycle. As energy systems decarbonize at different rates in different economies the balance of embodied and operational carbon outcomes will change over time and with location. Designers need to be aware of embodied/operational carbon balance of energy efficiency interventions, and the potential for that balance to be marginal or even negative in some cases. Striking this balance ensures that new developments contribute meaningfully to long-term sustainability goals.

In the global north, leading organizations are already pushing forward with net-zero initiatives, despite the absence of a universally agreed-upon definition of "net-zero." Their proactive efforts set an important precedent, but the challenge is especially critical for the global south where nations need to avoid creating carbon-intensive infrastructure now that will require retrofitting or replacement in the near future.

The emerging understanding of net-zero energy shows that new buildings need to go well beyond simply meeting current building codes, and be designed to achieve net-zero performance outcomes in operation from day one. This forward-thinking approach is a significant shift from the conventional design-for-compliance mindset that has been prevalent for many years, but is essential to help avoid future carbon liabilities and support global climate targets.

02. Case studies: New build
The Emma and Georgina Bloomberg Center, NY, USA

Net-zero academic building

The Emma and Georgina Bloomberg Center pioneers new standards of environmental sustainability and energy efficiency in its award-winning design. An all-electric building, it is among the largest academic buildings in the world designed for net-zero energy consumption. The building design uses solar arrays, a green roof, geothermal wells, smart building technology and innovative insulation to meet its energy goals.

Project overview

The Cornell Tech is a graduate campus and research center of Cornell University on Roosevelt Island in Manhattan, New York City. The organisation's aspirations for a net zero campus are demonstrated by the multi-faceted sustainable outcomes and high-performance design of the Emma and Georgina Bloomberg Center. The 150,000 sq ft center is the pioneering foundation for Cornell Tech's net-zero energy campus ambitions. The project team developed an integrated design approach, producing an exemplary green building consistent with Morphosis' vision of an inspiring LEED Platinum modern facility for research and learning.

The Emma and Georgina Bloomberg Center is the first academic building on the Cornell Tech campus, aspiring to reach net-zero and LEED Platinum status, with all of the energy needed to power the building generated on campus. The campus is employing multiple strategies including solar power, geothermal ground source heat pumps, an energy-efficient façade balancing the ratio between transparency and opaqueness to maximize building insulation and decrease energy demand, and smart building features monitoring lighting and plug load use. A solar array also provides critical additional renewable energy for The Emma and Georgina Bloomberg Center.

High-performance multidisciplinary solutions included specifying healthy materials, recycling stormwater collected from the site and green roofs, designing for flood resilience and resource optimization. Deep reductions in operational carbon were achieved through balancing shade and daylight at the glazed façades, using active chilled beams for comfort indoors, eliminating on-site fossil fuel use by deriving heating and cooling from the earth via ground source heat pumps, and incorporating energy generation from an acre of roof-mounted photovoltaic panels. The outcome is an exemplar facility for Cornell Tech that, before application of solar power, uses half the operational energy of comparable campus buildings and trends towards net-zero energy performance.

02. Case studies: New build
The Emma and Georgina Bloomberg Center, NY, USA

The strategy to achieve a low energy building is through a stepped approach prioritizing reduction in energy demand through load reductions as well as maximizing passive and energy efficient design and using renewable energy to power the building systems. Strategies to achieve net-zero at The Emma and Georgina Bloomberg Center include:

- **An all-electric building**
  No fossil fuel is used in the building.
- **Geothermal wells**
  80 closed-loop geothermal wells, each 400 feet deep, were drilled below the main campus public open space. The electrically powered ground-source heat pumps are used to heat and cool the building in conjunction with an active chilled-beam system.
- **Solar power**
  An acre-sized photovoltaic array tops The Emma and Georgina Bloomberg Center and neighboring Tata Innovation Center building, generating solar power. Instead of locating remote solar panels off site, the designs of The Emma and Georgina Bloomberg Center and Tata Innovation Center incorporate the panels as an integral building design feature, bringing together engineering requirements and architecture. The array on The Emma and Georgina Bloomberg Center provides building shading while harvesting solar power.
- **Highly insulated façade**
  A unitized, continuously insulated rainscreen wall system covered by an iconic metal panel façade designed by Morphosis architects balances exterior views and daylight while maximizing façade insulation.
- **Smart building technology**
  Smart building features, designed by Morphosis and engineering firm Arup, link lighting control, occupancy sensors, security and other building controls to provide on-demand power and respond to user needs and occupancy, contributing to reducing energy usage.
- **Green roof**
  A low-maintenance green roof incorporates native plant species along the southeast edge of the building to help cool the lower roof surface.

Key energy efficiency measures

- Elimination of on-site fossil fuel use by sourcing heating and cooling from ground source heat pumps;
- Balancing shade and daylight at the glazed façades to reduce energy consumption;
- Active chilled beams used for indoor comfort, improving energy efficiency;
- Energy generation through roof-mounted photovoltaic panels, covering an acre of the building's roof;
- Stormwater recycling collected from the site and green roofs, reducing water and energy use;
- Flood resilience built into the design to ensure long-term sustainability.

Campus to use photovoltaic arrays, geothermal ground source heat pump, and more for greatest efficiency and lowest energy use.

Key stats

Platinum
LEED

50%
Improvement on ASHRAE 90.1 benchmark

Net-zero
Energy accounting for on-site renewables

Project team
Cornell University (Client);
Morphosis (Architect);
Arup (Multidisc. Engineer).

02. Case studies: New build
AIRSIDE, Hong Kong

Energy-efficient mixed use development

An innovative commercial development that seeks to embrace all the needs of urban life, from shopping to culture, from work to wellness, in complete connection with nature. More than a district, a vision.

Project overview

Owned by Nan Fung Group, AIRSIDE is a 1.9 million sq ft mixed-use commercial development in Kai Tak, Kowloon, Hong Kong. With cutting-edge sustainable solutions, the iconic landmark redefines the future of urban living. The development consists of two towers of 200m and 90m, with a 6-level podium and 4 levels of basement offering spaces for office, retail, leisure and entertainment.

With the United Nations' Sustainable Development Goals as the development's design blueprint, the team has built a new 'CO6 metrics' framework – covering community hub creation, comfortable & healthy environment, carbon dioxide (CO_2) reduction, conspicuous performance & consumption and cost-effective smart technology.

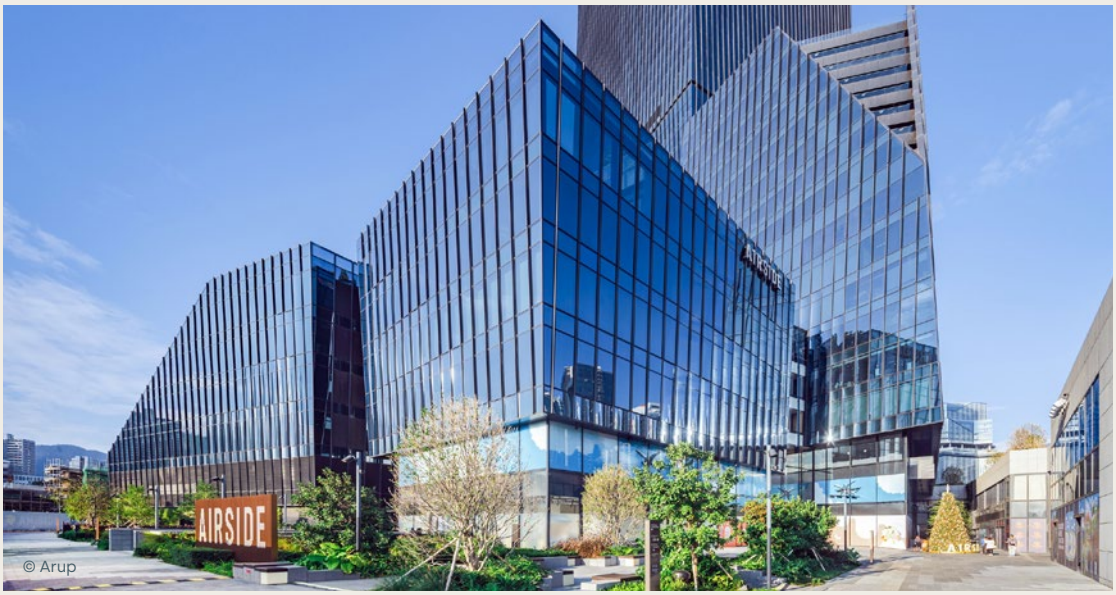
Microclimate studies were conducted to shape the building form with an urban window, enhancing outdoor comfort and local wind environment. Water features have been crafted to reduce the heat island effect in the compact urban environment. The building features Hong Kong's first and largest office-building PV farm, a high-performance façade with solar-responsive fins, and is the first to connect to the Kai Tak District Cooling System, using chilled seawater for climate control.

AIRSIDE has launched the Automatic Refuse Collection System (ARCS), a pioneering solution in Hong Kong featuring smart waste chutes for efficient disposal and separation of four type of wastes. It includes automated waste weighing and tenant identification, to track individual waste generation, supporting tenant engagement programs for behavioral change.

Additionally, AIRSIDE has implemented an Automatic Underground Bicycle Parking System (ABPS) to promote eco-friendly transportation and reduce carbon emissions.

Extensive research led to the development of a bio-filtration system that uses wetland plants to treat greywater from hand-washing, aiming to revolutionize onsite water purification with organic, nature-based methods. AIRSIDE also created a unique interior fabric made from recycled plastic bottles, demonstrating circular economy principles. This project used over 109,000 bottles, achieving an impressive 84% reduction in CO_2 emissions compared to traditional wood fiber acoustic panels.

Furthermore, the development features Neuron, an integrated digital data platform that continuously assesses carbon performance using data from energy, waste, and water sources, enabling the quantification and reduction of the building's carbon footprint throughout its lifecycle.



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02. Case studies: New build
AIRSIDE, Hong Kong

Key energy efficiency measures

- Hong Kong's first and largest office-building monocrystalline PV farm and walkable PV: ~1,350m². Generates 270,000 kWh/year renewable energy, equivalent to the monthly average electricity consumption of 981 residential flats in Hong Kong. This offsets 189 tonnes of CO_2;
- First commercial development to link to the Kai Tak district cooling system, using chilled seawater distributed from a central plant for climate control;
- High-performance façade with solar-responsive vertical fins designed to prevent excessive glare for nearby sensitive residences;
- AIRSIDE has achieved an exemplary energy reduction with design Energy Use Intensity (EUI) of 155 kWh/m², exceeding the minimum code requirements by over 33%;
- 16% of recycled plastic adopted in the base of walkable PV;
- Generates 270,000 kWh/ year which is equivalent to the monthly average electricity consumption of 700 residential flats in Hong Kong;
- Offsets 189 tonnes of CO_2, equal to the planting of around 8200 trees annually.


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Key stats

Platinum
BEAM Plus, new building

Platinum
SmartScore

Platinum
BEAM Plus, neighbourhood

Platinum
WELL Standard

3 star
China Green Building Label

Platinum
WiredScore

Platinum
LEED

Project team

Nan Fung Development Limited (Client);
Snøhetta (Architect);
Arup (Multidisc. Engineer).

02. Case studies: New build
Chiesi Farmaceutici Headquarters, Parma, Italy

Low energy headquarters

Designing a flexible, inspiring workplace to foster collaboration, enhancing common spaces that promote social interaction and improve wellbeing, while focusing on sustainability were the three key drivers behind Italian pharma group Chiesi Farmaceutici's new headquarters.

Project overview

Strategically located beside the company's research centre in Parma to form a campus, the smart, net-zero new headquarters brings together Chiesi staff from multiple sites into a single new working environment, creating a space for connectivity and collaboration and acting as a catalyst for the company's future strategic growth. The project delivers a new concept to support Chiesi's ambition to design a people-first workplace, creating a campus centered on health, wellbeing and comfort. Chiesi staff were actively involved throughout the design process.

Space has been organized to provide the right balance between collaborative and intense-focus working styles within the open-plan office environment, with generous common areas promoting social interaction within the Chiesi community. An energy saving of 40% has been achieved by detailing the façade according to its orientation (south façade more massing, green roofs), adoption of smart lighting with extensive use of presence sensors and daylight, large use of solar panels and purchase of renewable energy and carbon credits. Based on these extensive design solutions, the net-zero building received a Platinum LEED certification.

02. Case studies: New build
Chiesi Farmaceutici Headquarters, Parma, Italy

Key energy efficiency measures

- → **Smart energy control**
  CO_2 sensors in each room, digital energy management system, automated shading;
- → Advanced natural daylight, acoustics, air quality, temperature and material analytics for optimal environmental comfort and control;
- → **Façade design**
  Tailored by orientation with massing on south side, green roofs for insulation;
- → **Efficient lighting**
  Smart lighting with presence and daylight sensors;
- → **Renewable energy**
  Solar panels, purchase of renewable energy and carbon credits.

Key stats

Platinum
LEED

40%
Operational energy savings

40%
Overall carbon emissions savings

Project team
Chiesi Farmaceutici (Client);
EFA Studio di Architettura (Architect);
Arup (Multidisc. Engineer);
Nativa (LEED Partner).

02. Case studies: New build
The Henderson Building, Hong Kong

Sustainable new office tower

The newly built iconic landmark in Hong Kong, The Henderson showcases its unparalleled potential to transform the central metropolis into a vision that is both unique and enchanting, together with exemplary ESG credentials through 10 numbers of green, healthy, smart and sustainable transportation accreditations, which all achieved the highest ratings.

Project overview

Set to become a prominent architectural icon in Central, Hong Kong's CBD, The Henderson is a 190m tall grade-A office building.

The Henderson has received numerous awards and accolades, achieving Platinum Pre-certifications in both WELL and LEED, the China Smart Building Certificate and the China Healthy Building Design Label. The building also boasts WiredScore and SmartScore Platinum certifications in recognition of its outstanding digital connectivity and advanced smart technology. With over 44 international and local awards, The Henderson is widely recognised for its exceptional design and performance.

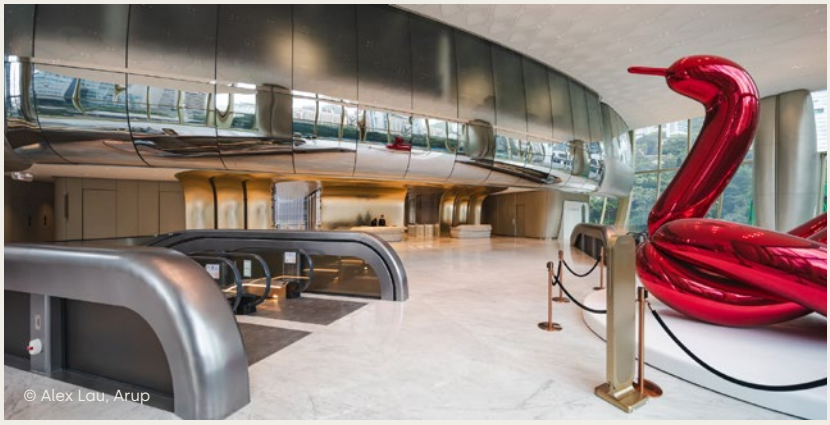
The Henderson prioritises whole-life cycle carbon emissions reduction through a range of green building strategies, recognising the significant impact of user behaviors on operational carbon emissions. It emphasises the importance of enabling occupant behavior change and customizing the workplace environment, which are often more effective than merely optimizing building designs and operations.

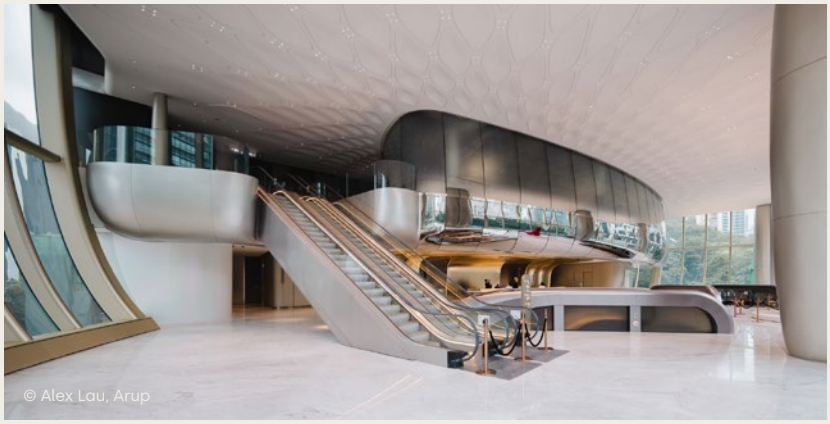
© Alex Lau, Arup

02. Case studies: New build
The Henderson Building, Hong Kong

Key energy efficiency measures

- **Smart office application**
  Tenants can control workplace systems (e.g., windows, blinds, air-conditioning) through a mobile app to reduce energy consumption and carbon emissions;
- **Building performance data**
  The digital twin and analytic module provide real-time performance data, helping tenants track and adjust building systems for carbon neutrality;
- **AI-enabled energy optimization**
  Integrated AI systems enable energy optimization and predictive analytics to manage building energy use efficiently;
- **IoT sensors**
  Installed IoT sensors monitor the building environment to ensure optimal indoor climate and air quality, reducing energy waste;
- **Integrated Tenant Experience Platform (ITEAP)**
  Facilitates real-time interaction and energy-efficient practices between tenants, building operators, and external services to improve operational efficiency;
- **Green building technologies**
  Incorporates advanced technologies like a zero UV, double-laminated façade and Solar Responsive Ventilator, which contribute to reducing energy consumption and carbon emissions.





Key stats

Platinum
ActiveScore and ModeScore

Platinum
BEAM Plus

3 star
China Green Building Label

3 star
China Healthy Building Label

Platinum
LEED

Platinum
WELL Standard

Platinum
WiredScore and SmartScore

26%
Operational energy savings

Grand award
Green Building Award 2021

Project team
Henderson Land Development (Client);
Zaha Hadid Architects (Architect);
Arup (Multidisc. Engineer).

Theme 4 *Technologies*

The preceding case studies demonstrate that net-zero buildings are deliverable with today's technologies. However, technological advancements do have an important role to play in bringing net-zero into the reach of more building types in more locations.

The emergence of genuinely new technologies is important, but equally important is the percolation of existing technologies through different locations and market sectors, as manufacturers find ways to reduce upfront costs and embed more energy-efficient technologies in lower price point equipment.

In some cases, such as with energy storage, technology is emerging that is driving a change in the way we currently think about and evaluate energy and carbon performance (refer to Energy vs. carbon). Whilst energy storage can have a material impact on real-world carbon emissions, it does not yet influence reported carbon performance, which relies on annual average carbon factors.

This will become a more important issue as national and regional electricity grids gradually transition to intermittent renewables and storage becomes more important. Going forward we will need to find more sophisticated ways of evaluating net-zero performance to capture the genuine benefits of these technologies.

02. Case studies: Technologies
Taikoo Li Sanlitun, Beijing of Swire Properties, Beijing, China

Photovoltaics, energy storage and DC distribution

Photovoltaics, Energy Storage, Direct Current and Flexible Power (PEDF) Systems use DC generated renewable energy from photovoltaics directly in low voltage distribution, avoiding transformer losses. Combining with on-site electrical storage optimizes the energy and carbon savings that can be achieved through on-site generation.

Project overview

As our capacity to generate renewable energy at our properties increases, there is a growing need to explore more efficient ways to utilize the energy produced. Most of our on-site renewable energy comes from photovoltaic systems, which supply direct current (DC). By increasing on-site DC equipment and using a power distribution system which runs on DC instead of alternating current (AC), it is possible to reduce the energy losses incurred by up to 10% when converting between AC and DC.

A DC-operated battery storage system also adds flexibility to a building's power demand control and maximizes the capture of variable grid-provided solar and wind power supply. PEDFs are also being promoted by the Chinese government to accelerate the optimization of building energy consumption.

Swire Properties is piloting a PEDF solution at Building N15 and the RED at Taikoo Li Sanlitun in Beijing. On-site implementation work was completed in 2023 and the system performance has been evaluated. A PEDF connection hub and two bi-directional electric vehicle chargers have been installed in the development's basement car park in 2024. System performance has been evaluated to ensure the design standards were fulfilled. The function of dynamic response to the grid provides further support to the sustainability initiatives of both the Company and the government.

The pilot required extensive liaisons with our piloting tenants, as well as a detailed study to persuade and convince them of the safety, reliability, stability and sustainability of the technology. This project was the only commercial PEDF application to receive a "Top 10 Building PEDF Best Practices" award from the committee of Photovoltaic Energy Storage Direct Current and Flexibility, a branch of the China Association of Building Energy Efficiency. This was given at the First China PEDF conference held in Chifeng, Inner Mongolia in July 2023. Building on the success of the innovative application of PEDF at Taikoo Li Sanlitun, Beijing, we have expanded the pilot in our other portfolio such as Taikoo Hui Guangzhou, Pacific Place and Citygate in Hong Kong.

02. Case studies: Technologies
Taikoo Li Sanlitun, Beijing of Swire Properties, Beijing, China

Key benefits

- → Capture solar energy;
- → Feed into DC microgrid;
- → Energy directly utilised by tenants, and avoid conversion loss between DC and AC.

Internal carbon pricing

In 2023, Swire Properties began piloting the use of internal carbon pricing ("ICP") to determine the potential impacts of carbon emissions on our investments, quantify carbon risks to our business operations and better reallocate capital towards additional low-carbon and energy-efficient investment and opportunities. ICP also facilitates engagement across departments and teams, allowing them to integrate carbon-reduction strategies with business objectives and achieve our common decarbonization goal.

We also apply a shadow price to investment decisions for future projects, ensuring climate-related risks and opportunities are factored into future capital investments. Currently, the carbon fee is priced at USD22/tCO_2e, and the shadow price is set at USD100/tCO_2e. We regularly review and adjust the price as well as the mechanisms to enhance the program's effectiveness.

Key energy efficiency measures

- → P – Solar photovoltaic power generation system;
- → E – Energy storage devices;
- → D – Direct current distribution system;
- → F – Flexibility to actively adjust the power down from the municipal grid;
- → The DC microgrid, together with the DC equipment, saves up to 10% of energy compared to conventional system, which is equivalent to approximately 56,000 kWh annually;
- → PV panels generate free renewable energy of approximately 110,000 kWh annually;
- → Shifting load demand (from high to low usage time) by energy storage can save approximately RMB 84,000 annually.

02. Case studies: Technologies
Arup office, Manchester, UK

Luminaire refurbishment

As part of the refurbishment of Arup's Manchester (UK) office, existing fluorescent luminaires were upgraded to LED, achieving significant energy savings and substantially reduced embodied carbon impact compared to new luminaires. The award-winning project was completed with minimal disruption compared to a new installation.

Project overview

The completion of a landmark lighting remanufacturing project at Arup's office in Piccadilly Place, Manchester, was awarded a Build Back Better 'Green Award' on the basis of its luminaire refurbishment approach. The project involved expanding and refurbishing the office, a key objective being to reduce whole-life carbon by renovating or repurposing furniture and equipment.

The Regen Initiative offered a luminaire refurbishment service that aligns with circular economy principles. This approach provided a sustainable alternative to simply installing new luminaires. Their collaboration included designing, prototyping and testing the retrofit gear tray solution to maintain optical performance, define light quality specifications and integrate smart wireless lighting controls to replace the outdated DALI system.

In addition to the desk spaces, the project involved the creation of a new breakout area, for which it was decided to re-purpose luminaires stripped out from another office refurbishment project, offering a significant capital cost saving, reducing electronic waste and avoiding material being unnecessarily recycled.

The LED refurbishment approach enabled 214 fluorescent lamp luminaires to be upgraded out-of-hours to minimise disruption and significantly reduced the transport costs of equipment to site compared to new luminaires. The remanufactured LED luminaires, and smart controls optimizing illumination, resulted in a significant energy reduction and carbon avoidance compared to replacing the old luminaires with new.

02. Case studies: Technologies
Arup office, Manchester, UK

Key energy efficiency measures

- → New lighting controls, optimized for occupancy and available daylight;
- → Greater light source efficacy (>120lumen/W vs <60lumen/W).

"We actively support and promote the circularity in lighting, and were keen to put it into practice. Now, having been through the process, with no disruption to our daily work and validation of the energy and carbon savings, we can share our experience with our clients with confidence and promote luminaire refurbishment as a realistic proposal."

Richard Morris, Associate and Manchester Lighting Team Leader

The new LED gear trays (all fitted in one van, the equivalent new luminaires would require a lorry for transport).

Key stats

TM65
CIBSE/SLL

72%
Operational energy savings

5,550kg/CO_2
Carbon avoidance

47.5%
Carbon reduction to remanufacture

85%
Luminaire housing retained

£20,950
Investment

1.7 years
Payback period

Project team
Arup (Client and Engineering Designer);
The Regen Initiative (Luminaire refurb. specialist).

02. Case studies: Technologies
Dr. Oetker, Johannesburg, South Africa

Cooling-as-a-Service

An ammonia refrigeration plant supplies cooling-as-a-service (CaaS) for the Dr. Oetker building's HVAC systems, process areas, process fluids, blast freezers, holding freezers and cold rooms, estimated to be 20% more efficient than a baseline installation with a further 21.5% saving realised through operational optimization. The project is innovative both in terms of the technology and the commercial service model.

Project Overview

Doctor Oetker food production factory, approximately a 6,000 sqm space requiring cooling 24 hours a day, 365 days a year for operation 16 hours a day, 6 days a week. This cooling requirement equates to an estimated 1,671kW (475.2TR) total cooling capacity.

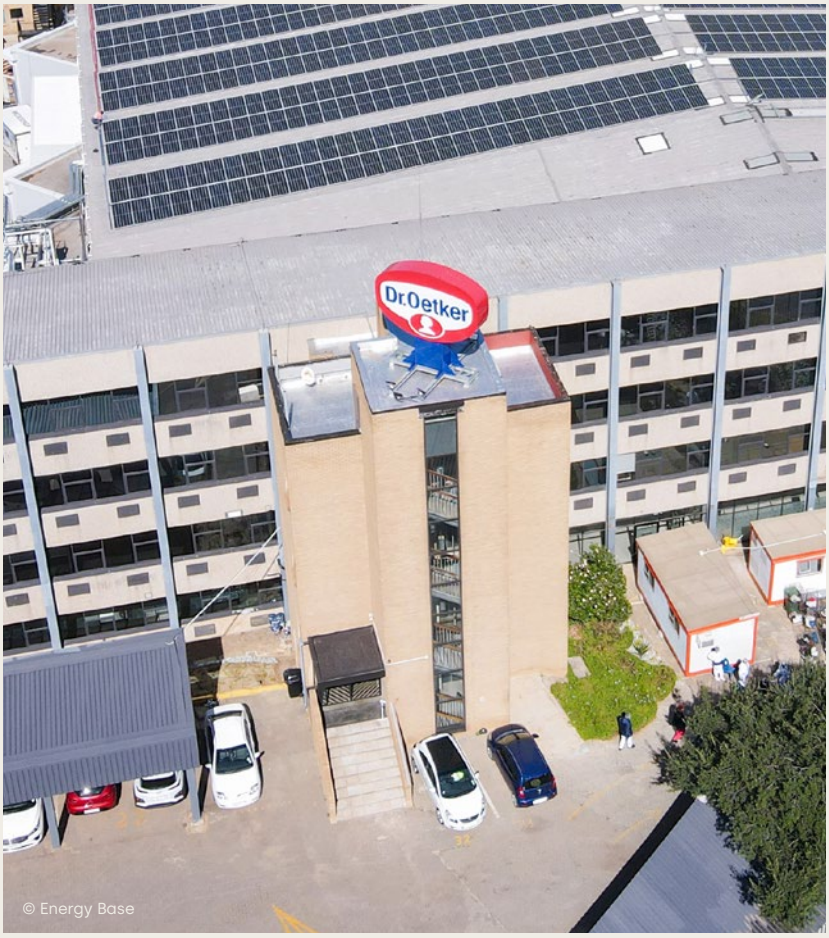
EPR supplied refrigeration and solar power to the customer, Dr. Oetker, for their new food production facility which began operation in 2020. The ammonia refrigeration plant supplies cooling for the building HVAC, process areas, process fluids, blast freezers, holding freezers and cold rooms.

The project offered great savings at the facility in terms of energy efficiency and reducing CO_2 emissions. A baseline plant estimated to be 20% less efficient would use 334MWh more electricity per annum, which results in 317 tons of CO_2 per year being avoided in this installation based on energy savings alone. When taking in an average refrigerant leak rate of 15%, the amount of CO_2 emissions avoided goes up to an annual total of 1,200 tons. The energy cost saving was 20% using an ammonia system. These savings also meant that despite having a higher upfront capital cost than solutions such as synthetic gas, the ammonia refrigeration system had a much lower life cycle cost.

The actual energy efficiency of the plant, after 4 years of operation, has steadily been improved (based on consistent iteration, optimization and focused attention) to increase the initially designed 20% saving by another 21.5%. This has effectively doubled the annual savings in terms of emission avoidance. Cooling consumption over the first 4 years has been 550,000 kWhR on average, which is close to the 600,000 expected consumption, which equates to an average of 755kW. Peak consumption during this period is approximately 75% of design capacity.

Traditionally owned-and-operated refrigeration plants generally degrade at a conservative rate of 1.5% efficiency per annum, which translates to an additional 5.1% over 4 years.

Dr. Oetker building benefited from having its cooling systems on a cooling-as-a-service (CaaS) business model. With CaaS, the customer makes no CAPEX investment. Instead, they pay an OPEX fee based on usage of refrigerated air.
The provider (EPR) is responsible for the investment, design, installation, operation, maintenance, repair and ownership of the asset. To finance the asset EPR collaborated and partnered with local financial institutions. Today, EPR own the refrigeration assets (and solar panels) and are responsible for their operation, maintenance, and repairs.



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02. Case studies: Technologies
Dr. Oetker, Johannesburg, South Africa

Key energy efficiency measures

- → Cooling/refrigeration;
- → Hot water from the waste heat of the refrigeration system;
- → Electricity from Solar PV.

"Not having to invest a huge amount of capital, as well as the cost savings, has enabled us to complete the entire project."

Erkan Yagar, Project Manager Dr. Oetker

Key stats

20%
Cost savings

1,200 tonnes
Overall carbon emission savings

Cooling-as-a-service
Funded through a cooling-as-a-service model

02. Case studies: Technologies
1 Elpro Park, Pune, India

Cooling-as-a-Service

India's most intelligent air-conditioning system, the AI-powered chiller plant at 1 Elpro Business Park runs on 100% solar energy and provides a surplus of clean energy that can power over 200 Indian households for a year. It was installed by Kaer, who is also maintaining it – all under a cooling-as-a-service (CaaS) contract.

Project overview

1 Elpro Business Park & Elpro City Square are part of Elpro Park, a mixed-use development in Pimpri Chinchwad, Pune (India), totalling approximately 10,000m² and comprising a retail centre, offices, and community spaces. It is part of a larger development that includes residential, schools, and offices. Elpro Park is an innovative, state-of-the-art commercial development designed to host the business of 'tomorrow today'. It offers solar-powered offices complete with centralised air-conditioning, rainwater harvesting, energy efficient lighting, along with a unified facility management to be in sync with nature.

Kaer is a 70-year-old Singapore-based company that introduced air-conditioning to Asia in the 1950s and pioneered cooling-as-a-service in 2013. Its business expanded to India in 2019 to bring the benefits of cooling-as-a-service to the world's fastest growing air-conditioning market.

The solution delivers highly efficient, zoned comfort with the help of a centralised chilled water system provided through the cooling-as-a-service (CaaS) model. The solution responds to customer demand for a business park that has a more positive impact on the environment than standard buildings. As such, the cooling is provided by a highly efficient air-conditioning system that offers superior indoor air-quality monitoring as well.

Residents, office workers and users only pay for the cooling service they receive, while operation, maintenance and repairs are managed by the cooling provider. The entire system can be run and monitored remotely from the provider's offices. The central solution requires a much lower cooling load when compared to standard air-conditioning systems because the air-side systems operate on a variable speed demand response basis, automatizing air-conditioning in such a way that it operates only when needed and when the spaces are occupied. The AI-driven algorithms help to optimize the operation of the system.

The customer benefits from the cooling systems on a cooling-as-a-service (CaaS). With CaaS, the customer makes no CAPEX investment, instead they pay an OPEX fee based on usage of cooled air. The provider is responsible for the investment, design, installation, operation, maintenance, repair and ownership of the asset.

The journey to carbon neutral cooling is urgent, expensive and complex. The current business models are not delivering the transition we need in the time needed and are far too expensive and complicated for business owners to implement. This case study demonstrates that an alternative model for cooling provision offers an attractive solution for customers whilst achieving significant decarbonization.

02. Case studies: Technologies
1 Elpro Park, Pune, India

Key energy efficiency measures

- → The highly efficiency cooling system is served by 100% renewable energy served from on-site solar panels;
- → Improved energy efficiency of the cooling system serving the business park by 70% compared to industry standards in the area.

"Working with KAER allowed us to guarantee clean air for all our customers. They're able to provide unmatchable levels of service with a system that is 100% run on solar energy."

Deepak Kumar, Managing Director, Elpro International Ltd

Key stats

70%
Energy demand improvement on local standards

20%
Cost savings

100%
Annual electricity from on-site renewable sources

1,200 tonnes
Overall annual carbon emissions savings

Cooling-as-a-Service

Funded through a cooling-as-a-service model

Project team

Elpro International (Client);
KAER (turnkey cooling-as-a-service provider).

02. Case studies: Technologies
Daikin R&D, Bangkok, Thailand

Energy recovery ventilation

This case study, part of the Cleaner Energy Future Initiative for ASEAN (CEFIA) demonstrates the benefit of energy recovery ventilation, along with optimized temperature and humidity control to reduce air-conditioning energy demand in hot and humid regions, such as Thailand. The test case shows it is possible to realize energy savings of 35-45% through an integrated system of air-conditioning and energy recovery ventilation.

Project overview

As we move toward a decarbonized society, the transition to renewable energy such as solar power is inevitable. At the same time, the development of energy-efficient buildings is also essential. The majority of energy used in a building comes from air-conditioning. Therefore, it makes sense to reduce energy usage. Air-conditioning energy consumption has been growing due to increased ventilation rates resulting from the spread of the Corona virus, as well as rising temperatures. Electricity costs have also skyrocketed in recent years due to the unstable international situation. The proposed Healthy and Energy Efficient Air-Conditioning System for regions with high temperature and high humidity such as ASEAN is necessary for a greener future. We have demonstrated the impact of this system at the Daikin R&D building in Thailand.

Cooling culture in Thailand, common in regions with high temperatures and high humidity such as ASEAN, etc.

There is also an issue prevalent in Thailand and many other Asian countries: people demand excessive cooling of office buildings. The room temperatures provided are often below the the indoor comfort conditions specified by ASHRAE (STD55), and can in addition result in people feeling uncomfortable due to inadequate dehumidification. For example, we have seen that people who stay in the room longer wear jackets because it is too cold, since the AC temperature in the room is set to 23°C.

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02. Case studies: Technologies
Daikin R&D, Bangkok, Thailand

Demonstration of AC-ECP: air-conditioning system with excessive cooling protection

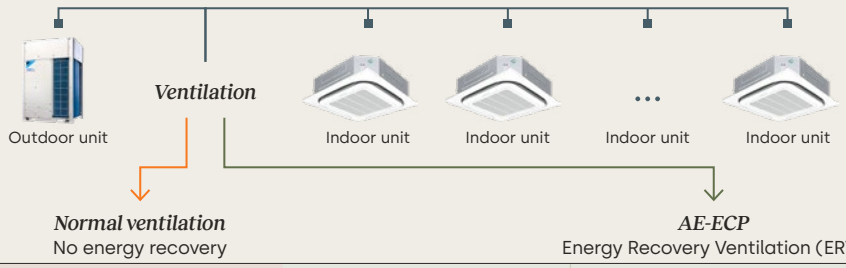
In order to achieve both energy saving and comfort by maintaining optimal indoor temperature and humidity, various types of the AC-ECP solution are proposed.

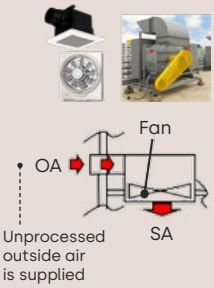
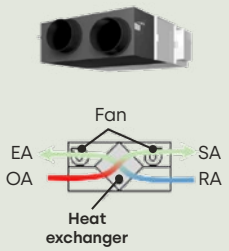
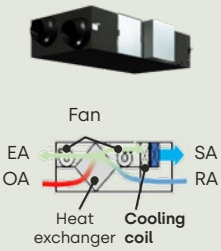
Unlike conventional ventilation systems (system A), which only use a fan to bring in outside air and exhaust the conditioned air directly outside, without any treatment, AC-ECP system (system C, D) makes it possible to provide you with comfort even at 26℃, to remove heat load and humidity by replacing the conventional fan with Energy Recovery Ventilation (ERV) system equipped with a heat exchanger and cooling coil.

Simply raising the room temperature from an excessively low setting, such as 23℃, to 26℃, along with improved control of humidity, can save a lot of energy and improve people's health. Taking into account the higher set-points, and therefore lower required capacity, in addition, the initial product cost of implementing this new system is almost the same as the existing system.

We have demonstrated each system (system E will be done later) at our office in 2023-2024 and proved that it can achieve almost 34% of saving in case of system D. At the 5th CEFIA, held in Bali, Indonesia, on August 25 2024, we reported the successful outcome of our verification of AC-ECP in Thailand as a CEFIA flagship project. While conducting demonstration tests of AC-ECP with cooperating universities, we will be promoting our new concept in ASEAN countries through the CEFIA platform.

Figure 20: Demonstration of AC-ECP: air conditioning system with excessive cooling protection

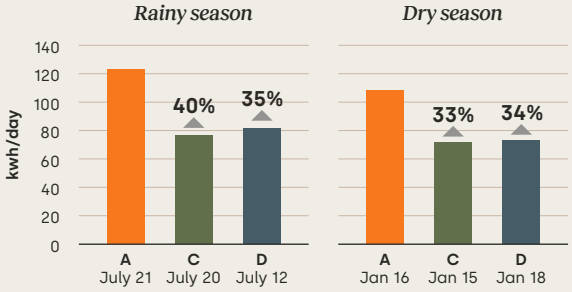


	System A	System C	System D	System E
Ventilation type				
AC set temperature	**23°C**	**26°C**		
Comfort	**Excessive cooling**	**Within ASHRAE STD55 comfort zone**		
	No	**Between No and Yes**	**Yes**	
AC capacity	**18 HP**	**12 HP**		
Cost index			Down-sizing of AC to almost offset ERV	
Energy consumption	**100%**	**66%**	**66%**	**53%**
Equipment (AC, Venti)	**100%**	**75%**	**99%**	**101%**

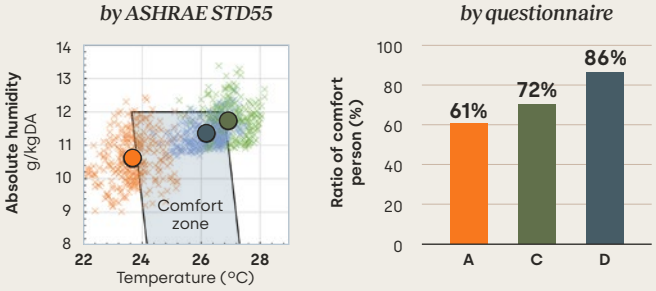
Note
Condition: 250m² office area; actual cost depends on project site.

Figure 21: Demonstration results in Bangkok, Thailand

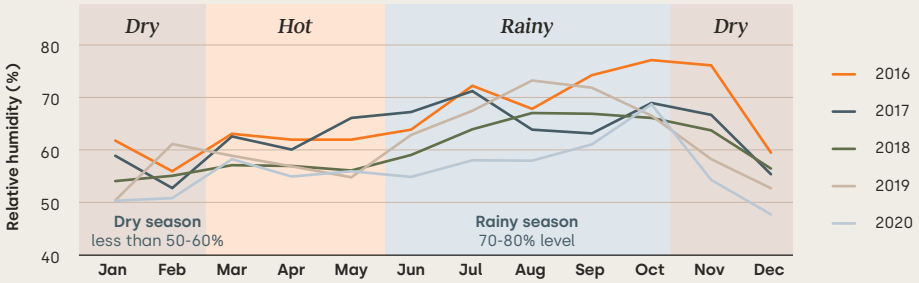
Energy consumption per day



Comfort zone – rainy season



Bangkok relative humidity by season



Reference information

Verification site
Daikin R&D building in Bangkok, 4th floor

Target office area
Office area: 250m²
Ceiling height: 2.7m
People: 20-50

5 sensors
Measuring temperature, humidity, CO_2

Key energy efficiency measures

- → VRF+ERV system D (with cooling coil) to recover waste energy and reduce absolute humidity;
- → VRF capacity is reduced because of operation temp increase resulting in lower capital cost, largely offsetting the additional cost of ERV;
- → In a further enhancement, additional energy saving is achieved through the addition of CO_2 demand controlled ventilation (System E).

"CEFIA (Cleaner energy future initiative for ASEAN) flagship project"

FP-Healthy and Energy Efficient AC System
CEFIA Digital Platform (cefia-dp.go.jp)

Key stats

80kWh/day

Operational energy for 250m² office when operating from 6:45am to 5pm (Daikin Bangkok R&D building case at rainy season)

35-45%

Approximate running cost savings compared to normal ventilation without heat recovery

Endnotes

1 WBCSD Achieving Net-zero buildings – Key actions for market transformation, 2024. Retrieved from: https://www.wbcsd.org/resources/achieving-net-zero-buildings-key-actions-for-market-transformation/

2 WBCSD Net-zero buildings – Halving construction emissions today, 2023. Retrieved from: https://archive.wbcsd.org/Pathways/Built-Environment/Resources/Net-zero-buildings-Halving-construction-emissions-today

3 Copernicus 2024 is the first year to exceed 1.5°C above pre-industrial level? Retrieved from: https://climate.copernicus.eu/copernicus-2024-first-year-exceed-15degc-above-pre-industrial-level

4 UN Environment Programme Global Status Report for Buildings and Construction, 2024 update. Retrieved from: https://www.unep.org/resources/report/global-status-report-buildings-and-construction

5 WBCSD Net-zero Operational Carbon Buildings – State of the Art, 2024. Retrieved from: https://www.wbcsd.org/resources/net-zero-operational-carbon-buildings-state-of-the-art/

6 Climate Change 2022 – Mitigation of Climate Change", IPCC. AR6 p.100. Retrieved from: https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf

7 The Buildings Breakthrough – Global push for near-zero emission and resilient buildings by 2030 unveiled at COP28, 2023. Retrieved from: https://www.unep.org/news-and-stories/press-release/buildings-breakthrough-global-push-near-zero-emission-and-resilient

8 Buildings and Climate Global Forum – Declaration de Chaillot, 2024. Retrieved from: https://www.unep.org/news-and-stories/press-release/buildings-and-climate-global-forum-declaration-de-chaillot

9 WBCSD Built Environment – Market Transformation Action Agenda. Retrieved from: https://www.wbcsd.org/built-environment-market-transformation-action-agenda/

10 Better Buildings Partnership – Office EPCs show a poor correlation with actual energy use, 2024. Retrieved from: https://www.betterbuildingspartnership.co.uk/sites/default/files/media/attachment/REEB%20EPC%20Insight%202024.pdf

11 CRREM. Retrieved from: https://www.crrem.eu/

12 Nabers Annual Report 2021-22. Retrieved from: https://nabers.info/annual-report/2021-2022/major-achievements/

13 Arup – Retrofit at scale. Retrieved from: https://www.arup.com/services/retrofit-at-scale/

14 United Kingdom Net Zero Carbon Buildings Standard: https://www.nzcbuildings.co.uk/

15 NABERS (National Australian Built Environment Rating System). Retrieved from: https://www.nabers.gov.au/about/what-nabers

16 Office of Energy Efficiency & Renewable Energy of the United States. Green Building Workforce Development Initiatives. Retrieved from: https://www.energy.gov/eere/buildings/green-building-workforce-development-initiatives

17 EDGE Zero Carbon certification. Retrieved from: https://edgebuildings.com/certify/certification/

18 NESO Carbon intensity dashboard. Retrieved from: https://www.neso.energy/about-neso/our-progress-towards-net-zero/carbon-intensity-dashboard

19 Government of South Africa. National Energy Act: Regulations: Mandatory display and submission of energy performance certificates for buildings. Retrieved from: https://www.gov.za/documents/notices/national-energy-act-regulations-mandatory-display-and-submission-energy-0

20 Systemiq – LOTUF Seeing is Believing: Unlocking the Low-Carbon Real Estate Market. Retrieved from: https://urban.partners/articles/seeing-is-believing-unlocking-the-low-carbon-real-estate-market

21 Government of the UK – UK to enshrine mandatory climate disclosures for largest companies in law (2021). Press release. Retrieved from: https://www.gov.uk/government/news/uk-to-enshrine-mandatory-climate-disclosures-for-largest-companies-in-law

22 Greater London Authority. The Mayor of London's Energy Efficiency Fund. Retrieved from: https://www.london.gov.uk/programmes-strategies/environment-and-climate-change/climate-change/zero-carbon-london/london-climate-finance-facility/mayor-londons-energy-efficiency-fund

Endnotes

23 Systemiq – LOTUF. Retrieved from: https://www.systemiq.earth/lotuf/

24 IIGCC: Making NDCs investible – the investor perspective. Retrieved from: https://www.iigcc.org/resources/making-ndcs-investable-the-investor-perspective

25 Holcim Academy. Retrieved from: https://holcimacademy.com/about

26 Knight Frank – How can NABERS sustainability rating benefit occupiers?, 2022. Retrieved from: https://www.knightfrank.com/research/article/2022-04-20-how-can-nabers-sustainability-rating-benefit-occupiers-

27 Gold Standard. Retrieved from: https://www.goldstandard.org/

28 International Carbon Reduction and Offset Alliance (ICROA). Retrieved from: https://icroa.org/

29 BusinessLDN – UK businesses urged to join forces to tackle carbon emissions. Retrieved from: https://www.businessldn.co.uk/news-publications/news/uk-businesses-urged-to-join-forces-to-tackle-carbon-emissions

Acknowledgements

Disclaimer

This report is released in the name of WBCSD. Like other reports, it is the result of collaborative efforts by WBCSD staff and experts from member companies. WBCSD's Built Environment pathway participants reviewed drafts, ensuring that the document broadly represents the majority of pathway members' views. It does not mean, however, that every member company of WBCSD agrees with every word. Please note that the data published in the report are as of 09 November 2023.

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About Arup

Arup is a sustainable development consultancy providing services in management, planning, design and engineering. As a global firm we draw on the skills of nearly 20,000 consultants across the world. Our reputation in striving to continually develop innovative tools and techniques shared with industry, is founded on the people, expertise, processes engaged in delivering holistic solutions for clients.

Our work is shaped by our mission statement, to shape a better world, and in 2020 we revised our global strategy to put sustainable development at the heart of everything we do. Arup has committed to undertake lifecycle carbon assessments on its building projects globally and align its ambitions with the UN 2030 Breakthrough Outcomes, which state: all new and refurbished buildings should be both net-zero in operation and achieve at least a 40% reduction in embodied carbon by 2030.

In addition to its project aims, Arup has committed to achieving net-zero emissions across its entire operation by 2030, covering everything from the energy used in offices to goods and services purchased. To achieve this the firm has set a target to reduce its scope 1, 2 and 3 global greenhouse gas (GHG) emissions by 30% by 2025 from a 2018 baseline.

We are Race to Zero signatories and founding signatories of UK Architects and Engineers Declare Climate and Biodiversity Emergency.

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About WBCSD

The World Business Council for Sustainable Development (WBCSD) is a global community of over 220 of the world's leading businesses, representing a combined revenue of more than USD $8.5 trillion and 19 million employees. Together, we transform the systems we work in to limit the impact of the climate crisis, restore nature and tackle inequality.

We accelerate value chain transformation across key sectors and reshape the financial system to reward sustainable leadership and action through a lower cost of capital. Through the exchange of best practices, improving performance, accessing education, forming partnerships, and shaping the policy agenda, we drive progress in businesses and sharpen the accountability of their performance.

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