Net-zero operational carbon buildings *State of the art*

→ *Where we are on the journey to net-zero buildings in operation*

World Business Council *for Sustainable Development*

ARUP

Contents

"In the scenarios we assessed, limiting warming to around 1.5°C requires global greenhouse gas emissions to be reduced by 43% by 2030."

Intergovernmental Panel on Climate Change (IPCC)
The evidence is clear: the time for action is now. We can halve emissions by 2030

"CO_2 emissions from buildings operation have reached an all-time high of around 10GtCO_2, around a 5% increase from 2020 and 2% higher than the previous peak in 2019."

UN Environment Programme
Global Status Report for Buildings and Construction

Foreword

In September 2023, the average monthly global temperature was a full 0.5 degrees Celsius above the previous record. At the time of writing 2023 looks highly likely to be the hottest year ever.[1] A stark reminder if any were needed of the urgent need to take action to address the climate crisis.

Representing around 40% of global carbon emissions, the built environment is a critical sector to tackle on the road to net-zero. The UN High Level Climate Champions 2030 Breakthrough Goals set a target to halve global carbon emissions by 2030, for 100% of building projects completed in 2030 to be net-zero in operation and to reduce embodied carbon by 40%.[9] This is a huge challenge when you consider that in 2023, as this publication demonstrates, we don't even have a global consensus on what a net-zero building is.

This document is part of a publication series by the World Business Council for Sustainable Development (WBCSD) that seeks to take stock of our progress to date on the journey to net-zero emissions across the whole-life carbon of buildings and to bring global consistency in mapping the path ahead.

Previous publications have explored embodied carbon, which while it represents half of property life-cycle carbon impact in new build, is a relatively new area of study and focus. The previous report, Net-zero buildings: Halving construction emissions today demonstrates that we have the potential to make a substantial shift with technologies already available.

The operational carbon landscape is somewhat different in that, from a technical point of view, stakeholders understand energy efficiency. We have the technical solutions we need to deliver net-zero buildings in operation. However, as evidenced by the 2030 Breakthrough Goals, our overall objective is to reduce whole-life carbon (WLC) emissions – both operational and embodied. Therefore, we need to have an eye on the balance between the two. We have yet to embed this principle well in practice, with operational and embodied carbon largely considered as separate issues.

This publication demonstrates that we are missing a clear direction to help drive the change needed in behaviors, from investment CEOs through supply chains (design, construction and operation) to individual occupants. It takes stock of the existing situation, highlights where we are making progress and identifies gaps, both in policy and practice. In this publication we set out the fundamental principles of what a net-zero building is. We will follow up with a research program in partnership with our members to set out in detail our proposals to address current shortcomings, so that we can shine a brighter light on the road ahead.

"There is a real sense that we are on the cusp of a major shift towards a large-scale transition to net-zero emissions in the property sector. But the target is not yet clearly in sight. This WBCSD report series is a crucial step on the journey to creating clarity and thus unlocking the change that is desperately needed."

Stephen Hill, Associate Director, Arup

"The buildings sector is critical to achieve the energy transition, as it consumes more than half of the world's electricity. Reducing energy consumption and switching to renewable energy are two sides of the same coin to achieve net-zero operational buildings at scale in line with available capacity."

Roland Hunziker, Director, Built Environment, WBCSD

Executive summary

An assessment of the 2,000 largest public companies, representing sales of nearly USD $14 trillion, shows that one-fifth now have net-zero commitments.[2]

Despite the rise in corporate net-zero commitments, in the property sector there is:

- No globally consistent and robust **definition** of a net-zero building;
- Not one **national policy** requiring buildings to be truly net-zero now or in the future;
- Substantial **variation in net-zero standards** set by industry certifications;
- A **negligible number** of truly net-zero buildings globally.

We are seeing increasing demand for net-zero buildings – from building owners looking to align their property portfolio to corporate commitments, from tenants searching for space that meets their corporate requirements, and from investors looking to deploy green finance in the property market. But the lack of a consistent definition is holding us back and preventing this growing demand from driving a desperately needed market transformation.

This publication identifies and highlights shortcomings and inconsistencies of the current global approach to operational net-zero emissions for the property sector. Through an international review of key definitions, policy and industry standards, it seeks to understand variations around the world and to highlight key best practice examples that could help achieve this transition. It is the first step in a WBCSD research program that will seek to draw on expertise across our membership to produce recommendations on how to dramatically accelerate progress.

Defining net-zero operational carbon buildings

At its simplest, a net-zero building can be defined as one that is 100% powered by its own on-site renewable energy. However, for the vast majority of buildings this goal is out of reach. Achieving net-zero requires a combination of both the building itself (demand side) and the infrastructure that supports it (supply side), see figure 1 on next page.

The key demand side principles of a net-zero building are:

- Energy demand reduced sufficiently to remain within the long-term availability of renewable energy generation in that locality.
- Capable of operating on 100% renewable energy (electricity/thermal);

A building that meets these two principles is described as "net-zero ready". The Partnership for Carbon Accounting Financials (PCAF) definition is as follows:[3]

"A net-zero ready building has the same characteristics as a net-zero building. The only difference is that it uses an energy supply that is not fully decarbonized at the moment of new construction or renovation."

A key part of this definition is demand reduction – a building's energy demand must go down sufficiently to be consistent with the transition to net-zero emissions for the economy in which it sits. This is a critical point of equity: a net-zero building cannot take a disproportionate amount of the renewable energy available in the locality (either now or in the future). This capacity varies between countries and regions. With relatively few countries having set out explicit infrastructure transition plans, the Carbon Risk Real Estate Monitor (CRREM) decarbonization pathways are currently the best globally applicable source of demand reduction thresholds. It is a key recommendation of this publication that, in order to be net-zero, a building's energy use intensity must be below these long-term trajectories for the locality and typology.

To move from net-zero ready to truly operationally net-zero a building must also:

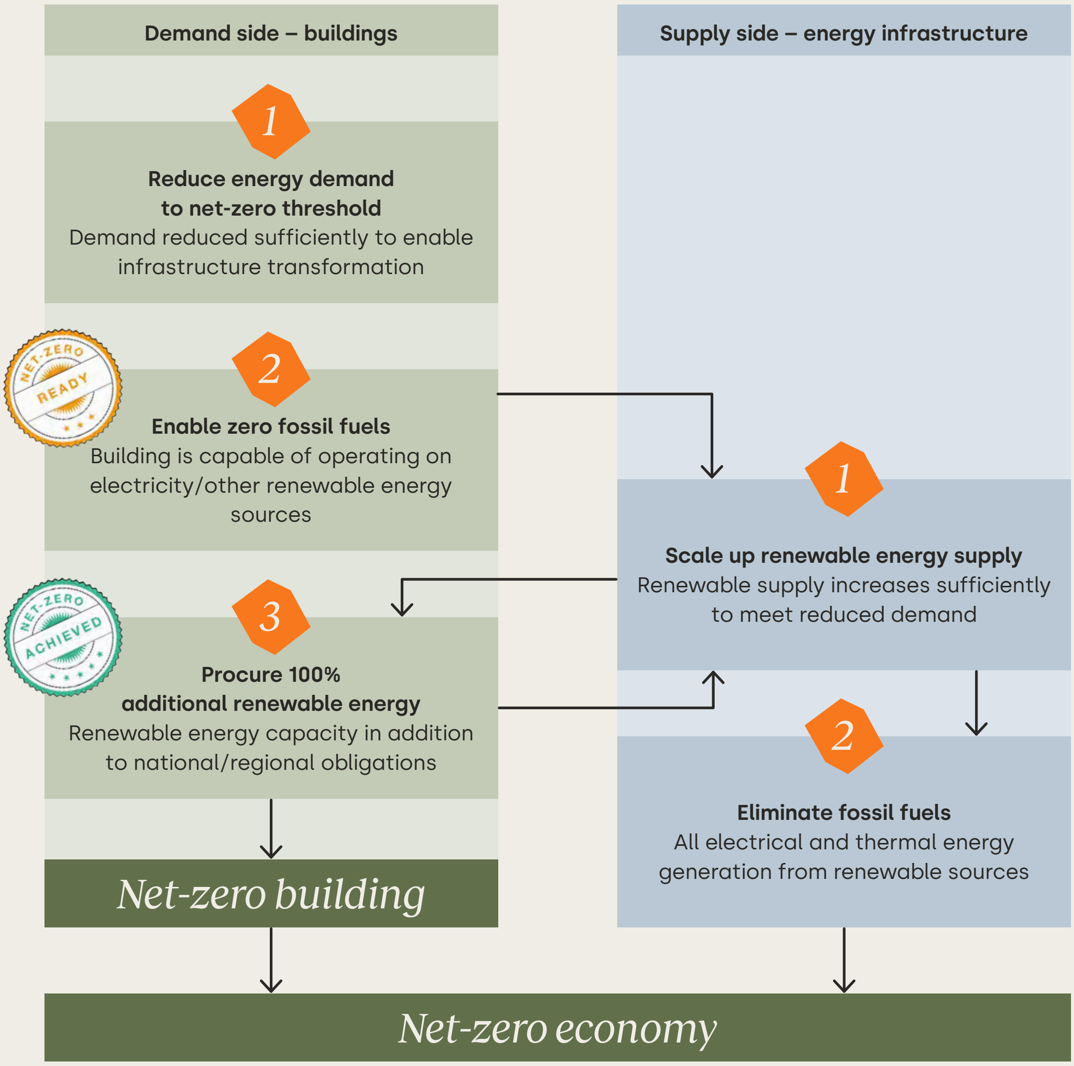
Purchase 100% renewable energy through a mechanism that demonstrates additionality beyond national renewable energy generation obligations.

This supply side principle requires scaling up the renewable energy capacity in the locality in order to meet the demand. Here, an important element is additionality – the renewable generation capacity that serves a net-zero building must be additional to what is required to meet local regulations. Going forward, we anticipate the demand for renewable energy from buildings to be a key driver of the supply side transformation. Once the supply side transition is complete and energy infrastructure is powered from 100% renewable sources, then the definition of a net-zero building is more straightforward. No country has yet made this transition.

In emerging markets where the required renewable procurement may not be feasible, purchasing carbon offsets to a recognized international standard would be an alternative means of achieving operational net-zero in the short term while transitioning toward net-zero.

This report provides an overview of supply-side infrastructure transformation in key markets, as it is significant to generate net-zero buildings. We do not intend to provide an extensive analysis of energy infrastructure transformation, which would justify a research publication of its own.

Figure 1: An integrated roadmap to a net-zero economy



Executive summary

Policy and guidance
Effective definitions of net-zero buildings, both in policy and government guidance, are lacking around the world. And we see no example of a policy fully embracing net-zero emissions requirements. While there is evidence that operational energy regulations are becoming increasingly demanding, in many cases they are based on a compliance rather than a performance approach. This, in turn, does not always translate into real-world energy demand reductions. As a result, we lack explicit alignment with a net-zero emissions outcome. Buildings' operations remain effectively unregulated.

An exception is Local Law 97, which was launched this year in New York City. This regulation places a cap on operational emissions for commercial buildings, requiring a 40% overall reduction in carbon impact by 2030.[4]

Voluntary sector guidance does provide a more comprehensive framework for assessing net-zero emissions, with the World Green Building Council (WorldGBC) and regional affiliates generally leading the way. The WorldGBC approach provides a degree of consistency. But with a range of other national and regional standards and certifications offering their own definitions of net-zero emissions, there is no consistent definition of what a truly net-zero operational carbon building is and how to measure it.

Market incentives to change
Progress is lacking globally in the generation of clear market incentives for the creation of net-zero buildings. There are notable successes, such as the National Australian Built Environment Rating System (NABERS) scheme (recently also launched in the UK), which demonstrates that a market-based energy rating system can be a powerful driver for change. NABERS is credited with achieving an average 53% reduction in greenhouse gas emissions for rated buildings in Australia over the last 14 years.[5] The launch of Local Law 97 signals a clear intent to achieve a similar transformation in the efficiency of New York's commercial building stock. Neither of these deliver truly net-zero buildings, as both focus on demand side only, but they are examples of the ambition required across all markets to meet the scale of the challenge.

While energy prices have been volatile recently, energy costs remain a relatively small proportion of overall operational costs in many markets, presenting a limited incentive for change. Investor pressure is gradually rising with tools such as the Carbon Risk Real Estate Monitor (CRREM) raising the profile of carbon stranding risk in the commercial sector but this has yet to result in widespread change on the ground.

The case studies collected in this publication demonstrate that while projects across all regions are striving for good outcomes, not everyone is speaking the same language in terms of measuring performance against net-zero requirements, with a range of metrics and definitions in play.

For businesses, portfolio owners and investors, particularly those who have made a corporate net-zero commitment, what is missing is a single robust certifiable definition. Once the market is able to reliably differentiate buildings that are net-zero from those that aren't, then it can start to attach a value premium to net-zero buildings, thus catalyzing investment and driving the kind of market acceleration that is needed. One of the key objectives for our next publication will be to further clarify this definition, taking a step towards the global clarity and consistency needed.

Overall, it is clear that while there is some movement in the right direction, there are few signs yet of the scale of transformation that is required across the global property sector if we are to step up to the challenge of the climate crisis.

Introduction

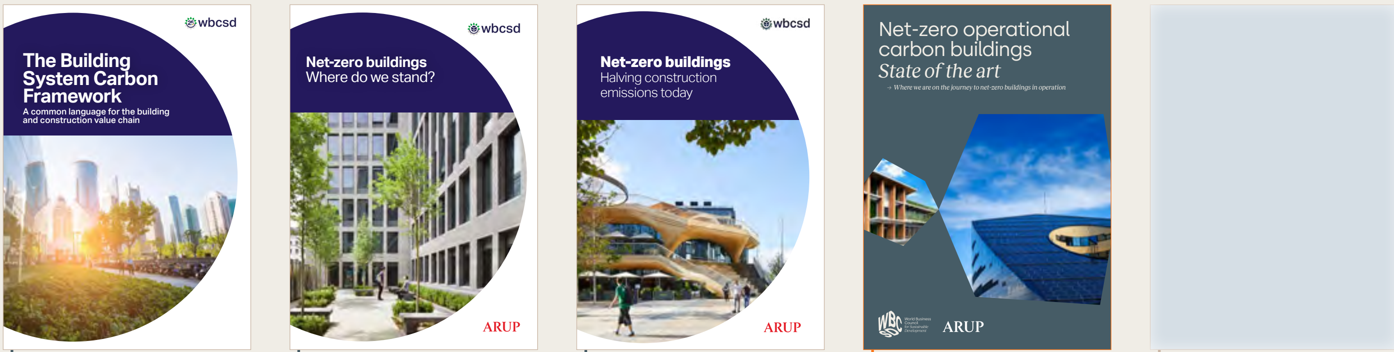
01.

01. Introduction
Built environment

This is part of a series of WBCSD publications looking at the transition to net-zero carbon emissions for the built environment.

This publication focuses on carbon impact in operation and the challenges and opportunities in achieving net-zero both for new and existing buildings. It considers both the buildings themselves and their relationship with the energy infrastructure that supplies them.

Figure 2: WBCSD net-zero emissions publication series



2020
The Building System
Carbon Framework
A common language for the building and construction value chain

2021
Net-zero buildings
Where do we stand?
Sets the scene for whole life carbon

2022
Net-zero buildings
Halving construction emissions today
Solutions to halve embodied carbon

2023
Net-zero operational carbon buildings
State of the art
Setting the scene for operational carbon

2024
Achieving net-zero
Operational carbon buildings
Solutions to reaching net-zero buildings in operation

The overall transition to net-zero emissions in operation requires progress at a building (demand-side) level – the removal of fossil fuels and substantial improvements in energy efficiency – as well as at an infrastructure (supply-side) level – rapid decarbonization of energy generation by scaling up renewable capacity.

We review the definitions of net-zero emissions in operation at the policy and industry level in various markets and how assessments aid in verifying these definitions. We also review the state of the transition to net-zero emissions from the demand and supply sides in various regions. We aim to highlight best practice and identify gaps and shortcomings in the current approach.

The next publication in the series will explore ways in which sector stakeholders can achieve the transition to net-zero emissions in operation practically and effectively.

Transitioning corporate portfolios
For many organizations, buildings are a significant part of their direct carbon footprint.[6] Therefore, the transition of those buildings to net-zero carbon plays an important role in the corporate transition roadmap.

We provide practical guidance and a critical review of how organizations define net-zero carbon in operation, in principle and in practice, at the corporate, portfolio and asset-levels; ways to assess a building, including a review of leading net-zero carbon rating schemes; and an introduction to practical guidance on making the transition.

We focus on how organizations can achieve the net-zero emissions transition at an asset level, for both new assets and through the refurbishment of existing ones, and seek to understand what is holding the sector back.

The state of the transition in key markets
We look at the state of the transition to net-zero emissions in key regions in terms of supply and demand and market and policy drivers.

We highlight key local and regional successes – approaches that companies, industry bodies and policy-makers could replicate to help drive the transition in other regions. The world will not achieve net-zero emissions by relying on global companies to "do the right thing". But through a combination of policy and market incentivization, it is possible to align commercial incentives with the net-zero transition.

Leading examples of the transition
Finally, we highlight some best practice – individual buildings and initiatives that are leading the transition. We have chosen these inspiring examples to show the road ahead for others to follow. The WorldGBC Advancing Net Zero Status Report (July 2023) includes complementary analysis and case studies from the global network of Green Building Councils.

"CO_2 emissions from buildings operation have reached an all-time high of around 10 $GtCO_2$, around a 5 per cent increase from 2020 and 2 per cent higher than the previous peak in 2019."

UN Environment Programme[7]

Global context – built environment
Decarbonization trajectories, that are in line with the 1.5°C Paris Agreement, aim to halve global carbon emissions by 2030 and reach net-zero emissions by 2050. The United Nations-backed Marrakech Partnership for Global Climate Action released a climate action pathway which echoes the need for the built environment to halve emissions by 2030.[8] To attain these challenging 2030 goals, it is imperative to achieve mass transformation of the built environment to net-zero emissions.

Global context – whole life carbon
The UN High Level Climate Champions 2030 Breakthrough Goals state that all new and refurbished buildings must have net-zero operational emissions by 2030.[9] Given that buildings in operation represent 28% of global CO_2 emissions,[10] it is clear that this transformation is essential if the global economy is to meet the overall challenge of mitigating the worst impacts of climate change. However, it is also clear that, given the current rate of progress, this is a significant challenge for the property sector.

While the operational carbon of buildings is a significant proportion of global carbon emissions, embodied carbon of materials and construction is also important and the other key part of a building's whole life carbon footprint. This document is one in a series published by WBCSD exploring building carbon emissions and the transition to net-zero carbon emissions from buildings, with the previous publication Net-zero buildings: Halving construction emissions today, exploring the impact of embodied carbon.

Figure 3: Estimated distribution of carbon emissions per building life cycle stage
From the WBCSD 2021 report Net-zero buildings: Where do we stand?

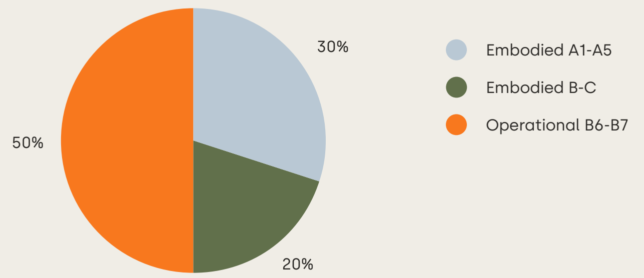
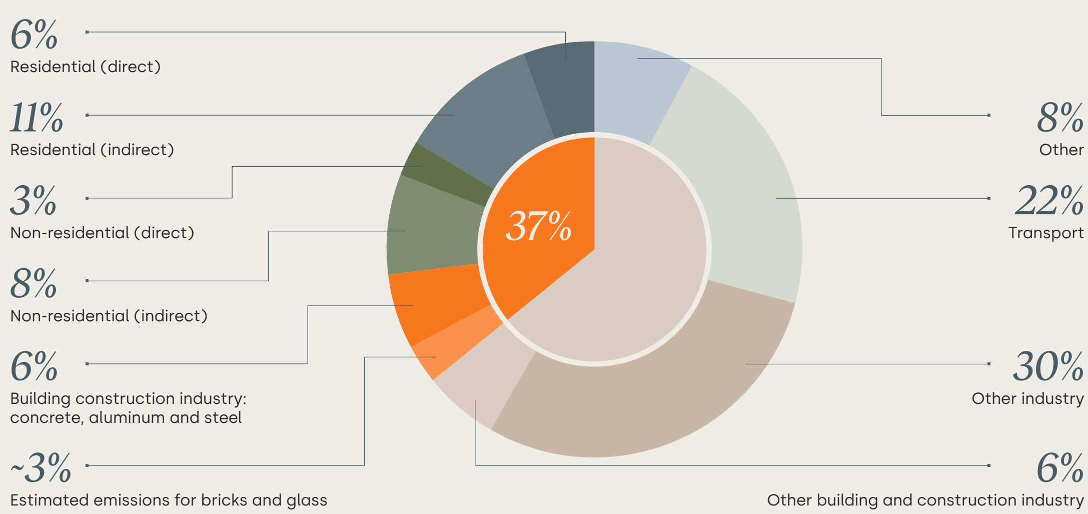


Figure 4: Share of buildings in global energy and process emissions in 2021
From the United Nations Environment Programme (UNEP)-hosted Global Alliance for Buildings and Construction (GlobalABC) 2022 Global Status Report for Buildings and Construction (Buildings-GSR)



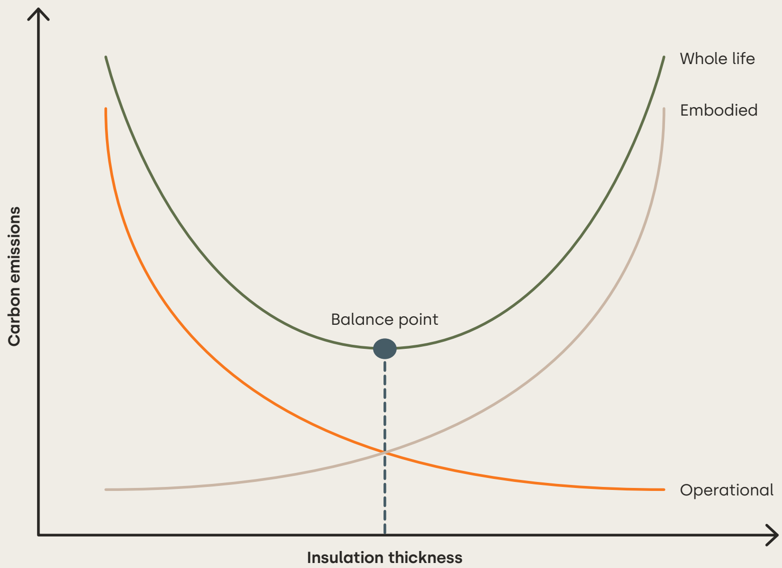
01. Introduction
Optimizing whole-life carbon

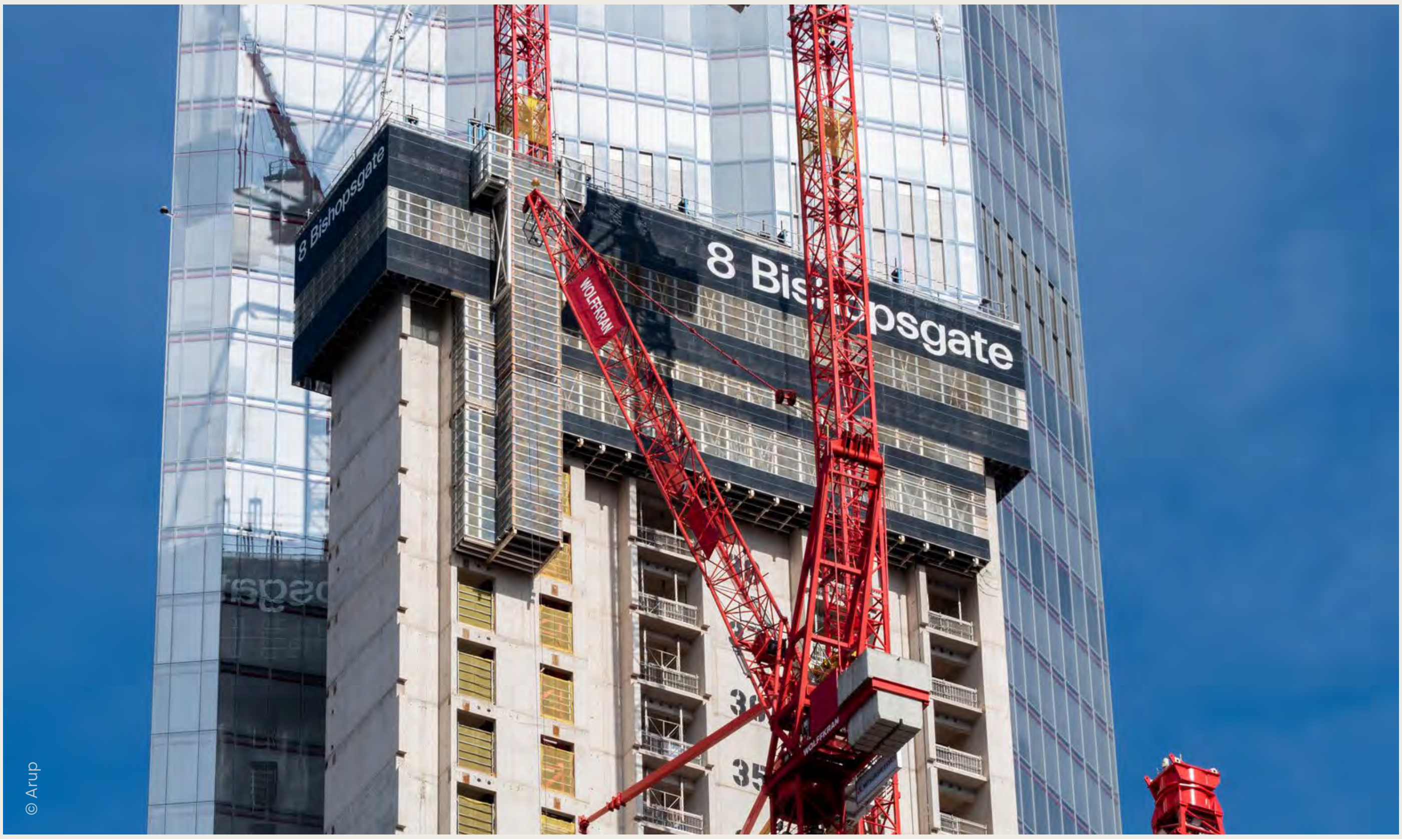
It is important to remember that the operational carbon footprint is half or often less than half of a building's total whole-life impact, with the remainder being embodied impacts at the various lifecycle stages.

Companies must consider the objective of net-zero carbon emissions in operation fully in the context of the building's whole life footprint to avoid unintended consequences. This balance between operational and embodied impacts plays out differently around the world due to changes in climate and carbon intensity factors (for energy and materials). The picture is changing all the time.

Emerging best practice is a closer integration between operational and embodied energy/carbon analysis such that the industry understands and analyzes the trade-offs between the two in the context both of a whole project and individual key decisions.

Figure 5: Whole life carbon balance points





Defining net-zero carbon buildings *in operation*

02.

02. Defining net-zero in operation
Key principles

While companies understand the broad principles, there are gaps and inconsistencies in the definitions of a net-zero emissions building in use around the world and these are holding the sector back. Creating effective incentives for their creation requires greater clarity on what a net-zero building should to be able to do. Critical to the definition is the combination of the performance of the building and that of the infrastructure to which it connects.

Demand-side transition
Building transformation
A zero-carbon building in operation is relatively easy to define: a building 100% powered by its own on-site renewable energy. However, for the vast majority of buildings around the world this is not a feasible outcome and the objective is to be a net-zero emissions building, an outcome that involves both the building and the energy infrastructure that supplies it.

Therefore, for a net-zero carbon building, it is necessary to make a distinction between the requirements of the building itself and the infrastructure to which it connects. A building that meets the required characteristics of net-zero emissions is "net-zero ready".

To be net-zero ready, a building would need to:

→ Have reduced its energy demand sufficiently to be consistent with the transition to 100% renewable energy for the market in which it operates;

→ Be capable of operating on 100% renewable energy sources (electricity/thermal).

It is a key principle of a net-zero ready building that it not only emits no carbon on an annual basis but also reduces demand for renewable energy sufficiently to change with the economy in which it sits. This means that if all buildings performed at that level, the long-term available renewable capacity would be sufficient to meet demand.

The best globally consistent definition of the level of energy efficiency required to achieve net-zero in different economies around the world comes from the CRREM pathways (see section 02 on demand reduction trajectories).

Supply-side transition
Infrastructure transformation
Ultimately, a net-zero building would connect to a zero fossil fuel/100% renewable energy fuel source. However, while grid carbon intensities vary around the world, no country has yet made the transition to 100% renewable energy.

There are two ways in which a building can have net-zero operational emissions in this infrastructure transition phase:

→ Purchase 100% renewable energy through a tariff (guarantee of origin) or power purchase agreement (PPA) that is demonstrably additional to national renewable obligations;

→ In emerging markets where the above is not feasible, purchase carbon offsets meeting a recognized international standard to counterbalance 100% residual emissions on the journey to net-zero emissions (see section 04 on carbon offsetting for further details).

"A new or renovated net-zero building is highly energy efficient, does not cause any on-site GHG emissions from fossil fuels and reduces embodied carbon to a significant extent. It uses renewable energy, preferably generated on-site, if technically feasible, and/or off-site to fully cover its remaining, very low energy use."

Partnership for Carbon Accounting Financials (PCAF),
Guidance on financing the European building transition to net-zero

"As the golden rule of achieving net-zero, measures that will help reduce energy demand to ensure buildings are highly energy efficient are always prioritized. How the energy is supplied to meet the remaining demand varies. For example, if 100% of energy demand is met by on-site renewable energy, it can be called a net-zero energy building. In reality, it may not be possible in all building types and locations. If renewable energy from off-site is imported to meet the balance, it can be called net-zero operational carbon."

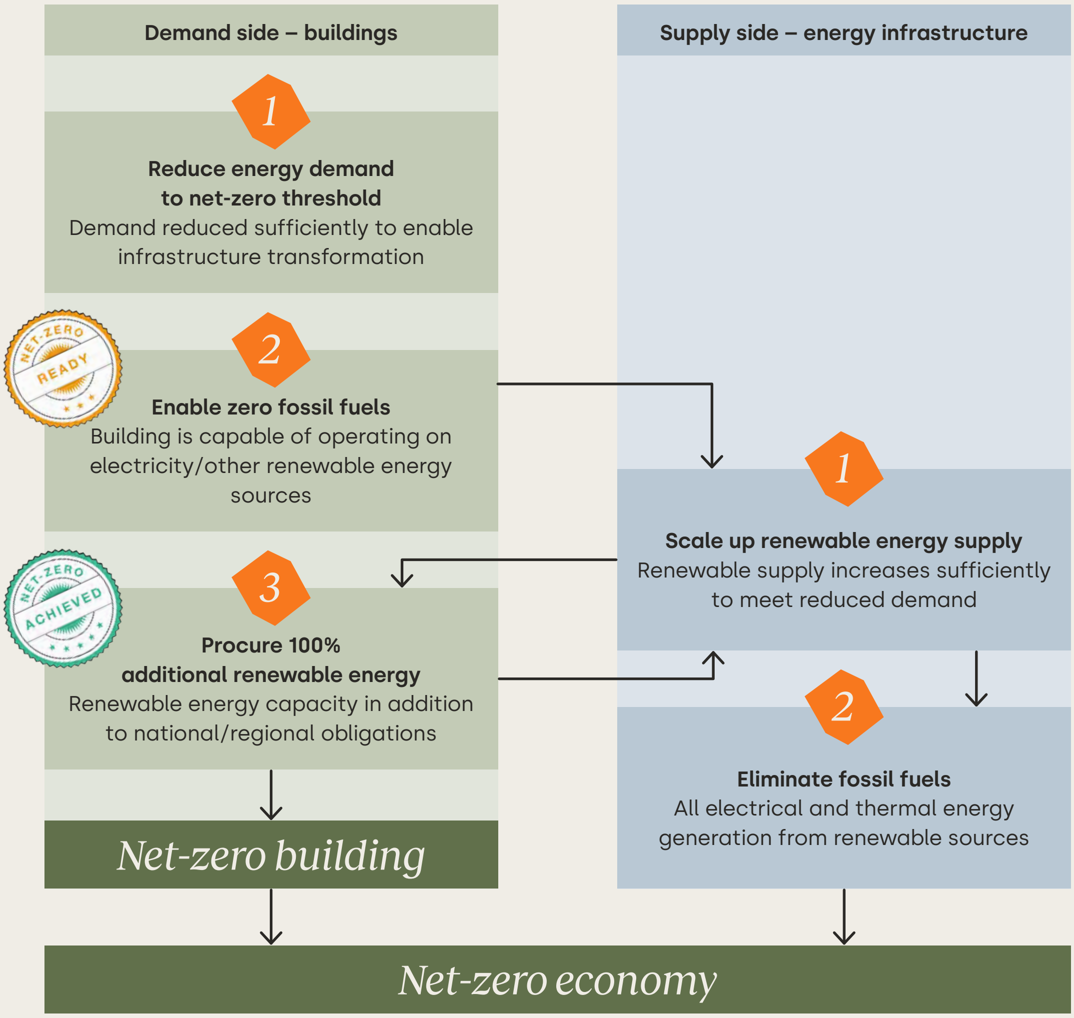
WorldGBC,
What is a net-zero carbon building?

02. Defining net-zero emissions in operation
Transformation pathway

The Intergovernmental Panel on Climate Change (IPCC) defines net-zero carbon as a balance of carbon emissions with carbon removals over a specified period of time.[11]

There is no market anywhere in the world that has realized this goal. However, the transition has started and is progressing at varying speeds in different markets. Achieving a full transition to net-zero emissions requires the transformation of buildings and infrastructure. These two are interdependent. Figure 6 illustrates the interconnection – a 100% renewable infrastructure is only possible if building demand is reduced sufficiently. At the same time, a building ultimately can only achieve net-zero emissions when connected to a 100% renewable infrastructure.

Figure 6: An integrated roadmap to a net-zero economy



02. Defining net-zero emissions in operation
Building vs. portfolio vs. corporate

Many organizations define net-zero emissions primarily as a corporate objective, with targets either expressed as "net-zero by x date", or through the setting of a science-based target verified by the Science Based Targets initiative (SBTi). The former requires a supplementary definition of scope to be effective, while the latter sets a trajectory target, typically aligned with a 1.5°C trajectory, which mandates marginal improvements on an annual basis rather than an absolute figure in a number of years.

Building/portfolio level
The definition of a net-zero carbon building in operation has two components – "net-zero enabled" involves the elimination of on-site fossil fuels and improvement in energy efficiency to meet the local net-zero threshold. Companies are increasingly using tools such as the CRREM to compare building energy/carbon performance against market decarbonization trajectories to evaluate carbon stranding risk (see next section on **demand reduction trajectories** for a more detailed CRREM definition).

In addition to the above, to achieve net-zero emissions, a building will need to use 100% renewable energy. While energy markets remain partly reliant on fossil fuels, renewable energy for a net-zero building must demonstrate additionality, meaning the associated generation capacity must be additional to that required by local/national regulations for allocation specifically to that building.

Corporate level
Many corporations set a science-based target (as defined by SBTi – see section 03) as the means of expressing an overall approach to climate change mitigation. To date this has not been sufficient to put a building or property portfolio on a trajectory to net-zero emissions as per the definition adopted here.

This is because while SBTi requires an absolute reduction trajectory for scope 1 (on-site fossil fuels), the assessment of scope 2 (grid-supplied energy) can be market based.[12] Therefore, the possible procurement of 100% renewable energy reduces the drive for energy efficiency improvements.

This is understandable for science-based targets, which may apply to organizations in any sector. Therefore, absolute judgments on the required level of energy efficiency to achieve a transition to net-zero emissions are not realistically possible.

However, this is a changing landscape. SBTi published a **draft guidance for the buildings sector** in May 2023. This is applicable to property sector organizations, namely building owners, developers, property managers, significant tenants and financial institutions, and is therefore more focused on the development and the performance of buildings. In the draft documents released as a part of the SBTi's stakeholder engagement processes, the SBTi explores options to put more emphasis on energy efficiency as a priority in the industry's decarbonization journey.

02. Defining net-zero emissions in operation
Demand reduction trajectories

The Carbon Risk Real Estate Monitor (CRREM) project offers the most comprehensive source of global decarbonization trajectories for property.

Initially developed for European Union countries, CRREM has since expanded to include key global economies. A program of alignment between the SBTi and CRREM brought an update on trajectories in 2023.

Trajectories are available for most major global economies and a range of asset classes. As such, they represent the best means of consistently assessing building transitions to net-zero emissions around the world.

Energy trajectories plot a path from the current market average energy intensity for each asset class in the chosen market down to a demand that aligns with achieving net-zero emissions for that economy. The ultimate energy intensity varies between economies based on the balance of demand and renewable supply in the locality.

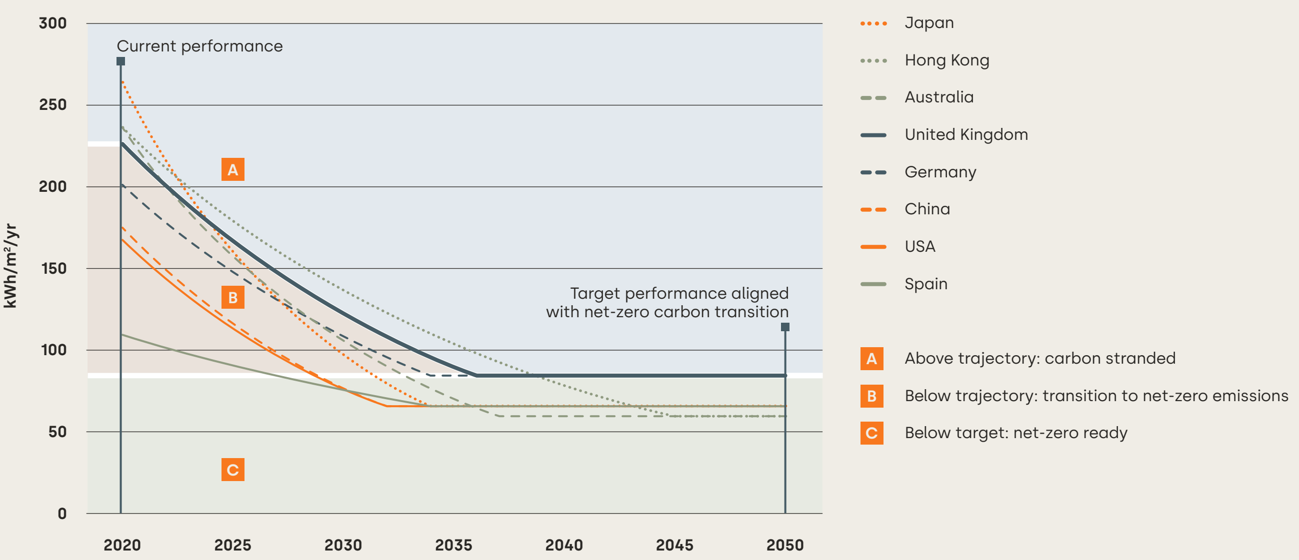
In energy-efficiency terms, a building would need to perform below the ultimate energy intensity level for the relevant market and asset class to be considered net-zero emissions. A building above the ultimate intensity but below the trajectory for the year in question would be considered in transition to net-zero emissions, whereas a building above the trajectory would be considered carbon stranded.

Carbon stranding

The global property investment market is increasingly recognizing CRREM's definition of carbon stranding, partly thanks to its inclusion in the Global Real Estate Sustainability Benchmark (GRESB).[13] Carbon stranding is a crucially important driver of change in the commercial property sector. By creating a direct link between property value and operational energy performance and embedding the need for continuous improvement, it makes a direct link between property value and a 1.5°C Paris-aligned decarbonization trajectory.

As figure 7 shows, in most global markets, target trajectories reach the ultimate energy intensity by 2035 or before. Therefore, within the next 10-12 years, the vast majority of global assets will need to achieve energy intensities consistent with net-zero emissions or will be considered carbon stranded.

Figure 7: CRREM 2023 pathways (office buildings)



02. Defining net-zero emissions in operation
Definitions around the world

From research carried out to support this publication, we have found that there is no government legislation that fully defines a net-zero carbon emissions building and there are no examples of regulation of embodied carbon.

However, **national and regional policies are in many cases increasing operational energy requirements in recognition of the need to transition to net-zero emissions alignment.**[14] These legislative definitions, such as the EU ZEB (zero-energy building) and the Japan Zero Energy Building Policy, are important to informing future operational energy reduction targets in these locales but do not define what a net-zero carbon building is. Transparency can be an important agent for change in markets by increasing demand for high-performing assets, as evidenced in particular in Australia, with local regulation requiring a minimum NABERS rating (refer to NABERS case study in section 06).

While not yet widespread, **governments are starting to issue non-legislative definitions or frameworks addressing net-zero emissions.** In the EU, the taxonomy for sustainable activities ties energy performance to a clear definition of minimum requirements for sustainable finance.

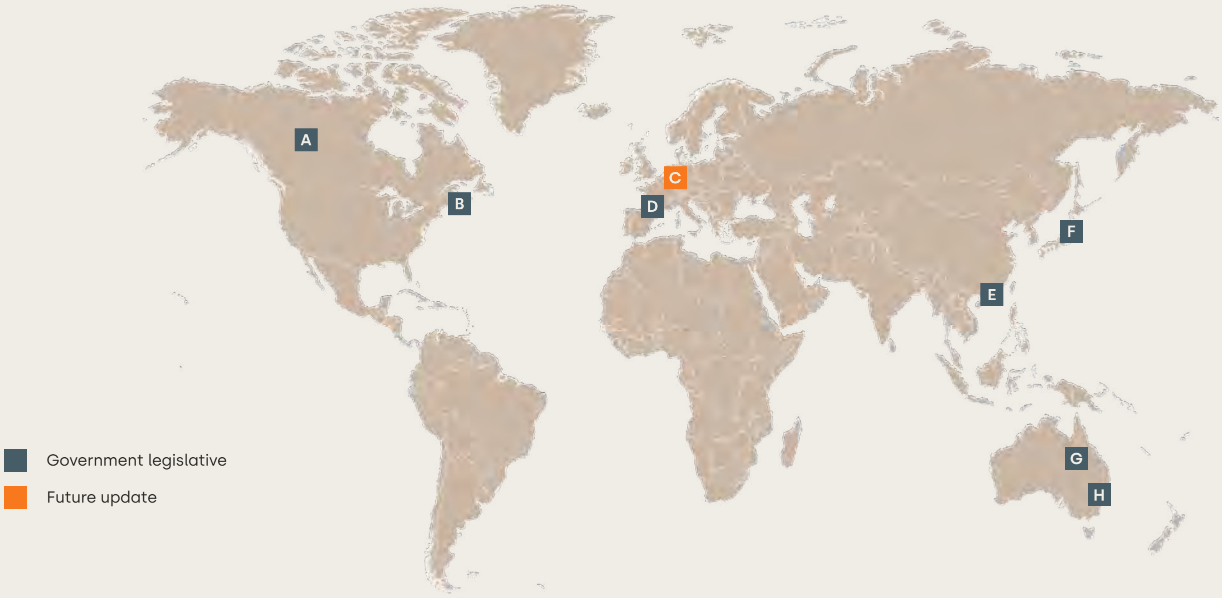
This is an important first attempt to introduce standardization into the green or sustainable finance market, which has grown rapidly in recent years but is still much like the "Wild West" due to the lack of any consistency in definition of what constitutes "green" or "sustainable" in this context. The interconnected nature of the finance market means that this standard is already having an impact beyond the EU. There is a general expectation that over time other jurisdictions will follow suit in introducing similar definition frameworks as a means of harnessing the potential of green finance as an agent for change. In China[23,24] and the US,[21] net-zero emissions energy definitions are in place that encourage substantial energy consumption reductions but with no target or link to regulation. Nevertheless, this is an important step forward in the clarification of definitions in those markets.

Stakeholders have left the heavy lifting to the WorldGBC and associated local Green Building Councils (GBCs) to put in place working definitions of what a net-zero carbon building actually is.

In 2018, the WorldGBC launched its Advancing net-zero program, which calls on GBCs worldwide to work towards total sector decarbonization by 2050. This means operational and embodied emissions are to be zero for all buildings. Organizations can achieve this through a mixture of emissions reductions, renewable energy procurement and carbon offsetting. Since this announcement, the separate GBCs have developed their own frameworks and definitions to achieve this headline aspiration and set their own interim targets, with variations on what each country considers net-zero emissions, as well as their own requirements for renewable energy procurement and carbon offsetting.

The following pages map the net-zero emissions buildings definitions that we analyzed for key markets relevant to WBCSD members. We have split the definitions in terms of government (legislative and non-legislative) and voluntary market definitions advanced by non-governmental organizations.

02. Defining net-zero in operation
Government legislative - current and future



A

Canada 2020 National Proposed Model Codes
New buildings built to net-zero energy-ready standards by 2030, i.e., designed to be as energy efficient as possible. No embodied carbon or carbon offset requirements.[15]

B

New York city, Local Law 97
In 2024, Local Law 97 in New York City will require buildings over 25,000 square feet to meet annual carbon emission caps as part of the city's efforts to achieve ambitious climate goals by 2050. The new law aims to reduce carbon emissions produced by the city's building stock by 40% by 2030 and 80% by 2050.

C

EU Fit for 55
Buildings sector to become part of the EU Emissions Trading Scheme from 2026 onwards, setting maximum emissions and planned to equate to a 43% reduction compared to 2005 levels. This will include updates to the Energy Efficiency Directive (EED) and Energy Building Performance of Buildings Directive (EPBD).[16]

D

EPBD
In the EU, the Energy Performance of Buildings Directive (EPBD) required all new buildings to be nearly zero-energy (NZEBs) by the end of 2020. Updated requirements define a zero-energy building (ZEB) as a building with a very high energy performance, with residual demand fully covered by renewable sources, and without on-site carbon emissions from fossil fuels. The ZEB requirement should apply as of 1 January 2030 to all new buildings. Every country in the EU will have to abide by these rules, as will the Emissions Trading Scheme. This could significantly impact any operational reduction targets that companies set across in Europe and is likely to lead to a significant increase in future demand for renewable energy.

E

Hong Kong Building Energy Efficiency Ordinance (BEEO)
The BEEO covers new construction and major retrofits of existing commercial buildings. The Building Energy Code sets minimum standards and requirements for energy efficiency and the Energy Audit Code mandates a public energy audit every 10 years.[17]

F

Japan Zero Energy Building Policy
All new government/regional public buildings will be zero energy by 2020 and all new public/private buildings on average by 2030. A ZEB has high energy savings through load reduction, without decreasing the environmental quality both indoors and outdoors.[18]

G

National Construction Code (Australia)
Set by the Australian Building Codes Board on behalf of the Australian Government, the National Construction Code sets minimum design standards for thermal building envelope and building services equipment efficiencies.[19]

H

City of Sydney Council
In the City of Sydney, new office buildings, hotels and shopping centers, along with major redevelopments of existing buildings, must have a minimum NABERS energy rating of 5.5 from January 2023. New developments must also achieve net-zero carbon emissions in their energy use from 2026.[20]

02. Defining net-zero emissions in operation
Government non-legislative – current and future

A

US Department of Energy
A zero-energy building produces enough renewable energy to meet its own annual energy consumption requirements. Operational energy consumption should reduce substantially through design and operational measures to increase energy efficiency. No embodied carbon or carbon offset requirements.[21]

B

EU Taxonomy
The EU Taxonomy on Sustainable Finance, Climate Change Mitigation category: Acquired and owned buildings built before 31 December 2020 must have a class A Energy Performance Certificate (EPC) or be in the top 15% of the market. The primary energy demand of new buildings should be at least 10% lower than the threshold set for nearly zero-energy buildings.[22]

C

Ministry of Housing and Urban-Rural Development of the People's Republic of China
A zero-energy building produces at least as much renewable energy as its own annual energy consumption requirements. A nearly ZEB should reduce its operational energy by 75% from the building energy consumption criteria in 2016. No embodied carbon or carbon offset requirements.[23]

D

Ministry of Housing and Urban-Rural Development of the People's Republic of China
In April 2021, the ministry and the China Academy of Building Research launched the preparation of the technical standard for zero-carbon buildings. It aims to accelerate the implementation of China's "Dual Carbon" goal, by providing carbon reduction targets for the building field. It is voluntary and the issue date is unknown.[24]

02. Defining net-zero emissions in operation
Industry bodies – standards and future trends

A

WorldGBC

The WorldGBC's **Net Zero Carbon Buildings Commitment** states that all buildings must achieve net-zero emissions by 2050, including operational and embodied emissions. By 2030 all new buildings and renovations will have at least 40% less embodied carbon and all new buildings have net-zero operational carbon.

The commitment declares that buildings in businesses' direct control should achieve net-zero carbon for operational energy by 2030. Companies are to offset all residual emissions by 2030.

C

UKGBC

In the UKGBC **Net Zero Whole Life Carbon Roadmap for the Built Environment**, new buildings must deliver the energy performance levels required for net-zero. It has set an average energy intensity reduction target of 60% for commercial offices that is "Paris Proof" to reach zero-carbon energy in 2050. Its framework includes steps to achieve a net-zero carbon building without associated targets and encourages businesses to sign up to the WorldGBC Net Zero Carbon Buildings Commitment.[26]

E

Dutch GBC

The DGBC has developed a **Paris Proof Commitment** for signatories to meet the goals of the Paris Agreement. This involves measuring actual energy consumption in order to make significant energy savings and reach CO_2 neutrality.

Signatories must commit to ensuring that all existing and new buildings in their direct control will be Paris Proof by 2040 and to monitor progress. This aligns with the WorldGBC Net Zero Carbon Buildings commitment.

B

PCAF

According to the Partnership for Carbon Accounting Financials (PCAF), a new or renovated net-zero building is highly energy efficient, does not cause any on-site GHG emissions from fossil fuels and reduces embodied carbon to a significant extent. It uses renewable energy, preferably generated on-site, if technically feasible, and off-site to fully cover its remaining, very low energy use.[25]

D

UK Taskforce for Net-zero Carbon Buildings

UKGBC is among the stakeholders developing a net-zero Carbon Buildings Standard for the UK market. Expected to launch later in 2023, this will define net-zero-aligned targets for operational and embodied carbon emissions across a range of asset types.

F

Dutch GBC

The DGBC is exploring linking up to the Global Reporting Initiative (GRI) and GRESB, the system in which real estate funds report via the CRREM module. Furthermore, a link will be made with the Building Research Establishment Environmental Assessment Method (BREEAM).[27]

Assessing net-zero emissions
Global/international net-zero certifications

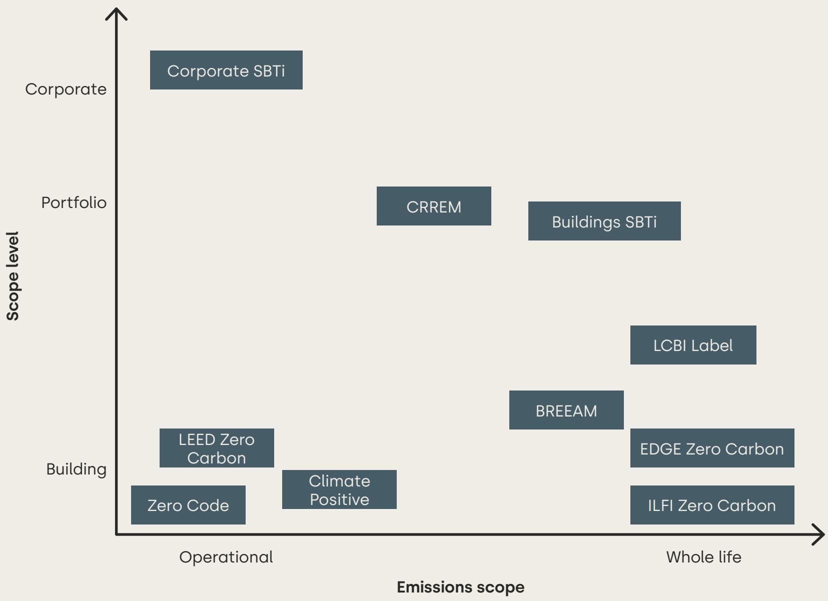
03.

03. Assessing net-zero emissions
Global/international net-zero certifications

Net-zero carbon certifications offer both a robust methodology for assessing different aspects of net-zero emissions and a means of attaching market recognition and therefore value to a net-zero carbon outcome.

The certifications presented here are either global or applicable across a wide range of regions. Certifications described include those related to corporate emissions (not limited to buildings), building portfolios and individual buildings. Our research generally focused on markets and geographies of relevance to WBCSD members. Both the scope of the assessments and the degree of diligence varies; therefore, it is important to understand which assessment or assessments are applicable to your specific needs. The net-zero ratings schemes shown here are applicable internationally.

Figure 8: A sample comparison of net-zero carbon certifications applicable across nations



03. Assessing net-zero emissions
Global/international net-zero certifications

Corporate SBTi

The Science Based Targets initiative (SBTi) validates corporate carbon reduction targets to ensure they are in line with a specified decarbonization trajectory (typically 1.5°C). Companies must achieve defined reduction trajectories for scope 1 and 2 emissions. Scope 2 includes renewable procurement. Companies have to evaluate scope 3 emissions and set reduction targets, although these may be indirect and SBTi does not mandate trajectory alignment.[28]

LEED Zero Carbon

LEED Zero Carbon is globally applicable and includes operational and transport emissions in scope, but with no targets set for either and no prioritization of building energy efficiency. It requires LEED design certification, the purchase of green energy and a commitment to offsetting residual emissions. It allows fossil fuels.

Zero Code

Architecture 2030's Zero Code Renewable Energy Procurement Framework is globally applicable and includes operational emissions in scope, with minimum energy efficiency and on-/off-site renewable energy requirements. Companies must offset operational emissions but there is no guidance and the certification cost is unclear.

Climate Positive

Climate Positive originated in Germany but is applicable globally. The scope is operational but there is no target for emissions reductions. It allows on-site and off-site renewables, yet its carbon offsetting stance is unclear. Buildings must already have certification for Buildings In Use.[29]

CRREM

The EU has developed the CRREM (Carbon Risk Real Estate Monitor) tool but it has expanded globally. It assesses the carbon intensity of an individual asset against the projected property market decarbonization trajectory (1.5°C aligned). The tool identifies the carbon stranding year for the asset, i.e. the year in which the asset's operational carbon intensity moves above the market average. Investment companies are increasingly using this as a means of evaluating operational carbon performance across a portfolio. SBTi and CRREM have recently released a joint set of new decarbonization trajectories, that should improve the accuracy of assessments going forward.[30]

BREEAM

BREEAM (Building Research Establishment Environmental Assessment Method) is an internationally recognized hallmark for a sustainable building. Developed in the UK, it is now in use in a number of jurisdictions around the world. While both operational energy and embodied carbon feature in the assessment, BREEAM doesn't yet include a net-zero emissions objective. However, BREEAM UK will soon introduce alignment with a net-zero carbon trajectory.

LCBI Label

The Low Carbon Building Initiative (LCBI), launched in 2022, unites major European real estate stakeholders to promote low-carbon buildings and reduce the CO_2 emissions of European real estate by half as measured through a life-cycle analysis. LCBI aims to create the first pan-European low-carbon label to do so.

Buildings SBTi

SBTi published its Buildings Guidance drafts in May 2023. It provides a methodology for developing a 1.5°C aligned decarbonization trajectory at a building level. The methodology takes location-based emissions as the basis and so is more focused on demand-side (building) performance than the infrastructure, which is a key difference from the corporate SBTi method. The method also includes embodied carbon specifically alongside operational carbon.

EDGE Zero Carbon

The World Bank developed EDGE Zero Carbon certification for developing countries. The scope includes both operational and embodied emissions, with targets of 40% energy reductions on a localized baseline and a 20% reduction in water and embodied energy in materials. Companies must offset operational emissions. It only grants certification after 1 year of building operation at 75% occupancy.

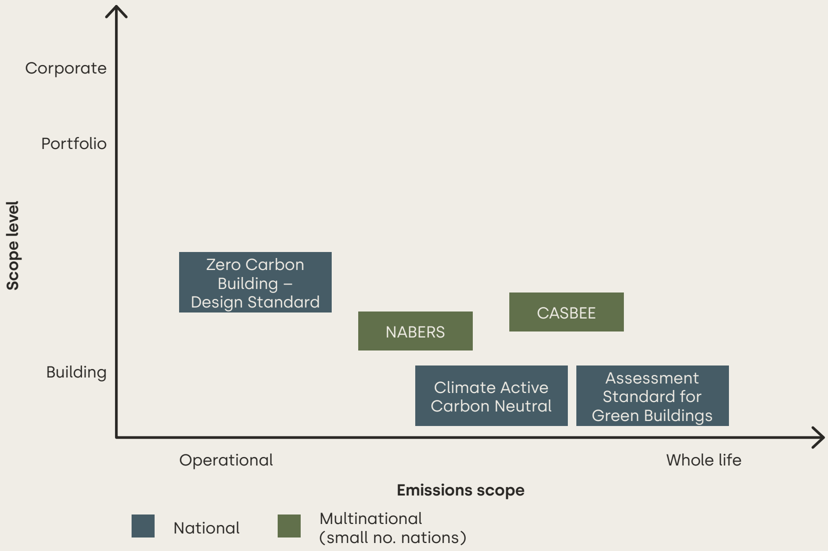
ILFI Zero Carbon

The International Living Futures Institute's Zero Carbon Certification is the most closely aligned with CRREM and the Paris 1.5°C trajectory through clear operational and embodied emissions reduction targets: 25% energy reductions for new buildings on an ASHRAE 90.1 baseline and 10% reduction on an embodied carbon baseline, with total embodied carbon not exceeding 500 $kgCO_2e/m^2$ (A1-A5). 100% of the operational energy must come from new on-/off-site renewable energy. It is applicable globally, does not allow fossil fuels, and requires offsets for operational and embodied emissions in line with international guidance.

Global/international net-zero certifications

The net-zero ratings schemes shown here are either applicable nationally or to a limited number of international locations.

Figure 9: A comparison of international/national net-zero emissions certifications



Zero Carbon Building – Design Standard

The Zero Carbon Building – Design Standard certification in Canada includes operational emissions with a target 25% reduction in site energy use intensity compared to building regulations, prior to renewable energy. The thermal energy demand intensity is 30-40kWh/m²/yr as a function of climate zone.

NABERS

NABERS (National Australian Built Environment Rating System) assesses building efficiency in operation across energy, water, waste and indoor environment. The measured operational performance translates directly to the star rating given, providing full transparency on real performance.

There is a detailed methodology for estimating the performance of new buildings in the design stage.

NABERS is well established in Australia and in the UK, since its launch in 2020, it is becoming increasingly popular in the office sector.

See more information about the NABERS initiative in section 06.

CASBEE

The Comprehensive Assessment System for Built Environment Efficiency certification is most popular in its country of origin, Japan, but is applicable internationally. It measures diverse quality criteria against the environmental load defined as CO_2 emissions per capita per year. The resulting qualification supports the development of effective sustainability measures. CASBEE provides a tool to complete the required life-cycle assessment of the carbon dioxide emitted during the construction, operation and demolition of a building.

The results are compared to a reference building that satisfies the standard according to the Energy Conservation Law, with a final star rating awarded.[31]

Climate Active Carbon Neutral

In Australia, the Climate Active Carbon Neutral Certification standard gives flexibility to pursue either NABERS or Green Star but brings an additional cost. It is a nationally recognized hallmark for a net-zero emissions building. Carbon offset requirements are in line with international guidance but this entails higher costs due to the inclusion of scope 3 emissions. It allows both on-site and off-site renewables. It could potentially be expensive for the first few years as cost is based on carbon produced.[32]

Assessment Standard for Green Buildings

This is the nationally recognized standard for a green building in China. The scope includes operational and embodied emissions but there is no target; buildings that meet the standard requirements cannot claim to be zero-carbon buildings. The credits related to operational and embodied carbon are not mandatory. As long as the total score is higher than 85 points, owner/designer/engineers can select the most suitable credits for the project.[33]

03. Assessing net-zero emissions
Global/international net-zero certifications

The Science-Based Targets initiative (SBTi) validates corporate carbon reduction targets to ensure they are in line with a specified decarbonization trajectory (typically 1.5°C).

Corporations are required to achieve defined reduction trajectories for Scope 1 and 2 emissions. For Scope 3 trajectory alignment is not mandated, but emissions have to be evaluated and reduction targets set. The CRREM (Carbon Risk Real Estate Monitor) tool assesses the carbon intensity of an individual asset against the projected property market decarbonization trajectory (1.5°C aligned) and identifies the year in which the asset's operational carbon intensity moves above the market average. This is used increasingly by investment companies as a means of evaluating operational carbon performance across a portfolio.

SBTi and CRREM have recently released a joint set of new decarbonization trajectories, across a variety of asset classes and markets, which are anticipated to improve the accuracy of assessments going forwards. This is an important step towards aligning metrics used in carbon assessments and metrics used to financially assess individual assets and portfolios. However, there is still some work to do, particularly at the individual building net-zero certification level.

At the individual building level, LEED Zero Carbon, Zero Code, EDGE Zero Carbon and ILFI Zero Carbon are the four net-zero schemes that are truly applicable to assets globally; Climate Positive has only had true traction in Germany and BREEAM does not currently include a net-zero objective; although this is incoming with an unknown timeframe.

The Zero Code standard does not have a target for a % reduction in operational carbon and additionally does not appear to be well recognised internationally. LEED Zero Carbon is a follow-on certification to the internationally recognised LEED, but it does not put any additional specific requirements on either operational or embodied carbon performance. Both are required to be assessed under LEED, but the performance aspect is a tradeable credit in both cases. LEED Zero Carbon simply requires a LEED design certification, purchase of green energy, and a commitment to offsetting of residual emissions.

The International Living Futures Institute's (ILFI) Zero Carbon certification is most aligned with CRREM and a decarbonization trajectory to net-zero out of all the certifications, since it includes both operational and embodied emissions targets. In emerging markets where supply chain restrictions put ILFI's targets out of reach, EDGE Zero Carbon is a suitable alternative, since it also includes operational and embodied emissions targets. EDGE was developed by the International Finance Corporation (IFC) and considers a smaller scope of sustainability measures and is less net-zero compliant than ILFI due to the allowance for fossil fuels. EDGE is also less flexible than ILFI as it has requirements for an initial 'EDGE standard' certification and for occupancy levels.

Delivering net-zero emissions

04.

04. Delivering net-zero emissions
Design and construction

This section provides an overview of some tools and techniques that contribute to the transition, in practice, to net-zero emissions buildings in operation. We will explore this in greater detail in the next publication in this series.

The first part of the demand-side transition is to deliver buildings at the end of construction that are capable of operating at net-zero carbon. Whether for the construction of new or the refurbishment of existing buildings, this is all about the design and construction process. Carbon emissions increase through the design and construction cycle, meaning that improving early-stage decision-making requires aggregated data derived from construction stage emissions.

1 **Brief**
The design brief, whether defined for a building, masterplan or portfolio, needs to clearly set out an objective of net-zero carbon emissions in operation, alongside a clear definition relevant to the particular circumstances (including local availability of renewable energy sources) and expressed in performance (not compliance) terms. In addition, companies need to establish key input targets consistent with that objective, including power demand, building fabric performance, internal environmental conditions and key system efficiencies. It is important that energy/carbon objectives align well with other aspects of performance, including the well-being and productivity of occupants.

2 **Design process**
In many jurisdictions, the design process focuses largely on code compliance outcomes. Moving the focus onto real-world energy performance requires a mind-set change on the part of design teams. Control algorithms and system/component-level part load efficiencies are examples of issues that design codes often neglect but are influential in terms of the actual outcome.

3 **Digital strategy**
Digital tools are a powerful weapon in the battle to achieve net-zero emissions. Effective user interfaces and access to analytics can be transformational in the ability of building users and operators to manage energy. In addition, the application of artificial intelligence (AI) to real-time building control and optimization increasingly has the potential to yield transformational results in the right circumstances.

These tools and approaches are considerably more effective when embedded throughout the design process, rather than added at the end as an afterthought. On the supply-side, digital tools may be crucial to unlocking the grid flexibility needed to balance intermittent renewable generation.

4 **Construction and commissioning**
The process of testing and commissioning buildings is gradually transitioning from a focus on capacity and comfort to testing energy efficiency at a component and system level. Along with this change comes the recognition that it is not possible to demonstrate energy efficiency fully prior to occupation. Therefore, the commissioning process needs to extend through completion, leading into a building-tuning process that will often last two or three years into operation before achieving optimum performance. This in turn requires a different approach to the procurement of design and construction services, recognizing the on-going engagement and including commercial success key performance indicators (KPIs) linked to performance metrics.

5 **Handover and fit-out**
The change described above, where designers and contractors remain engaged in a building well into operation, clearly implies a change in the way buildings are handed over to operation, with the asset and facilities managers taking overall control. The extended overlap with designers and contractors provides an opportunity for a much more gradual handover, which in turn allows for greater skills transfer to the operational team. Equally, liaison between base-build and fit-out designers and contractors is essential to ensure that the golden thread of design intent remains intact.

The ultimate goal is for the building handover to only be complete once it has fully demonstrated its operational performance, such that the operator's responsibility is then to maintain and, where possible, enhance that performance over time.

04. Delivering net-zero emissions
Handover and operation

The second part of the demand-side transition is about taking a building that is capable of operating at net-zero emissions and turning it into a building that is actually operating at net-zero emissions. This is all about the way in which companies manage and operate these buildings. Arguably, this is the biggest challenge.

1

Facility manager procurement
Facility managers are the day-to-day custodians of how a building performs, including energy and carbon efficiency. If the companies employing them do not empower and support them in running the building efficiently, it simply won't happen.

The norm in many countries is to procure facility management in a way that does not align with the objective of energy efficiency and carbon reductions. The conventional approach is instead based on a schedule of "planned preventative" checks with little to no attention to operational performance unless there is complete failure. Ironically, many buildings have extensive operational performance data available from meters and building management systems that managers could draw from to make facility management more energy and cost efficient.

To achieve net-zero emissions in operation it is essential to procure facility management with contracts that explicitly require and support the managers to proactively monitor operational performance and contribute to achieving and sustaining low-carbon operation.

2

Leasing
Where present, tenants usually have the potential to profoundly affect the energy and carbon performance of buildings. This is not just in terms of their immediate electricity consumption from lights and appliances but also the influence they can have on central equipment: boilers, chillers, fans and pumps.

Tenants frequently, though to varying degrees, have some responsibilities over the fit-out, maintenance and operation of equipment that provides final delivery of heating, cooling and ventilation to a space. If undertaken incorrectly, it can profoundly increase the overall energy use of a building (frequently inadvertently causing decreased comfort too).

Therefore, to achieve net-zero emissions it is essential to give clear guidance and requirements to tenants and robustly monitor and enforce them.

3

Building tuning
Whether brand new or existing, buildings will invariably benefit significantly from reviewing and tuning their operation.

There will invariably be areas where actual operation shows opportunities to adjust control to improve performance and perhaps identify some oversights in the commissioning of a building. This is quite common under the pressure of completing a building on time.

With an existing building, the actual use of a building can diverge from the initial intent over a period of operation. Taking this together with facility management procurement that typically does not align with proactively monitoring and improving performance, means inefficiencies can creep in. Therefore, it is frequently necessary to make significant improvements through tuning.

4

Energy management – monitoring and targeting
Energy management is also critical to achieving net-zero operational carbon buildings. In addition to monitoring headline annual energy and carbon performance against targets, energy management also contributes to the proactive monitoring and management of the detail of where energy is being used and if there are opportunities to improve efficiency:

→ What is energy being used for?
Heating, cooling, ventilation, lighting, etc.

→ Where is it used?
Such as comparing floors

→ When is it used?
Day vs night, weekday vs weekend, etc.

→ How does energy use respond to demand?
Such as the weather or levels of occupation

All such insights will be valuable to achieving and sustaining low-energy and low-carbon performance. However, it is not trivial to ensure that energy management is robust. To start with, there must be confidence that meters are in the right place and are accurate and the approach and responsibilities for energy management must be clear.

As the world transitions to more renewable sources of energy, which by their nature are more intermittent, when occupants use energy will become nearly as important as how much they use, and energy demand management will need to come to the fore as a means to achieve decarbonization.

04. Delivering net-zero emissions
Net-zero carbon renewable energy procurement

Throughout this document, we make reference to the importance of reducing the overall energy demand of a building in parallel with on-site renewable power generation. The final step is to procure 100% renewable energy to power the building. In rare cases this may come solely from on-site generation. However, for the vast majority of buildings, it is necessary to rely on the local energy market. No markets have yet made the transition to fully renewable energy supply. Therefore, it is necessary to procure the remaining off-site energy demand from a renewable source.

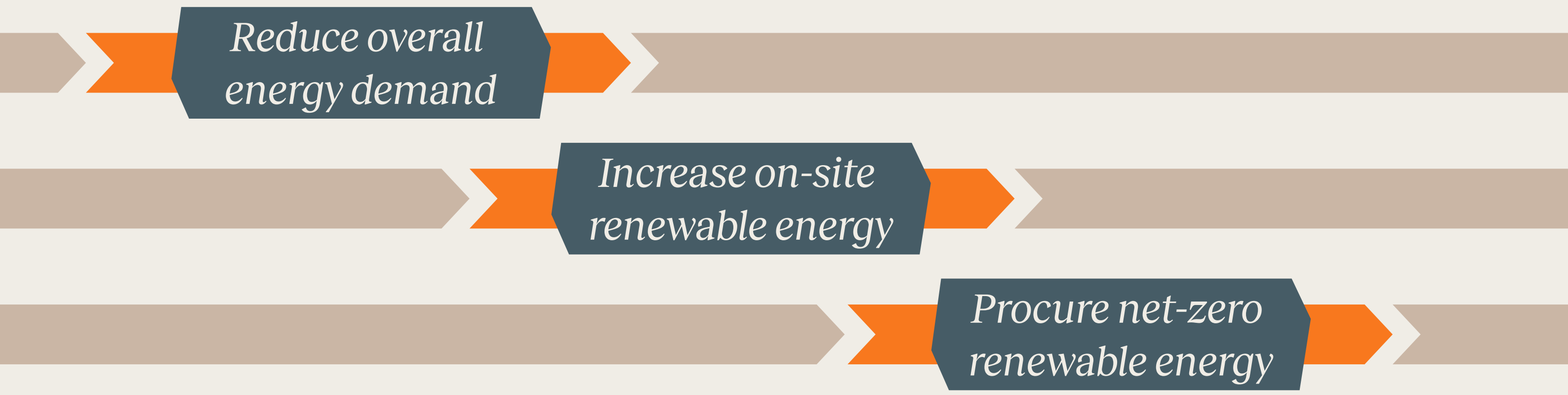
In most energy markets around the world, generation is from a mixture of renewable and fossil fuel sources. To be considered net-zero emissions, all the energy supplied to a building must be from a renewable source. Simply allocating a disproportionate amount of the existing local renewable generation using a certificate-based green energy tariff is not sufficient for net-zero emissions status. The requirement is for additionality, meaning that the sourcing of renewable energy leads to a net increase in the capacity of renewable generation in the local grid beyond that required by local/national regulations.

For a project to successfully achieve net-zero carbon in operation, it must publicly demonstrate: that all consumed energy comes from a renewable source, clear evidence of the exclusive ownership of the energy consumed, and that the investment provides credible additionality, meaning it adds to the total renewable generation capacity for that local grid.

Companies should take care when procuring renewable energy to ensure that the energy purchased is renewable, with the certificate or evidence of the renewable source included to show that someone else cannot use those units. This is important because in some global markets, it is possible to trade the energy source and the evidence of its energy credentials and ownership independently from one another. Note that publicly funded renewable projects are not generally considered additional, as these projects are delivered in response to policy rather than market demand. Companies will need to carry out appropriate due diligence, including reviewing the guidance from national energy regulators and independent bodies, as the transparency of supply schemes and tariffs varies widely. Examples of renewable energy procurement that satisfy the above criteria in line with net-zero carbon in operation would include:

- → Long-term power purchase agreements (PPA), which provide exclusive new renewable power generation without the need for subsidies and require independent verification.
- → Green tariffs from a supplier with 100% renewable-sourced tariffs only. This is often referred to as "High Quality Green Tariffs" and requires independent verification.

To claim net-zero carbon in operation, it is best practice to make the information associated with the renewable energy procured public for full transparency. This is important in demonstrating the project has satisfied the listed criteria and acts as a market leader to drive change in the industry. Companies should include this in any net-zero carbon accounting process.



04. Delivering net-zero emissions
Carbon offsetting

The need for and use of carbon offsets for net-zero buildings strategies is still often debated and inconclusive. This raises the question of if, how much and when companies should use offsets to make such a claim. But are offsets the right approach for net-zero buildings claims? And do they contribute to achieve the decarbonization of the built environment holistically? The information below provides an overview of current practice and an opportunity to raise some discussion points we would like to address in our future work.

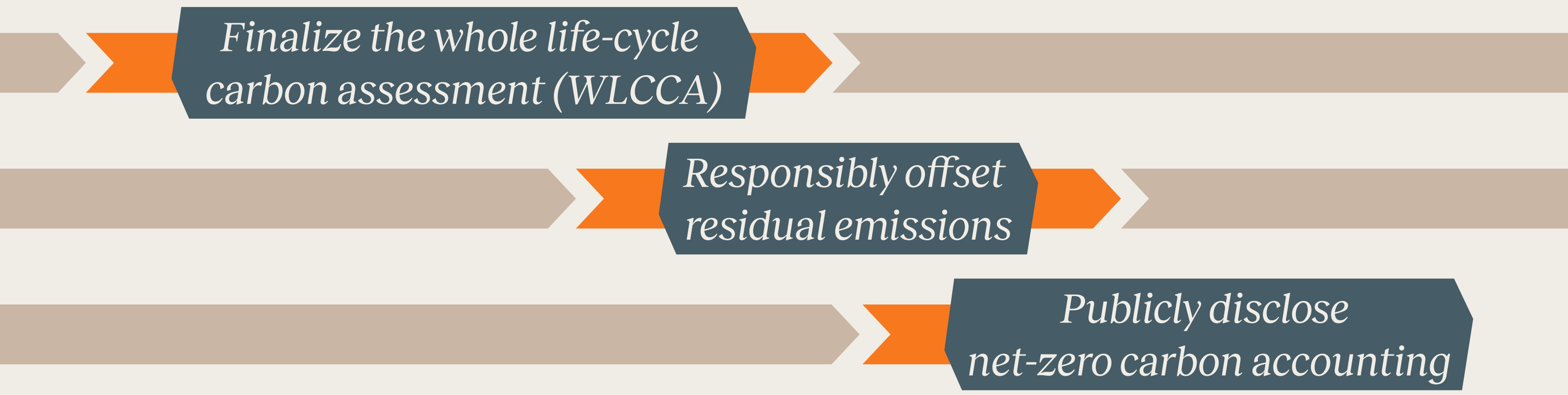
The role of offsets in the property sector
Understanding of carbon offsetting constantly evolves and is seen as a possible component in organization's journey to net-zero. The WorldGBC's Net Zero Carbon Buildings Commitment summarizes the role of offsets as follows: "As we transition, we also recognize the value of offsets as a means to compensate for and neutralize the impacts of the sector, and to facilitate positive social and environmental impact in pursuit of overall net-zero emissions."[34] Though there still is a way to go in terms of rigour and transparency in the carbon offset market, for the built environment there could also be an opportunity to develop sector-specific reduction and removal schemes, tackling the harder to reach parts of our sector, and driving much needed large-scale value chain collaboration, investment and innovation.

Offsets and net-zero operational carbon buildings
In a mature market with good availability of renewable energy onsite and the presence of PPAs and tariffs, net-zero operational carbon should be achievable without any carbon offsets. However, this is not always the case. For example, in emerging markets in particular, companies still use some short-term carbon offsetting either because of a lack of sufficient renewable energy or because of a lack of electricity grid capacity or stability leading to the need for on-site fossil fuel use. Whether considering a building, portfolio or market, carbon emission mitigation should always be the priority. As measures to decarbonize operational emissions are relatively easier to implement, the objective should always be to transition away from carbon offsets to achieve operational net-zero emissions. This is different from the broader whole-life carbon situation. Significant carbon mitigation options in construction already exist. However, the remaining emissions are still substantial. Carbon offsets are then currently required to claim net-zero carbon emissions throughout the entire life cycle of buildings.

The ISO Net Zero Guidelines (IWA42:2022)[35] state that offsets should only be used when no other emissions reduction alternatives remain, and that only offsets that counterbalance residual emissions should count towards an organization's net-zero target. The organization should not use offsets towards the achievement of interim targets.

Where carbon offsets are necessary, they should cover only the annual residual operational carbon emissions. These are the balance of annual energy demand not included in renewable energy procurement and will include, for example, diesel use in standby generators and refrigerant leakage, in addition to general operational energy consumption.

Carbon offset credits are certifiable and transferable units of emissions that an entity can purchase to balance emission outputs through investment in projects that reduce or, preferably, remove emissions elsewhere. A carbon credit is equal to 1,000kg of CO_2e. The terms carbon offset and carbon credit are used interchangeably, though they can mean slightly different things. Carbon offsetting is a complex area, with various solutions and approaches, from nature-based solutions to removal offsets – technologies that physically remove carbon from the atmosphere. Guidance from the WorldGBC[36] and more recently from the UKGBC[37] provide an overview of current practices and recommendations for the sector.



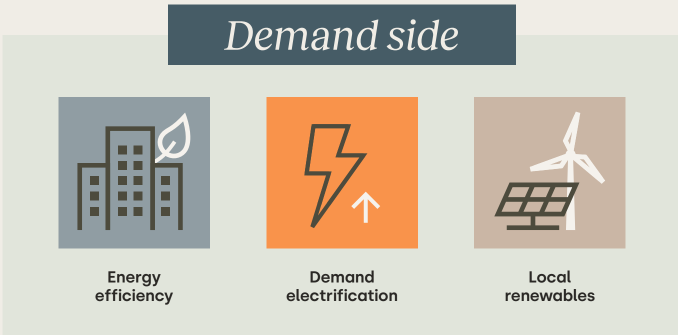
Regional progress overview

05.

05. Regional progress overview
Transition to net-zero carbon in operation – supply and demand

This section provides a high-level, impartial overview of the state of the transition of buildings to net-zero carbon from both the demand and supply side, with some examples of best practice highlighted in key geographies for WBCSD members.

There are two parts to the transformation of buildings that need to happen in parallel to achieve net-zero carbon in operation. The first is the demand side (on-site) – the buildings themselves need to transition to zero direct fossil fuel use. Then the demand for energy needs to reduce sufficiently to ensure the available renewable generation (on- or off-site) can meet this demand.



1

Energy efficiency
An energy-efficient building is one that uses as little energy as possible to deliver the required functional operation, through a combination of good design and attentive operational management. The behavior of users is an important aspect of energy efficiency but it is not well understood.

Improvements in building energy efficiency have been slow in many countries, with relatively low energy prices (despite the global energy crisis pushing up prices recently) and a lack of performance transparency conspiring to produce weak demand.

Australia is a notable exception to this, where the NABERS energy rating scheme has delivered a reduction in energy intensity by around 50% in the commercial property market over a 20-year period.

Building energy efficiency is becoming more important with increasing electricity demand, particularly due to air conditioning deployment as temperatures rise around the world.

2

Zero fossil fuels
The next step in a demand-side transformation to net-zero emissions is a transition away from any on-site fossil fuels to either electricity or other renewable energy sources, which opens the door to complete supply-side transformation.

Electrification is the most broadly applicable route to zero fossil fuels but other renewable energy sources are available. Some, such as geothermal energy in Iceland, are applicable across particular geographies; others, such as the distribution of waste heat from industrial processes, are more localized.

The transition to zero fossil fuels is under way in many developed economies through a combination of market forces and policy interventions. All-electric has been the default solution in some countries for many years, whether for climate, resource availability or political reasons. There are opportunities for knowledge transfer between these more mature markets and those in the earlier stages of transition.

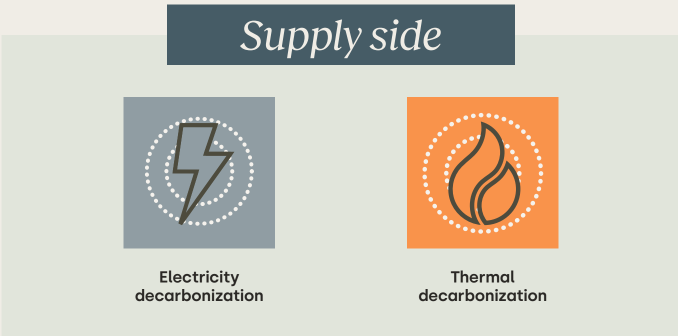
3

On-site renewable energies
Building-scale renewable energy is generally a demand-side measure if owned by the building and not subject to market incentives, although it generally falls lower in the hierarchy than energy efficiency/demand reduction. Physical constraints mean that on-site generation in urban areas rarely exceeds 5% of overall building demand. Initial take-up was dependent on subsidies but the need for this has reduced as prices have fallen. While many new buildings in developed countries include some renewable generation, across the whole building stock there remains a significant opportunity to increase deployment.

05. Regional progress overview
Transition to net-zero carbon in operation – supply and demand

The second part of the transition is the supply side – the energy infrastructure needs to transition to zero fossil fuel generation. Critical to the overall transition for an economy is the balance between supply and demand.

On the supply side, this equates to a rapid expansion in renewable capacity, allowing for the phasing out of fossil fuel generation while continuing to meet demand. Transmission networks need to transition alongside generation. Electricity is clearly a large part of the solution but the transition of gas networks – and district heating more locally – will also play a role.



1 International overview

With some notable exceptions, the energy infrastructure in most countries still relies primarily on fossil fuels. Long-term transition plans vary between countries and are the subject of national commitments to the United Nations climate change conferences.

National transition plans vary primarily on the basis of natural resources. Countries with a significant coastline are often able to draw on wind resources and those with high levels of annual sunshine can use solar generation. Iceland uses geothermal energy to generate the majority of its energy. Plans also take into account intermittent energy supply and issues of energy security.

2 Procuring renewable energy

In general, national policy is outside the control of most companies but the supply-side transition to net-zero emissions is a key part of a building- or portfolio-level decarbonization roadmap.

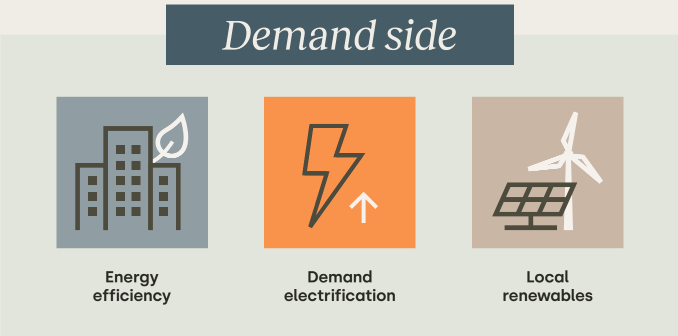
Buildings or portfolios will need to procure 100% renewable energy, whether via a suitable utility tariff, PPA or direct purchase of a generation asset that demonstrates additionality, for consideration as net-zero emissions. The availability and financial viability of these options varies country to country. In many countries, demand for renewable energy has been relatively low historically, leading to low premiums for renewable tariffs or PPAs.

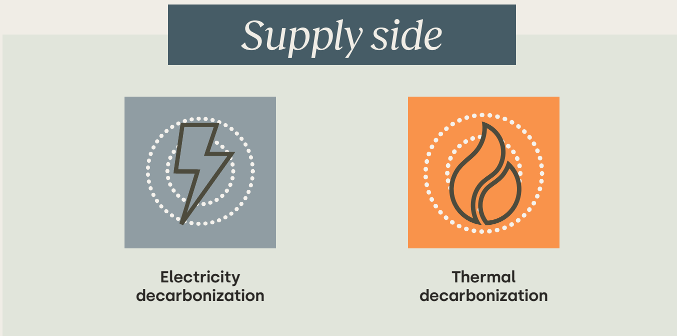
3 Renewable energy demand increase

There are some signs that the demand for renewable energy is rising. This in turn is pushing up prices. The price of carbon credits in the European Union Emissions Trading System (EU ETS), for example, has risen sharply recently, suggesting an excess of demand over supply. The general expectation is that as 2030 approaches – the date many leading companies have set to achieve net-zero emissions – demand for renewable energy and therefore the price of renewable energy will start to rise sharply.

In the long term this should be good news as it will improve the viability of new renewable energy generation and so will become a factor in accelerating its development alongside the trend in decreasing the costs. However, this requires long-term management to avoid the kind of steep renewable energy price rises that would put net-zero emissions out of reach for some organizations and locations. There is a critical role for government to maintain price stability and affordability and ensure the transition remains on track.

05. State of progress
Australia





1 **Energy efficiency** *Best practice*
The NABERS scheme for commercial buildings is successful and is expanding to many other typologies rapidly. It is a transparent and effective mechanism.

2 **Electrification of buildings**
A major transformation is occurring with large-scale electrification. Ambient temperatures are favorable for heat pump technology and companies are absorbing the additional costs. Existing building portfolios are planning to convert in the next decade.

3 **Electrification of residences** *Best practice*
It is already common to have electric heating and cooling, with split systems common practice, so residential property does not require large-scale change. It is common for all new residential buildings to be all electric.

1 **Electricity decarbonization**
The closure of coal-fired power stations will take place over the next decade or so and research shows it is increasingly commercially less viable compared to renewable energies. It is not policy-driven.

2 **Thermal decarbonization**
Renewable energy generation is lacking to date but the uptake of renewable energies is increasingly rapid, with plentiful and abundant potential for solar PV and wind onshore and offshore. Demand from PPAs is significant and state government policy is varied but increasing in ambition. Federal policy has been holding thermal decarbonization back for a number of years but the new government is more favorable.

3 **Hydrogen**
There is a significant focus on green hydrogen, recognizing the potential for excess renewable energy and the opportunity to convert to hydrogen for additional energy demand and export.

Figure 10: Average energy use reduction after multiple ratings
NABERS energy for offices (base and whole buildings)

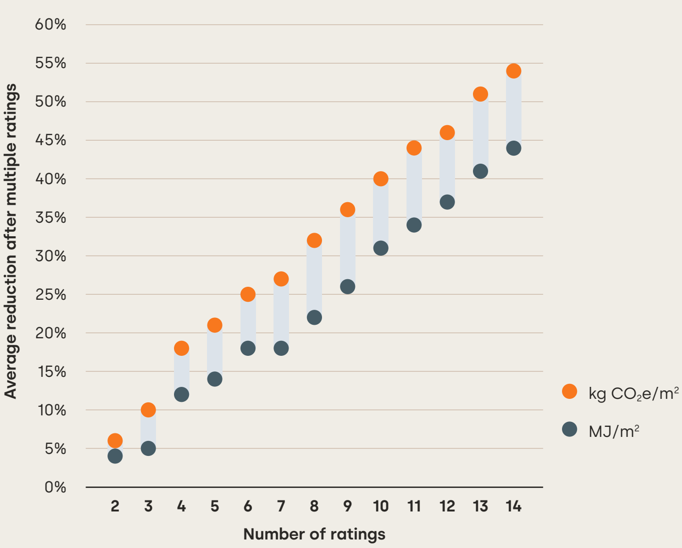
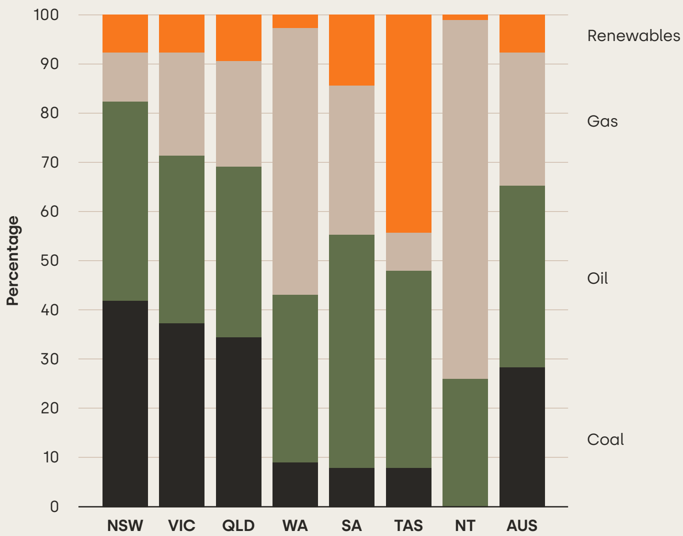
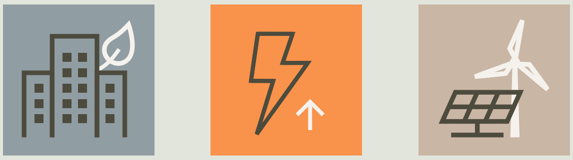


Figure 11: Australian energy mix by state and territory 2020-21[38]

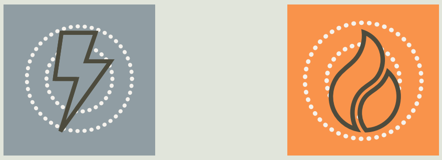


Demand side



Energy efficiency | Demand electrification | Local renewables

Supply side



Electricity decarbonization | Thermal decarbonization

1

On-site renewable energies *Best practice*

Companies should plan and design renewable energy systems (solar/wind/ground-source heat pump/ air-source heat pump) in buildings according to local resource conditions.[39] Since April 2022, new constructions generally must have solar energy systems that can operate year-round to support electricity supply, hot water and cooling/heating demand. Local standards state the on-site renewable energy installation requirement more specifically. For example, in Shanghai, new educational, municipal and industrial buildings should install solar PV for at least 50% of the rooftop area.[40]

2

Energy efficiency

China has formulated different standards and specifications for energy efficiency in residential, public and rural buildings, and energy-saving products, forming a relatively systematic energy-saving approach and standard system.

3

Electrification

As of 2021, building electrification levels had improved to 41.1%. China's 14th Five-Year Plan aims for the proportion of electricity consumption in building energy use to exceed 55% by 2025. The plan actively promotes clean electricity substitution: electricity instead of gas and oil; electrification in cooking, domestic hot water and heating; and high-efficiency building electricity equipment and products.[41]

1

Electricity decarbonization

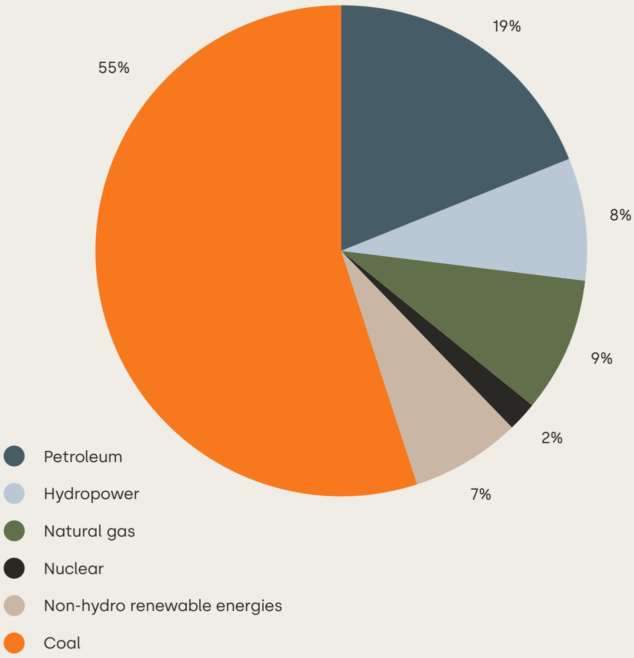
In 2021, the consumption of renewable energy power nationwide accounted for 29.4% of total electricity consumption. Hydroelectricity was responsible for more than half of total renewable energy supply.[42] Due to the abundance of coal resources, coal-fired electricity still plays a major role, accounting for more than 50% of the electricity supply. However, the government is promoting the transformation from coal-fired to biomass-based power plants or implementing advanced clean coal power technology that can help decarbonize and reduce pollutants.

2

Thermal decarbonization

In 2020, the clean energy thermal supply ratio reached 65% in the northern part of China. Natural gas supplies the majority of heat demand. In urban areas the focus is on the development of centralized heating; rural areas plan on the construction of small-scale coal-fired co-generation and biomass co-generation. Regions with suitable conditions actively promote the use of industrial waste heat for heating.[43]

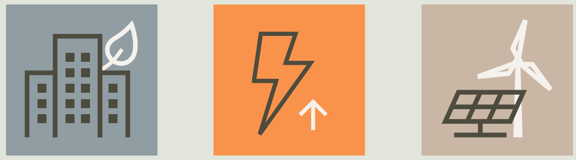
Figure 12: Total energy consumption in China by fuel type, 2021
Source: International Energy Agency (IEA)[44]



05. State of progress

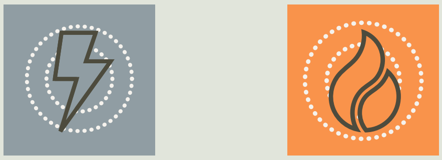
Hong Kong Special Administrative Region of the People's Republic of China (HKSAR)

Demand side



Energy efficiency | Demand electrification | Local renewables

Supply side



Electricity decarbonization | Thermal decarbonization

1 **On-site renewable energies** *Best practice*

In HKSAR, the power company has rolled out renewable energy feed-in tariffs that support on-site renewable installations and connection to the grid. Where on-site is not an option, there is a renewable energy credit (REC) scheme.[45]

2 **Energy efficiency**

In HKSAR, buildings account for about 90% of total electricity consumption. Thus the government's top priority is to improve building energy efficiency to save energy.

3 **Electrification**

The HKSAR government has set a target to reduce the fossil fuel consumption of commercial buildings from 70% to 40% by 2050, with the decarbonization chapter of the Climate Action Plan promoting energy performance regulation improvement and energy efficient infrastructure development.

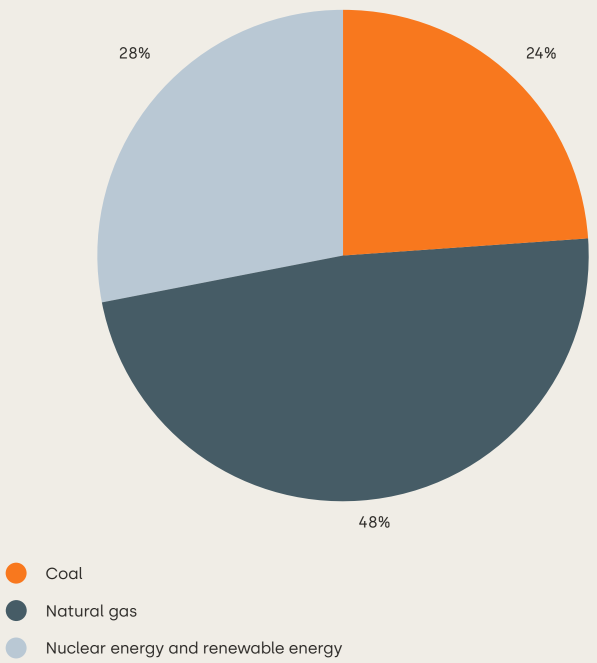
1 **Electricity & thermal decarbonization**

Fossil fuels, including natural gas and coal, account for over 70% of HKSAR's fuel mix for electricity generation. The government aims to increase the renewable energy proportion to 15% by 2050,[46] such as by partnering with water and power companies to explore offshore wind, hydrogen and floating PV.[47]

The power company has bid for the city's largest battery energy storage system, with a focus on renewable energy storage around the city.[48]

Figure 13: Fuel mix for electricity generation in 2020[49]

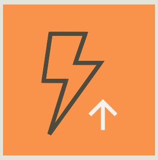
On sent-out basis



05. State of progress
European Union

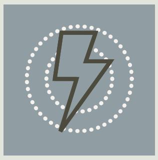
Demand side


Energy efficiency


Demand electrification


Local renewables

Supply side


Electricity decarbonization


Thermal decarbonization

1

On-site renewable energies
Research shows that European Union countries have the potential to generate 24% of their combined energy from rooftop PV.[50] Overall, the country profiles show that while some countries may be performing better on their rollout of residential rooftop solar PV, there are still significant barriers at the national level that impede greater uptake. Many EU Member States still lack the right regulatory framework and enabling environment.

The EU needs a much stronger commitment to solar PV. Barriers related to administrative processes and political and economic frameworks tend to block development. It is important to detect and overcome barriers at the national level and make sure the right incentives are in place to increase the uptake of rooftop solar PV.

2

Energy efficiency *Best practice*
The EU has developed a comprehensive regulatory framework based on energy-efficiency measures targeting buildings (EPBD, EED, Renovation Wave Strategy). The ZEB requirement should apply as of 1 January 2027 to all new buildings occupied or owned by public authorities and as of 1 January 2030 to all other new buildings.

3

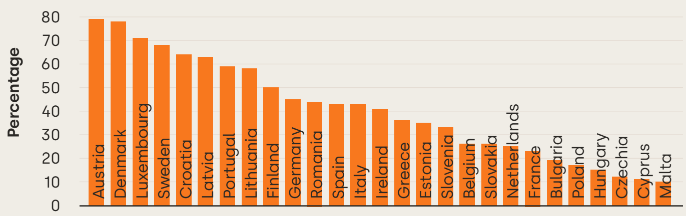
Demand electrification
European policy-makers have responded to diverse challenges, notably through the REPowerEU plan, and through a range of other measures to address energy prices and ensure security of supply. The EU generated a record 12% of its electricity from solar from May to August 2022 and 13% from wind. Early indications show that 2022 was a record year for the European solar photovoltaics market, with annual deployment growth of 17% to 26% in the largest EU country markets.[51]

1

Electricity decarbonization
Renewable electricity represented 38% of total electricity generated in 2021. This should grow to 69% in 2030.

This is an important moment in Europe's transition to clean energy after the signing of the European Green Deal, which lays out the path to climate neutrality and radically reducing greenhouse gas emissions by 2050. From the perspective of traditional energy suppliers – one of the world's largest consumers of fossil fuels – the green transition in Europe raises the risk of economic crisis and political instability.

Figure 14: Share of electricity generation that is renewable

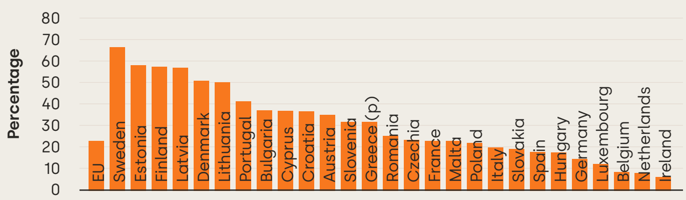


Source: Geopolitical Futures[52]

2

Thermal decarbonization
In 2020, 23% of the energy used for heating and cooling in the EU was renewable, compared to 12% in 2004. Among EU Member States, the share of energy from renewable sources in heating and cooling was more than half in Sweden (66.4%), Estonia (57.9%), Finland (57.6%) and Latvia (57.1%). But it was less than 10% in Ireland (6.3%), the Netherlands (8.1%) and Belgium (8.4%). In June 2023, the EU Commission released an online consultation as part of its plans to accelerate the roll-out of heat pumps across the EU.

Figure 15: Share of energy from renewable sources for heating and cooling



Source: Geopolitical Futures[53]

05. State of progress
Japan

Demand side

Energy efficiency

Demand electrification

Local renewables

Supply side

Electricity decarbonization

Thermal decarbonization

1 On-site renewable energies *Best practice*

Solar PV's greatest contribution is in the building sector. With the nationwide design initiatives that adopt the ZEB/zero energy housing (ZEH) concept, the integration of solar PV in buildings has advanced in the last 10 years due to attractive commercial incentives and has acted as a key zero-carbon contributor. The government's goal is to fit 60% of new residential buildings with solar PV. For instance, the Tokyo Government will introduce a legislative measure in 2025 to make rooftop solar a mandatory requirement for major house builders.[54]

2 Energy efficiency

Energy efficiency has improved by approximately 40% since the oil crisis in the 1970s due to government and private sector efforts, placing Japan as a leader in energy efficiency. For instance, the energy consumption per unit building footprint in the commercial sector has shown a steady declining trend. The stagnation of energy efficiency per GDP since the mid 1980s, however, casts a pall over this positive trend. Further nation-wide efforts are still necessary.[55]

3 Electrification

Markets have gradually recognized the electrification of building devices as a key step leading to a zero-carbon society by 2050, especially linked to government-led ZEB/ZEH initiatives. "Lock-in" issues in existing buildings have stalled the acceleration in the replacement of fossil-fueled devices such as gas-fired boilers with heat pumps. This is pertinent in private residential/housing markets due to the relatively long asset life cycle, the replacement cost and space availability issues.[56]

1 Electricity decarbonization

Japan has historically relied on nuclear and fossil fuel-based thermal power. The Japanese Government declared its commitment to carbon neutrality by 2050 in its "green growth" strategy. The new policy includes progressive initiatives to increase the ratio of renewable energy up to 38% by 2030 (current expectations are 34.6%) in total electricity production, compared to 20% as of 2021. Solar PV power generation has increased exponentially since 2012 and there are plans to increase wind to 5% of the total renewable energy proportion. The government has prioritized offshore wind due to the country's geography and climate. It has also decided to reduce the waiting period for the approval of renewable power projects to less than two years. The setting-up of renewable energy projects may also increase due to the establishment of a centrally operated grid.[57]

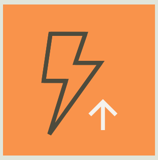
2 Thermal decarbonization

It is not easy to electrify the supply side to achieve an equivalent level of performance. Government initiatives have focused on fuel conversion, such as hydrogen, ammonia, "methanation" and "propanation". In low-temperature applications, the transition from conventional gas boilers to heat-pump based technology is underway. However, due to slow technical developments and the high cost in the face of market competitiveness, overall progress is still lacking.[58]

05. State of progress
United Kingdom

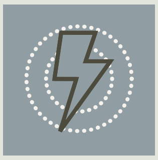
Demand side


Energy efficiency


Demand electrification


Local renewables

Supply side


Electricity decarbonization


Thermal decarbonization

1 On-site renewable energies
Installations of local renewables are increasing, with many new developments delivering renewable energy capacity as a contribution to achieving energy policy requirements. Installation cost reductions make renewable installations commercially attractive without the need for subsidies.

2 Energy efficiency
Companies have made limited progress in recent years on energy efficiency. Evidence suggests that existing policies are not effective in this area and commercial incentives are weak due to low energy prices (relative to other property costs). Changes in demand and increasing transparency in the commercial office market in particular are starting to drive change.

3 Electrification
Across UK markets there is a clear trend towards all electric buildings for new construction and major refurbishments, supported by both policy and market demand. Progress on the transition of existing building stock is more limited although some incentives are in place.

1 Electricity decarbonization *Best practice*
There has been substantial decarbonization of electricity generation through increases in renewable energy. Wind generation is now commercially competitive with fossil fuel generation.

2 Thermal decarbonization
Natural gas still provides the vast majority of heat demand throughout the country. Biogas injection has brought about limited decarbonization. The UK Government is developing plans for a transition to a hydrogen economy but there has been no meaningful progress to date and technical challenges remain.

Policy

UK Building Regulations tightened in 2022, with further tightening planned. For domestic property, this mandates a move to all electric. In the non-domestic market the government provides incentives to do so. However, research on compliance metrics used in the UK shows there is a relatively poor correlation with operational energy performance.

The government's long-term energy policy is driving the transition away from fossil fuels, with blue hydrogen (manufactured from natural gas with carbon capture) a proposed bridging technology to fully zero carbon. However, with a largely deregulated energy market in the country, there remains a considerable degree of uncertainty.

Market

The commercial market pressure driving the transition to net-zero emissions is increasing, with strong drivers from investors and tenants. Incentives are weaker in the domestic sector and so this largely falls back on policy. Approaches in the public sector are more variable, with the government's overall targets influencing departmental and local government policies and guidance in different ways.

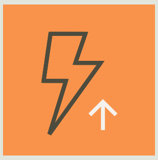
Market availability of 100% renewable tariffs is currently good, with a number of suppliers offering high-quality tariffs demonstrating additionality. However, there are indicators that regional demand for renewable energy is rising and the carbon price is starting to rise as a result.

> "The UK Government now has a solid net-zero strategy in place, but important policy gaps remain. Tangible progress is lagging the policy ambition."
>
> *UK Climate Change Committee,*
> *2022 Report to Parliament*

05. State of progress
United States of America

Demand side

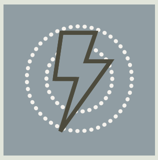
Energy efficiency



Demand electrification

Local renewables

Supply side



Electricity decarbonization

Thermal decarbonization

1 On-site renewable energies *Best practice*

Renewable energies are proving to be one of the most competitive energy sources in many areas. Its generation continues to accelerate, from 815 TWh in 2021 to 913 TWh in 2022, a 12% increase.[59]

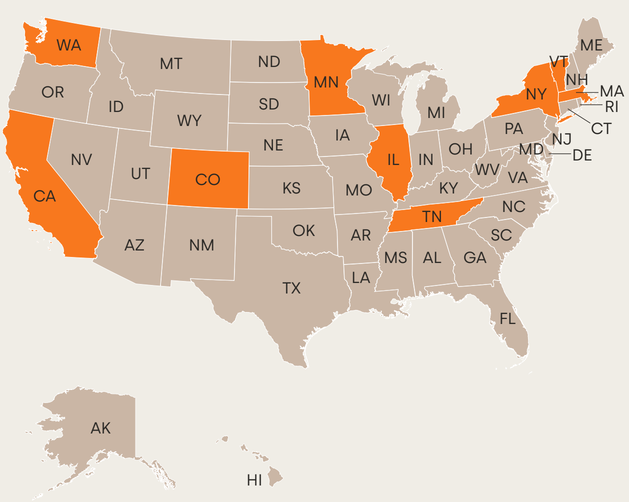
2 Energy efficiency

Innovative technologies are the primary driving force for energy efficiency in the market but policy also plays a role. In 2021, the U.S. Department of Energy awarded USD $82.6 million in funding to building energy efficiency projects.[60] Energy efficiency policy innovations that recognize system co-benefits such as cyber security, operability and social equity are becoming more common as well.

3 Electrification

Cities and states across the USA are getting behind the trend to electrify buildings. With no federal regulations for building decarbonization, cities are approaching the issue from different angles. There are city-wide requirements for electric infrastructure in new buildings, phasing out of gas hookups and goals to decarbonize existing buildings across cities in a decade.[61]

Figure 16: State legislation calling for beneficial electrification
Data from the American Council for Energy-Efficient Economy



1 Electricity decarbonization

Renewable energy accounts for 20% of total utility-scale electricity generation, with 9.2% from wind and 6.3% from hydropower. In 2022, 63% of planned new utility-scale electric generating capacity is to come from wind and solar.[62]

2 Thermal decarbonization

Natural gas satisfies about 50% of thermal, with about 40% provided by electricity.[63] Other sources for satisfying thermal demand include propane, fuel oil, wood and other hydrocarbons, which account for less than 10%. The Department of Energy has developed a strategic pathway to authorize USD $9.5 billion in investment for clean hydrogen for either hydrogen blending or fuel cell technology.[64]

Policy

While the US lacks federal regulations that impact the demand or supply side of net-zero emissions buildings, local jurisdictions have begun to set regulations and requirements. The federal government is incentivizing the transition: in August 2022, president Biden signed the Inflation Reduction Act (IRA), which provides policies and incentives to spur the American renewable energy sector, such as production tax credits for hydrogen and rebate programs for energy-efficient and electrified technologies.[65] The Infrastructure Investment and Jobs Act (IIJA) was signed into law in November 2021, authorizing USD $4.5 billion for energy-efficiency projects in homes, schools and communities.[66]

Market

Emerging renewable energy technologies are coming to the market quickly thanks to private investments, pilot projects and Federal research support. Technologies like green hydrogen, advanced batteries and other forms of long-duration storage complement existing variable renewables like wind and solar by boosting reliability, easing grid congestion and lessening renewable curtailment.

State of the art *Case studies sample of delivery and incentives*

06.

06. State of the art
Delivery

This chapter outlines examples of buildings that demonstrate best practice in various aspects of the transition to net-zero emissions in operation. Research indicates that there are not many examples around the world that demonstrate a full transition to net-zero emissions in operation.

Note that there are inconsistencies in the net-zero emissions transition statistics included in these examples given the difficulties associated with estimating operational performance data in the design stage, as well as challenges associated with measuring operational performance data once the building is occupied. See the glossary for building performance terms definitions.

State of the art case studies

06. State of the art
One Melbourne Quarter, Australia

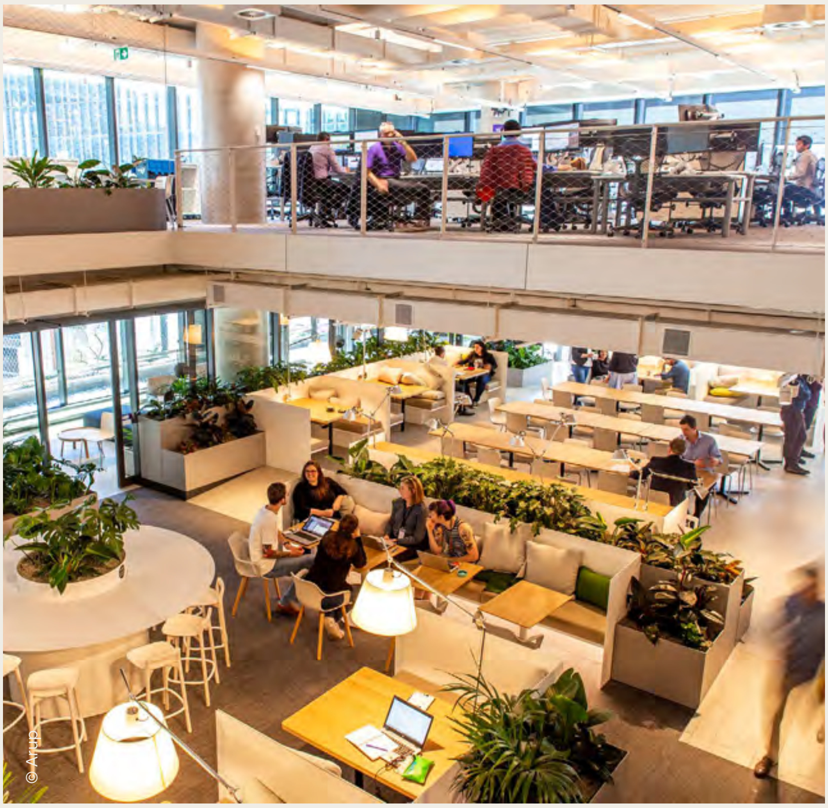
In 2018, Arup's Melbourne team moved to a new office, which set a benchmark for leading workplace design at One Melbourne Quarter. This award-winning design was based on the living.arup concept, which encapsulates Arup's goals for a new workplace that embodies the principles of sustainability, wellness, connectivity and flexibility.

HASSELL designed the space, with Arup providing engineering design across 12 disciplines and delivered in a new Lendlease development where the company was the anchor tenant. The 13-level building features a 6-star Green Star rating and a 6-star NABERS Energy rating. It features an airtight building envelope, a 201 kW PV solar array with white roof to reduce the urban heat island effect and a rainwater capture system.

The new three-level workplace received the WELL v2 Pilot Platinum Certification and achieved a 6-star Green Star Interiors rating, representing world-leading design.

The principles of WELL and wellness carry throughout the space, starting with a 1,000m² elevated garden. More than 600 plants provide biophilia and a fully programmable lighting system designed to mimic the body's natural circadian rhythm also assists in promoting mental and physical health.

Other features include an innovative eWater system that eliminates the need for toxic chemicals for cleaning while reducing plastic waste from cleaning products, the indoor air quality monitoring of air pollutants, and monitoring of the water system to comply with highest quality standards.[67]


© Arup

One Melbourne Quarter, Australia

Green Star Design and As-built v1.1 (2019)	*6**
NABERS energy rating (2022-2023)	*6**
Energy use intensity	*31 kWh/m²/year*
PV roof array	*201 kW*

Type	*Office base building*
Client	*Lendlease*
Design team	*DCM and Arup*
Status	*Operational*

Arup Office Tenancy, Melbourne

Green Star Design and As-built v1.1 (2019)	*6**
NABERS energy rating (2021-2022)	*5.5*/6* with Green Power*
Energy use intensity	*58 kWh/m²/year*
WELL v2 pilot (2019)	*Platinum*

Type	*Office fit-out*
Client	*Arup*
Design team	*HASSELL and Arup*
Status	*Operational*

NABERS Energy Rating Scheme, Australia, UK and New Zealand

The National Australian Built Environment Rating System (NABERS) demonstrates how multifaceted government and industry collaboration can drive genuine market transformation. NABERS provides a technically robust benchmark that translates into an easily understandable 6 star energy efficiency rating. Companies use the NABERS rating as a design target, a commissioning target and an ongoing operational measure of building performance.

NABERS Energy originated from the Australian Government's drive to better understand and measure the energy efficiency and greenhouse gas intensity of office buildings. Over the last 25 years, NABERS has evolved to provide greater visibility of environmental impacts including water, waste and indoor air quality and ratings for different building types. It also supplies ratings in the UK and New Zealand.

Public policy has helped drive industry participation; the Australian Commercial Building Disclosure (CBD) Program requires the provision of energy efficiency information – notably a NABERS Energy rating – when large commercial office space is offered for sale or lease.

Over the last 14 years, Australian offices rated using NABERS Energy have benefitted from average energy savings of 42% and have reduced greenhouse gas emissions intensity by 53%.

This is one of the fastest widescale building transformations recorded anywhere in the world. Those who use NABERS Energy ratings in Australia have saved an estimated AUD $1 billion in energy costs and driven down greenhouse gas emissions in the commercial building sector by more than 7 million tons since 1998.

NABERS has attracted the attention of other markets beyond the UK and New Zealand. Through close consultation with industry, NABERS has recently introduced a Renewable Energy Indicator for inclusion on NABERS Energy certificates underneath the main star rating result. It is also developing a method to compare the embodied emissions of new commercial buildings that could enable mandatory planning policy in the future.[68]

Figure 17: NABERS rating system

NABERS provides a rating system from 1 to 6 stars for energy efficiency

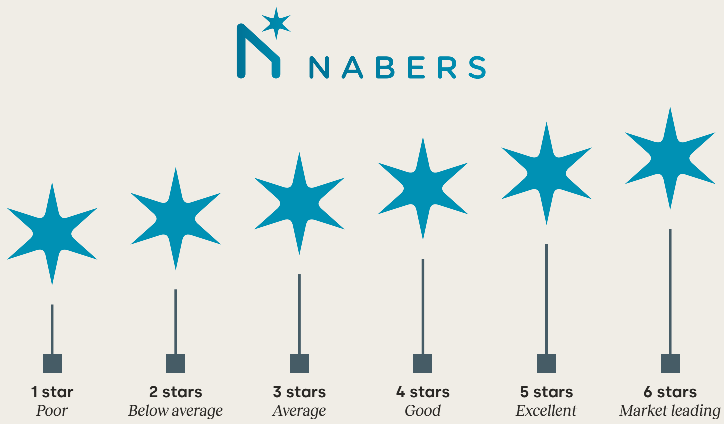
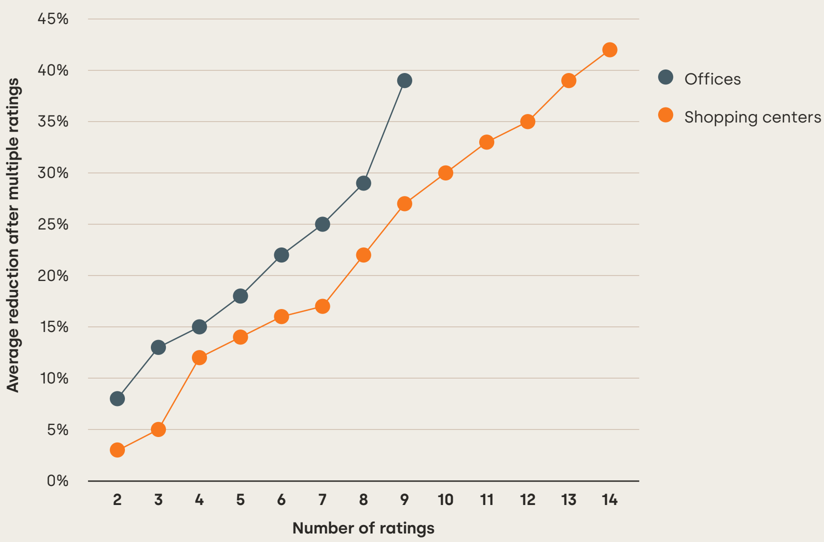


Figure 18: Average reduction in energy use after multiple NABERS ratings (%)[69]



06. State of the art
Parcela nº 28 del Parque Científico y Tecnológico de Gijón, Asturias

Initially, the design of this building aimed for energy autonomy and thus minimizing energy demand with passive systems. The design dispensed with possible energy storage batteries in line with the current trend of buildings with a neutral energy balance, finally resulting in a building that, due to its technical characteristics, offers a positive balance, generating more energy than it can consume.

The initial idea was to show the capacities of this building (which has a constructed area of 1,488m² divided into a ground floor, two upper floors and a roof) from the same access, which is achieved with the walkway that crosses the photovoltaic pergola and shows the main behavior of the building. Initially the project was conceived as a crack that emerged from the ground and developed along the south and north façades; while the west and east were vertical topography folds. This glass crack served to incorporate the technical systems into the façades.

Inside the building, an elevator in a concrete and glass box shows the machinery, including the energy recovery with batteries that charge with solar energy provided by the panels and the energy generated during the descent cycles. The elevator can carry out 100 ascent cycles disconnected from the electrical network.

This project is in a sustainable location and connected to the community, with efficient use of water, indoor air quality (control by plant with air quality probe) and high thermal comfort, use of regional materials, efficient facilities and an exhaustive start-up and monitoring plan for all the facilities.


© Tania Crespo

LEED certification	*Gold*
Net operational carbon emissions	*0 kgCO_2/m² year*
Net energy consumption	*1 kWhpe/m² year*
Energy consumption	*74 kWh/m² year*
Energy classification performance	*A*

Type	*Office building*
Client	*Green Space*
Design team	*Emase/Gesyges/Arup*
Status	*In operation*
Target performance	*1 kWh/m² NIA/yr net*

06. State of the art
Building 7 – ACCIONA Campus, Madrid, Spain

Fenwick Iribarren Architects, which won the architecture competition in 2019, carried out the comprehensive reform of ACCIONA Campus. The main idea was to develop and promote ACCIONA´s sustainable and healthy headquarters in a space that cares for biodiversity and has abundant green areas, inhabited by iconic, efficient and innovative buildings designed for people.

The ACCIONA Campus has a wide variety of services, from sports and leisure areas to office buildings and landscaped areas. In addition, its design encourages social interaction and new ways of working outdoors.

ACCIONA named Building 7 after Sustainable Development Goal 7, which supports the ambition to ensure access to affordable, safe, sustainable and modern energy for all. This building is in the final steps of certification for LEED New Construction v4.1 with a Platinum level and WELL v2 Platinum certification.

The previous building was demolished and the new one built from scratch, reusing more than 90% of the construction waste on-site. In terms of installations, Building 7 has a geothermal installation to service its air conditioning and a photovoltaic installation that produces 104 MWh of clean and renewable energy per year. After the complete removal of the previous gas installation, 100% renewable energy fulfills the remaining building demand.

Energy demand	*40.68 kWh/m²/year*
CO_2	*5.19 kg CO_2/m²/year*
LEED rating target	*New Construction v4.1 Platinum level*
Primary energy demand savings compared to NZEB* criteria for new construction (55% savings compared to EU Taxonomy criteria)	*60%*
PV production	*104,000 kWh/year*

Type	*Office building*
Client	*ACCIONA HQ*
Design team	*Fenwick Iribarren Architects*
Status	*Occupied Q2 2023*

*Nearly zero-energy building; see page 17 for the EPBD definition

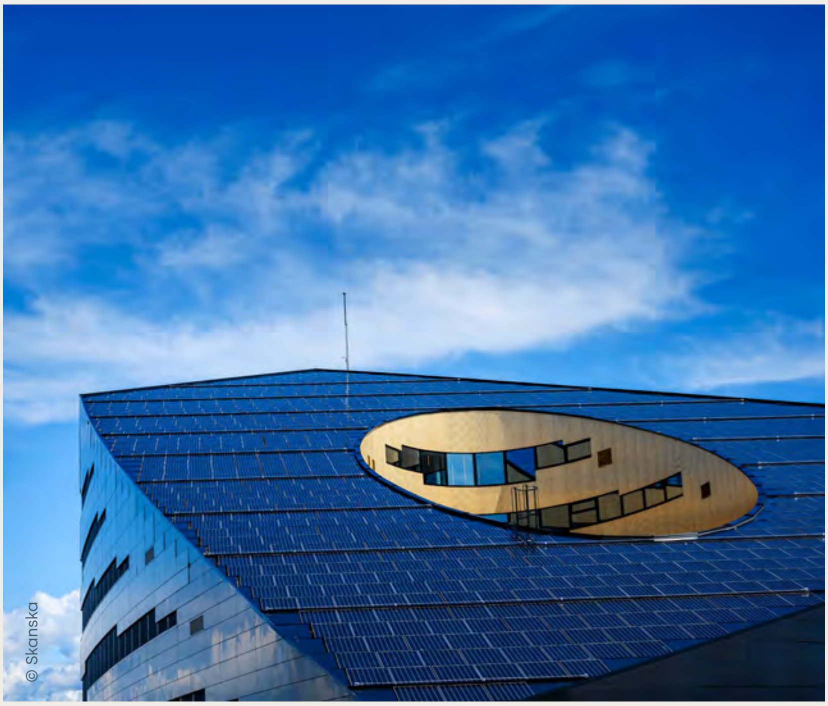
06. State of the art
Powerhouse Brattörkaja, Trondheim, Norway

The Powerhouse Brattørkaia office building is located by the harbor in Trondheim, Norway. The Norwegian Minister of Trade and Industry officially opened the project on 30 August 2019. It aims to be energy positive over the building's lifetime and has achieved the BREEAM Outstanding rating.

With a total area of 18,200m^2 spanning 8 floors, a mezzanine and underground parking, the building's design has environmental requirements as a central focus. The building is clad in black aluminum panels to match the integrated solar panels and at its center is a large oval void that contains a garden and allows daylight to flow into the office spaces. The interior's ground floor hosts a cafe and visitor center and the rest of the available floorspace is for offices.

The definition of a "Powerhouse" states that the building should be energy positive in operation, including tenant equipment. In addition, the building must have a reduced material carbon footprint in line with the Paris Agreement target of limiting global heating to 1.5°C.

The design phase was collaborative, with all parties involved from the start. It is a key premise for all Powerhouse projects to pay off for the developer, contractor and tenant. The building will generate profits from the energy generated in excess of building energy demand and from commerce.



BREEAM certification	*Outstanding*
Energy use heated area (measured)	*19.4 kWh/m²/yr*
Energy generation (PV)	*29.1 kWh/m²/yr*
Net positive energy	*9.7 kWh/m²/yr*
PV energy generated	*430 MWh*

Type	*Office*
Client	*Entra*
Design team	*Snøhetta/Skanska*
Status	*Completed*
Target performance	*Net energy positive over its lifetime*

06. State of the art
Hyllie Terrass, Malmö, Sweden

The Hyllie Terrace office building comprises 12 floors and will have an area of 14,000m² available for tenants. Construction work began in 2020 and tenants have been moving in since spring 2023. The building is part of the Sweden Green Building Council's pilot study on a net-zero CO_2 emissions certification for buildings.

With Hyllie Terrass, Skanska is taking another step towards reaching net-zero CO_2 emissions from its own operation and the entire value chain by 2045. The new certification aims to accelerate the transition to a climate-neutral construction industry. The certification requires the reporting of the building's life-cycle climate impact and ensuring that it balances with climate measures with a net-zero emissions climate impact. The life cycle includes everything from the manufacturing and transportation of building components to construction processes, the use of the building and final handling.

Other key features of the building and the site include green concrete, recycled construction steel, a fossil-free construction site and efficient energy consumption through cooperation with E.ON and the City of Malmö.

Skanska chose Hyllie Terrass's minimalistic façade because it leaves a small imprint. The fact that the house faces south is no coincidence: it affects how the light flows into the building and its energy consumption. The house's terraces collect water and benefit biodiversity. Skanska also asks suppliers and subcontractors to calculate and report their climate footprint.

WELL certification	*Pre-certified Gold*
LEED certification	*Platinum*
Swedish carbon certification	*ZeroCO_2*

Type	*Office*
Client	*Skanska*
Design team	*Skanska/COBE*
Status	*Completed 2023*
Target performance	*64 kWh/m² heated area/year*

06. State of the art
Tsukuba Research Institute New Research Building, Ibaraki, Japan

The New Research Building at Sumitomo Forestry's Tsukuba Research Institute is a pure mass timber structure built in 2019 for the study and proliferation of wood-related technologies.

The building's energy-efficient design featuring natural ventilation and lighting, combined with a HVAC system fueled by renewable wood pellets sourced from nearby forests, greatly reduces its overall energy demand by 40% compared to the Japanese national average.

The building also utilizes renewable solar power, with its rooftop solar panels generating a total of 51,728kW in 2022.

Additionally, the rooftop, balconies and exterior walls present researchers with great opportunities to plant experimental greenery. An employee survey suggests the new office, with its biophilic interior design, boosts intellectual productivity by 5.44% on average.

Building structure	*Mass timber*
Amount of wood carbon sequestration	*905 tCO_2*
Reduction in energy demand due to energy-efficient building design	*-40%*
Annual carbon saving from HVAC system fueled by renewable wood pellets	*73.3 tCO_2/year*
Annual electricity generation from rooftop solar panels	*51,728kW*
Productivity boost with biophilic design	*+5.44%*

Type	*Research building/office*
Client	*Sumitomo Forestry Co. Ltd.*
Design team	*le style h Atelier Asami Kazuhiro/ Sumitomo Forestry Co. Ltd.*
Status	*In operation*
Target performance	*Energy consumption supplied by renewable energy targeting net zero* *~73.3 tCO_2 saved annually*

06. State of the art
11 & 12 Wellington Place, Leeds, UK

11 & 12 Wellington Place is all-electric. It was the first building in the UK outside London and only the fourth in the UK to achieve a NABERS Design for Performance rating of 5 or above. This is a positive sign in terms of the perception of a NABERS rating as bringing added value in the UK commercial property market.*

Minimizing the building's reliance on fossil fuels and reducing energy demand was a key priority. An all-electric reversible air source heat pump system replaced gas fired boilers and air-cooled chillers to eliminate on-site fossil fuel use. Fabric upgrades, triple glazing, higher levels of air tightness, and lighting efficiency and control improvements also helped reduce energy demands.

The increase in roof-mounted solar PV aims to reduce net electricity demand from the grid. The remaining electricity comes via a renewable energy tariff, meeting the requirements of UKGBC's net-zero carbon emissions operational energy standard.

A dedicated, real-time energy management and metering system will provide live and continual feedback alongside the enhanced controls. The system will report into a smart building platform, accessible via a mobile app, that provides energy feedback among other features, giving tenants greater control of lighting and temperature.[70]

NABERS rating target	5*
Fitwell rating	2 star
Amount of carbon saved annually (forecast) compared to a business-as-usual Royal Institute of British Architects (RIBA) benchmark with gas heating	407 tonnes
BREEAM rating	Outstanding
EPC rating	A

Type	Speculative office development
Client	MEPC
Design team	Arup/TP Bennett/Wates
Status	Construction completed Q1 2023
Target performance	43 kWh/m² NIA/yr

06. State of the art
The Ridge, Cape Town, South Africa

The Ridge is a low-energy building designed to achieve a reduction of up to 82% in operational carbon emissions compared to local benchmarks. It is a new-build, four-story 8,500 m² office building located at the V&A Waterfront in Cape Town. The project design achieved 6 stars from Green Star and high ratings from the Green Building Council of South Africa – World Leadership in 2021.

A combination of mechanical air conditioning equipment such as heat pumps, passive cooling and natural ventilation provide heating and cooling to take advantage of the climate. It optimizes natural daylight penetration while minimizing heat load due to solar gains through the characteristic zigzag façade and reducing the amount of direct sunlight entering the building. This lowers energy consumption while prioritizing comfort. The Thermally Activated Building System (TABS) reduces internal temperature peaks, for example by circulating chilled water through pipes embedded into the concrete floor slabs, which is more energy efficient compared to an air duct system. Combining these different operational systems of natural ventilation, mixed mode and TABS into the energy model was a first in South Africa.

The mixed-mode design of The Ridge is reliant on how occupants operate the building to control their comfort and thereby reduce energy use. The building management system is designed to be intuitive for occupants and provides signals for suggested adjustments, such as green/red lights for optimum window position based on the external temperature and wind conditions.[71]

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Green Star design rating	*6**
Green Building Council South Africa Leadership Awards 2021	*Highest rated building*
Energy savings per annum compared to similar building in South Africa	*64% (2,430 tons CO_2)*
% of temperature control possible through natural ventilation per annum	*81%*
% of thermal comfort per annum with highest threshold	*90%*
Peak electrical consumption in the building delivered by solar photovoltaics	*30% (140kW)*

Type	*Office*
Client	*Victoria & Alfred Waterfront Holdings PTY Ltd*
Design team	*Arup and studioMAS*
Status	*In operation*

06. State of the art
Bullitt Center, Seattle, Washington, USA

The Bullitt Center in Seattle, Washington, is a net-zero emissions energy building and certified as a Living Building by the International Living Future Institute (ILFI).

The Bullitt Center uses all electric reversible heat pumps exchanging thermal energy between the building and 120 meters underground to radiantly heat the building in the winter and cool it in the summer, effectively using the ground as a thermal storage system. There is also a 1300m^2 array of photovoltaic solar panels on the roof, producing 230 MWh of electricity per year. The Bullitt Center sells excess electricity to the grid in the summer and purchases electricity during Seattle's cloud-covered seasons. It houses five electric heat pumps that work with geothermal heating (and cooling), meaning that the center uses only a small amount of energy compared to a natural gas system.[72]

The Bullitt Center is a model for holistic sustainability, not just energy efficiency. The carefully chosen building materials aimed to exclude over 360 toxic chemicals and used locally sourced Forest Stewardship Council certified timber for the structure, reducing the embodied carbon of the building materials. There is an on-site rainwater to potable water system that could provide enough potable water to offset the building's demand once the permitting of such a system is approved.

The site also has composting toilets that aerobically compost solid waste before transfer to a facility and turned into fertilizer.[73]


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Carbon certification	*International Living Futures Institute Zero*
Savings vs. 2009 Seattle Energy Code Design Building (baseline approx. 10–20% better than ASHRAE Standard 90.1-2007)	*79%*
Annual solar PV output	*230 MWh*

Type	*Office/commercial*
Client	*Miller Hull Partnership*
Design team	*DCI Engineers/PAE (and more)*
Status	*Opened in 2013*
Target performance	*EUI = 11 kBtu/ft^2* [72]

Measuring building performance definitions
Glossary

Energy – electricity and gas
Meters are the main way of measuring energy in the form of electricity and gas. Its units are kWh (kilo-Watt-hour) or kBtu (kilo-British thermal unit).

Energy use intensity (EUI)
Energy per square foot or meter per year. It is calculated by dividing the total energy consumed by the building in one year (measured in kBtu or GJ) by the total gross floor area of the building (measured in square feet or square meters).

Gross internal area (GIA)
The usable area in a building measured to the face of the internal finish of perimeter or party walls, ignoring skirting boards and taking each floor into account. See **Guidance: Code of measuring practice: definitions for rating purposes** from the UK Government. Also see the RICS **Code of Measuring Practice**, 6th edition, May 2015.

Net internal area (NIA)
This is the proportion of the gross internal area that is allocated to tenants.

Net-positive energy
Means that more energy is generated than is consumed, when measured on an annual basis.

Primary energy consumption
The EU defines this in the context of the ZEB (see page 17) standard as the measure of total domestic energy demand (electricity, fossil fuels), while final energy consumption refers to what end-users actually consume. The difference relates mainly to what the energy sector needs itself and to transformation and distribution losses. See the 2021 Eurostat article on **Primary and final energy consumption slowly decreasing**.

Endnotes

1 Copernicus 2023 on track to be the hottest year ever. What's next? Retrieved from: https://climate.copernicus.eu/2023-track-be-hottest-year-ever-whats-next

2 Energy & Climate Intelligence Unit and Oxford net-zero (2022). TAKING STOCK: A global assessment of net-zero targets. Retrieved from: https://ca1-eci.edcdn.com/reports/ECIU-Oxford_Taking_Stock.pdf

3 Partnership for Carbon Accounting Financials (PCAF) 2022. PCAF Guidance on financing the European building transition to net-zero. Retrieved from: https://carbonaccountingfinancials.com/en/newsitem/pcaf-launches-guidance-on-financing-the-european-building-transition-to-net-zero

4 New York City Sustainable Buildings – Local Law 97. Retrieved from: https://www.nyc.gov/site/sustainablebuildings/ll97/local-law-97.page

5 Energy efficiency in commercial buildings – How the National Australian Built Environment Rating System transformed the market. Retrieved from: https://www.nabers.gov.au/sites/default/files/energy_efficiency_in_commercial_buildings_full_length_guide.pdf

6 The carbon footprint is determined by the carbon dioxide equivalent (CO_2e), i.e., the equivalent number of metric tons of CO_2 emissions with the same global warming potential as one metric ton of another greenhouse gas (GHG).

7 UN EP 2022 Global Status Report for Buildings and Construction. Retrieved from: https://globalabc.org/sites/default/files/inline-files/2022%20Global%20Status%20Report%20for%20Buildings%20and%20Construction_3.pdf

8 UNFCCC. Marrakech Partnership for Global Climate Action. Retrieved from: https://unfccc.int/climate-action/marrakech-partnership-for-global-climate-action

9 UN Climate Champions – 2030 Breakthrough Goals (Human Settlements – Built Environment). Retrieved from: https://climatechampions.unfccc.int/system/breakthroughs/

10 UN Environment Programme – 2022 Global Status Report for Buildings and Construction. Retrieved from: https://www.unep.org/resources/publication/2022-global-status-report-buildings-and-construction

11 Intergovernmental Panel on Climate Change (IPCC) SPECIAL REPORT: GLOBAL WARMING OF 1.5 °C (Glossary). Retrieved from: https://www.ipcc.ch/sr15/

12 A market-based carbon footprint is calculated based on the type of electricity procured, so 100% renewable electricity would have a carbon footprint of zero. This is in contrast to location-based reporting, which uses the average grid electricity carbon factor for the locality.

13 The Global Real Estate Sustainability Benchmark (GRESB) assesses and benchmarks the environmental, social and governance (ESG) performance of real assets, providing standardized and validated data to capital markets. Retrieved from: https://www.gresb.com/nl-en/

14 Arup, 2019, "Five minute guide to Net-zero energy in buildings". Retrieved from: https://www.arup.com/perspectives/publications/promotional-materials/section/five-minute-guide-to-Net-zero-energy-in-buildings

15 **Canada 2020 National Proposed model Codes**
There is no specific carbon or energy reduction target; buildings should just be designed to be as energy efficient as possible.

Source: Codes4Climate (2021) Net-zero energy ready buildings in Canada. Retrieved from: https://codes4climate.efficiencycanada.org/Net-zero-energy-ready-buildings-in-canada/

16 **EU Fit for 55**
The European Commission has proposed for the buildings sector to become part of the EU Emissions Trading Scheme from 2026 onwards as part of its Fit for 55 package. This will set maximum emissions allowed, with stricter operational emissions reductions, equating to a 43% reduction in building emissions compared to 2005 levels. This will include updates to the Energy Efficiency Directive (EED) and Energy Building Performance of Buildings Directive (EPBD). The EED has set an increased target of an overall 9% reduction by 2030 compared to a 2020 baseline scenario. Member states will have to contribute via indicative national contributions. The EPBD amendment will have implications on setting minimum performance requirements for new buildings to achieve the EU definition of a zero-emissions building from 2027, factoring in their life-cycle global warming potential. Additionally, the harmonization of Energy Performance Certificates (EPC) and Building Renovation Passports for existing buildings will be introduced.

→ E3G (2021) Buildings Fit for 55 and beyond. Retrieved from: https://www.e3g.org/publications/buildings-fit-for-55-and-beyond/

→ Linklaters (2021) EU "Fit for 55": Energy Efficiency First. Retrieved from: https://sustainablefutures.linklaters.com/post/102h7a3/eu-fit-for-55-energy-efficiency-first

Endnotes

- → European Parliament (2022) Revision of the Energy Performance of Buildings Directive: Fit for 55 package. Retrieved from: https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)698901
- → EU Nearly zero-energy buildings definition: Retrieved from: https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/nearly-zero-energy-buildings_en

17 **C40 Cities (2015). Hong Kong Ordinance Drives Energy Efficiency through Strict Codes of Practice and Audits. Retrieved from:** https://www.c40.org/case-studies/hong-kong-ordinance-drives-energy-efficiency-through-strict-codes-of-practice-and-audits/

18 **Ministry of Economy, Trade and Industry (2016). METI Illustrates the Contents of the Report on the ZEB Roadmap in an Easy-to-Understand Way. Retrieved from:** https://www.meti.go.jp/english/policy/energy_environment/energy_efficiency/zeb.html

19 **Australian Building Codes Board. National Construction Code. Retrieved from:** https://ncc.abcb.gov.au/

20 **Lenaghan, N. (2022). New City of Sydney net-zero rules boost values of green buildings. Financial Review. Retrieved from:** https://www.afr.com/property/commercial/new-city-of-sydney-net-zero-rules-boost-values-of-green-buildings-20220912-p5bhdq

21 **Zero Energy Buildings (ZEBs)** use all cost-effective measures to reduce energy usage through energy efficiency and include renewable energy systems that produce enough energy to meet remaining energy needs. Source: US Department of Energy (2015). A Common Definition for Zero Energy Buildings. Retrieved from: https://www.energy.gov/sites/default/files/2015/09/f26/bto_common_definition_zero_energy_buildings_093015.pdf

22 **Property companies must meet the taxonomy requirements to classify their assets as sustainable according to the Sustainable Finance Disclosure Regulation (SFDR) and Corporate Sustainability Reporting Directive (CSRD) regulations. They must make a significant contribution to at least one of the six environmental goals in the taxonomy; most property companies choose the Climate Change Mitigation category. Source: Global ABC (2021). The EU Taxonomy – What does it mean for buildings? Retrieved from:** https://globalabc.org/resources/publications/eu-taxonomy-what-does-it-mean-buildings

23 **Ministry of Housing and Urban-Rural Development of the People's Republic of China (2019).** Technical standard for nearly zero energy buildings.

24 **Ministry of Housing and Urban-Rural Development of the People's Republic of China (2021).** General code for energy efficiency and renewable energy application in buildings. Retrieved from: http://www.jianbiaoku.com/webarbs/book/160785/4739756.shtml

25 **Partnership for Carbon Accounting Financials (PCAF) 2022. PCAF Guidance on financing the European building transition to net-zero. Retrieved from:** https://carbonaccountingfinancials.com/en/newsitem/pcaf-launches-guidance-on-financing-the-european-building-transition-to-net-zero

26 **UK Green Building Council (UKGBC)** Net-zero Carbon Buildings: A Framework Definition (UKGBC 2019) provides organizations with guidance on how to deliver net-zero carbon emissions buildings in the construction and operational phases. It includes guidance on establishing the scope of emissions, reducing construction impacts and operational energy use, offsetting and public disclosure. There is also additional detailed guidance on levels of energy performance with a trajectory to 2035, upfront embodied carbon and energy targets, avoiding fossil fuel consumption and high-quality carbon offsets. It is continuously updating this suite of guidance to account for developments in policy and practice. Retrieved from: https://ukgbc.org/wp-content/uploads/2019/04/Net-Zero-Carbon-Buildings-A-framework-definition.pdf

As a follow on from the Framework Definition report, the UKGBC recommends in its "Net-zero carbon: energy performance targets for offices" report (UKGBC 2020) that the office sector reduce energy demand by an average of 60% by 2050 to help the UK achieve net-zero emissions. In addition to offices, the government will likely set "Paris Proof" operational targets for other building types and propose minimum standards for embodied carbon and a change in Part L (UK building energy regulation) compliance for new buildings based on energy-use intensity (EUI) from 2027 onwards. If policy-makers adopt the proposed legislation, the primary impact would be minimum embodied carbon targets for new buildings. Retrieved from: https://ukgbc.org/resources/net-zero-carbon-energy-performance-targets-for-offices/

Endnotes

In the Net-zero Whole Life Carbon Roadmap for the Built Environment (UKGBC 2021) the UKGBC states that companies should prioritize renewable energy procurement to offset operational emissions, but there is no minimum requirement. Additionally, it states that companies must offset operational carbon annually. Retrieved from: https://ukgbc.org/our-work/topics/whole-life-carbon-roadmap/

27 **Dutch Green Building Council. FAQ – Paris Proof Commitment. Retrieved from: https://www.dgbc.nl/faq-paris-proof-commitment-186**

28 **Science-Based Targets initiative (SBTi)**
The Science-Based Targets initiative specifies decarbonization trajectories for sectors and companies aligned with a 1.5°C scenario. SBTi recently developed the Corporate net-zero standard to go beyond rapid and deep decarbonization to setting near- and long-term net-zero emissions targets and addressing residual emissions. SBTi has developed a buildings operational carbon pathway that matches CRREM. It will also develop a global pathway for buildings' embodied emissions aligned with 1.5°C and issue guidance on emissions accounting and reporting, and target setting and validation. Retrieved from: https://sciencebasedtargets.org/

29 **German Sustainable Building Council (DGNB)**
DGNB Award "Climate Positive": Making climate-friendly building operation visible. Retrieved from: https://www.dgnb-system.de/en/buildings/in-use/climate-positive/

30 **Carbon Risk Real Estate Monitor (CRREM)**
The CRREM tool aims to provide clarity to investors of the risk of stranding if they do not decarbonize their buildings over time. It calculates decarbonization and energy reduction pathways in line with the 1.5°C scenario for various building typologies in specific countries in EU, which will expand to include derived pathways and the corresponding carbon budgets on a global level. This is useful for understanding sector decarbonization trajectories but is harder to apply to individual assets that will naturally vary in energy intensity between typologies. Retrieved from: https://www.crrem.org/

31 **Comprehensive Assessment System for Built Environment Efficiency (CASBEE). Retrieved from: https://sustainable-infrastructure-tools.org/tools/casbee-for-buildings/**

Japan Sustainable Building Consortium (JSBC) and Institute for Building Environment and Energy Conservation (IBEC). Basic Concept. Retrieved from: https://www.ibec.or.jp/

Institute for Built Environment and Carbon Neutral for SDGs (IBECs). List of properties with CASBEE building evaluation certification (in Japanese). Retrieved from: https://www.ibec.or.jp/CASBEE/certified_buld/CASBEE_certified_buld_list.htm

32 **NABERS Climate Active Carbon Neutral Certification. Retrieved from: https://www.nabers.gov.au/ratings/our-ratings/climate-active-carbon-neutral-certification**

33 **International Energy Agency (IEA) (2021). GB/T 50378-2019 Assessment standard for green buildings (revision). Retrieved from: https://www.iea.org/policies/8507-gbt-50378-2019-assessment-standard-for-green-buildings-revision**

34 **The Net Zero Carbon Buildings Commitment. Retrieved from: https://worldgbc.org/thecommitment/**

35 **IWA 42:2022 (en) Net zero guidelines. Retrieved from: https://www.iso.org/obp/ui/en/#iso:std:iso:iwa:42:ed-1:v1:en**

36 **WorldGBC Advancing Net Zero Whole Life Carbon. Retrieved from: https://worldgbc.org/advancing-net-zero/advancing-net-zero-whole-life-carbon/**

37 **UKGBC Carbon Offsetting and Pricing Guidance. Retrieved from: https://ukgbc.org/resources/carbon-offsetting-and-pricing-guidance/**

38 **Energy Gov – Australian energy mix by state and territory 2021-22. Retrieved from: https://www.energy.gov.au/data/australian-energy-mix-state-and-territory-2020-21**

39 **General code for energy efficiency and renewable energy application in buildings > GB 55015-2021**

40 **Government of Shanghai. Shanghai green building 14th Five Year plan (建设管理_上海市住房和城乡建设管理委员会). Retrieved from: https://www.shanghai.gov.cn/nw44420/index.html**

41 **Chinese Ministry of Housing and Urban-Rural Development 14th Five Year Building Energy Efficiency and Green Building Development Plan (March 2022)**

Endnotes

42 Chinese National Energy Administration: National Renewable Energy Power Development Monitoring and Evaluation Report (2021). Retrieved from: http://www.nea.gov.cn/

43 Chinese National Energy Administration: Actively and Steadily Promote Clean Heating in Northern Areas. Retrieved from: http://www.nea.gov.cn/

44 U.S. Energy Information Administration (2022). China – Executive summary. Retrieved from: https://www.eia.gov/international/analysis/country/CHN

45 CLP. Renewable energy: Schemes related to renewable energy. Retrieved from: https://www.clp.com.hk/en/business/low-carbon-solutions/renewable-energy

46 Government of Hong Kong SAR (2021). Hong Kong's Climate Action Plan 2050. Retrieved from: https://cnsd.gov.hk/wp-content/uploads/pdf/CAP2050_booklet_en.pdf

47 Government of Hong Kong SAR Water Supplies Department. Floating Solar Power System. Retrieved from: https://www.wsd.gov.hk/en/home/climate-change/mitigating/floating-solar-power-system/index.html

48 CLP (2021). CLP Power Applies Smart Technology to Save Energy and Reduce Carbon Emissions at Hong Kong International Airport. Retrieved from: https://www.clpgroup.com/content/dam/clp-group/channels/media/document/2021/20210809_en.pdf

49 Energy Land – The Energy Scene of Hong Kong, China. Retrieved from: https://www.emsd.gov.hk/energyland/en/energy/energy_use/energy_scene.html

Government of Hong Kong SAR Electrical and Mechanical Services Department (2020). Energy: The Energy Scene of Hong Kong, China. Retrieved from: https://www.emsd.gov.hk/energyland/en/energy/energy_use/energy_scene.html

50 Climate Action Network Europe (2022). Rooftop Solar PV Country Comparison Report. Retrieved from: https://caneurope.org/rooftop-solar-pv-comparison-report/

51 European Commission (2022). 2022 State of the Energy Union report highlights challenges. Retrieved from: https://commission.europa.eu/news/2022-state-energy-union-report-highlights-challenges-2022-10-18_en

52 Geopolitical Futures (2021). Europe's Energy Transition. Retrieved from: https://geopoliticalfutures.com/europes-energy-transition/

53 Geopolitical Futures (2021). Europe's Energy Transition. Retrieved from: https://geopoliticalfutures.com/europes-energy-transition/

54 Energy Efficiency and Conservation Division, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry of Japan (2015). Definition of ZEB and future measures proposed by the ZEB Roadmap Examination Committee. Retrieved from: https://www.enecho.meti.go.jp/category/saving_and_new/saving/zeb_report/pdf/report_160212_en.pdf

Bureau of Environment, Tokyo Metropolitan Government. Tokyo Solar Power. Retrieved from: https://www.kankyo.metro.tokyo.lg.jp/en/climate/solar_portal/index.html

55 Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry of Japan. Improving energy efficiency. Retrieved from: https://www.enecho.meti.go.jp/en/category/special/article/energyissue2019_02.html#topic02

Japanese Business Alliance for Smart Energy Worldwide (JASE-W) (2023). Japanese Smart Energy Products & Technologies 2023: Japanese Energy-Efficient Technologies. Retrieved from: https://www.jase-w.eccj.or.jp/technologies/pdf/Japanese_Energy_Efficient_Technologies.pdf

56 Federation of Electric Power Companies of Japan. Plan for realization (実現に向けたプラン). Retrieved from: https://www.fepc.or.jp/sp/carbon-neutral/plan.html

International Environment and Economy Institute. Japan's Inconsistent Decarbonization Strategy: Considering Revision of the Energy Conservation Law (日本の脱炭素戦略の不整合 省エネ法の改正を考える). Retrieved from: https://ieei.or.jp/2021/07/takeuchi210715/

57 Global Data Energy (2022). Japan to nearly achieve 2030 renewable power generation target. Power Technology. Retrieved from: https://www.power-technology.com/comment/japan-2030-renewable-target/

Endnotes

58 Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry of Japan. Retrieved from: https://www.enecho.meti.go.jp/commitee/council/basic_policy_subcommittee/036/036_005.pdf

Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry of Japan. Methanation. Retrieved from: https://www.enecho.meti.go.jp/about/special/johoteikyo/methanation.html

59 U.S. Energy Information Administration. Electricity Explained. Retrieved from: https://www.eia.gov/energyexplained/electricity/electricity-in-the-us-generation-capacity-and-sales.php

60 U.S. Department of Energy (2021). DOE Announces Nearly $83 Million to Increase Building Energy Efficiency and Cut Consumers' Energy Bills. Retrieved from: https://www.energy.gov/articles/doe-announces-nearly-83-million-increase-building-energy-efficiency-and-cut-consumers

61 Marccaci, S. (2021). Top 5 U.S. Electrification Policy Wins Of 2021: Federal Investment, Electric Vehicles, Building Electrification. Forbes. Retrieved from: https://www.forbes.com/sites/energyinnovation/2021/12/20/top-5-us-electrification-policy-wins-of-2021-federal-investment-electric-vehicles-building-electrification/

62 U.S. Department of Energy Office of Energy Efficiency & Renewable Energy. Renewable Energy. Retrieved from: https://www.energy.gov/eere/renewable-energy

63 U.S. Energy Information Administration. U.S. energy consumption by source and sector, 2022. Retrieved from: https://www.eia.gov/energyexplained/us-energy-facts/images/consumption-by-source-and-sector.pdf

64 International Energy Agency. Infrastructure and Jobs act: Clean hydrogen initiatives. Retrieved from: https://www.iea.org/policies/14972-infrastructure-and-jobs-act-clean-hydrogen-initiatives

65 U.S. Department of Energy Office of Energy Efficiency & Renewable Energy. Financial Incentives for Hydrogen and Fuel Cell Projects. Retrieved from: https://www.energy.gov/eere/fuelcells/financial-incentives-hydrogen-and-fuel-cell-projects

66 The White House (Aug. 03, 2021). UPDATED FACT SHEET: Bipartisan Infrastructure Investment and Jobs Act. Retrieved from: https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/02/updated-fact-sheet-bipartisan-infrastructure-investment-and-jobs-act/

67 Arup. One Melbourne Quarter: A once in a generation transformation creates a benchmark workplace and Melbourne's first Sky Park. Retrieved from: https://www.arup.com/projects/one-melbourne-quarter

68 NABERS (2022). Energy efficiency in commercial buildings. Retrieved from: https://www.nabers.gov.au/sites/default/files/2022-11/Energy%20Efficiency%20in%20Commercial%20Buildings%20-%20Summary.pdf

69 Nabers Annual Report 2020/21. Retrieved from: https://nabers.info/annual-report/2020-2021/life-of-program-statistics/

70 Arup. 11 & 12 Wellington Place, Leeds, UK: Setting a new standard for future-proofed sustainable office development. Retrieved from: https://www.arup.com/projects/11-and-12-wellington-place

71 Arup. The Ridge, Cape Town: pushing the boundaries of sustainable design. Retrieved from: https://www.arup.com/projects/the-ridge

72 Hanford, J. et al. (2016). Building Change: Case Study – Bullitt Center. High Performing Buildings. Winter 2016. Retrieved from: https://www.hpbmagazine.org/content/uploads/2020/04/16W-Bullitt-Center-Seattle-WA.pdf

73 Lombardo, T. (2014). Bullitt Center: Seattle's net-zero Energy Building. Engineering.com. Retrieved from: https://www.engineering.com/story/bullitt-center-seattles-net-zero-energy-building

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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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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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