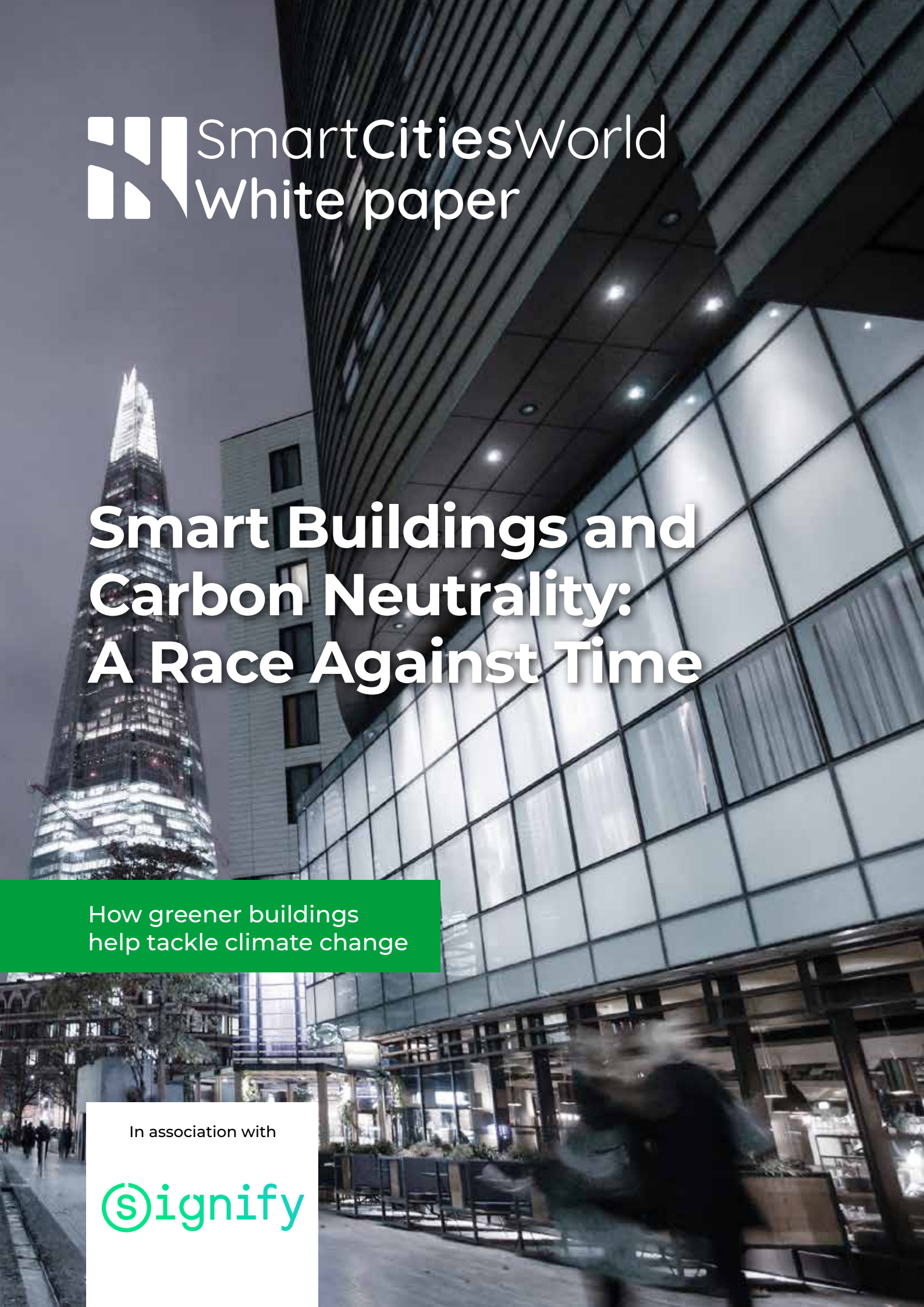

SmartCitiesWorld White paper

Smart Buildings and Carbon Neutrality: A Race Against Time

How greener buildings help tackle climate change

In association with

Signify

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SmartCitiesWorld **Trend Reports examine an emerging or growing trend in smart cities, highlighting progress so far and future potential, as well as spotlighting case studies from cities around the world.**

In this report, we examine the potential for policy interventions and innovative technologies to mitigate building emissions, support carbon neutrality measures and facilitate green initiatives.

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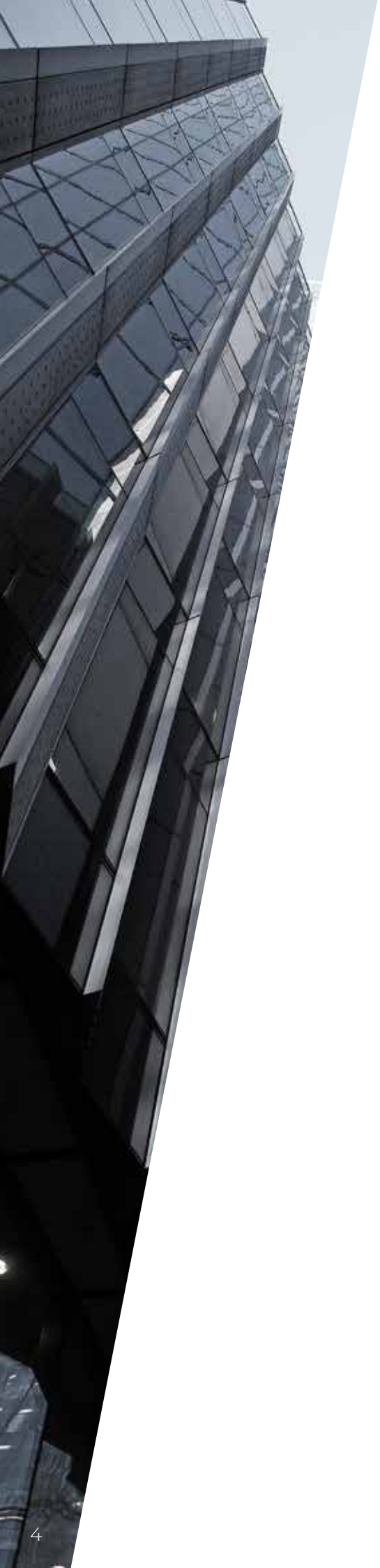
Making buildings smarter and greener

Our modern world depends on buildings and increasingly on smart buildings. However, the world's millions of buildings are among the main contributors to harmful emissions and climate change. Construction and operation of buildings "account for 36 per cent of global energy use and 39 per cent of energy and process-related carbon dioxide emissions," according to the United Nations Environment Program (UNEP). In Europe, buildings consume more energy and emit more carbon dioxide than any other economic sector.

The UN Intergovernmental Panel on Climate Change (IPCC) estimates that to "keep the global temperature rise to 1.5°C compared to pre-industrial times and limit the negative impacts of climate change, the world needs to rapidly cut its emissions of climate-warming greenhouse gases (GHG) to achieve net-zero emissions of CO_2 by 2050".

The transition to climate neutrality depends on smart buildings getting even smarter. The built environment must change. The process for designing and constructing new buildings must change. And existing buildings must be renovated at a much faster rate in this race against time.

In this trend report, we describe the potential for policy interventions and innovative technologies to mitigate building emissions, support carbon neutrality measures and facilitate green initiatives.



Cutting global emissions demands bold actions

Based on a collaborative university study, global energy demand increased by 2.3 per cent in 2018 (the highest increase since 2010), and CO_2 emissions from the energy sector reached a new record. This research indicates global warming – when compared to pre-industrial levels – is approaching 1.5°C, most likely before mid-century, and will have a severe impact.

According to figures from the World Research Institute (WRI), the European Union countries and nine others generate more than 68 per cent of global GHG emissions (China is responsible for 26 per cent of total emissions and the United States 13 per cent). The EU – known for its ambitious climate goals and legislation – reduced greenhouse gas emissions by 23 per cent between 1990 and 2018. Through its climate and energy framework for 2030, the EU plans to accomplish further emission reductions and has the target of reducing GHG emissions by 60 per cent by 2050. Despite its ambitions, clearly there is more work to be done.

A 2019 report from the Global Alliance for Buildings and Construction (GlobalABC) shows the buildings and construction sector is not on track to meet emissions targets by 2030 and beyond and – without urgent actions – "energy demands for this sector could rise by 50 per cent by 2060". In this report, Fatih Birol, Executive Director of the International Energy Agency (IEA) states: "Our analysis shows that the pace of energy efficiency improvement slowed to 1.2 per cent from 2017 to 2018 whereas we need a rate of improvement of three per cent to meet our Sustainable Development goals." While the report highlights some positive trends in the sector, such as increased penetration of efficient LED lighting systems and an increase in the use of renewables, it reveals disturbing trends. For example:

- CO_2 emissions from buildings are persistent, staying at about 39 per cent of the world's total emissions each year, while activities to mitigate emissions are lagging.
- Increased demand for space cooling is a growing problem, mainly a result of floor space growing 23 per cent since 2010 and building energy consumption growing seven per cent in this timeframe.
- Urgently needed energy efficiency measures suffer from under-investment.

An estimated 75 per cent of Europe's current building stock is considered energy inefficient, according to a report from the European Commission. "This means a large part of the energy used goes to waste. Such energy loss can be minimised by improving existing buildings and striving for smart solutions and energy efficient materials."

Technologies lead while policies lag

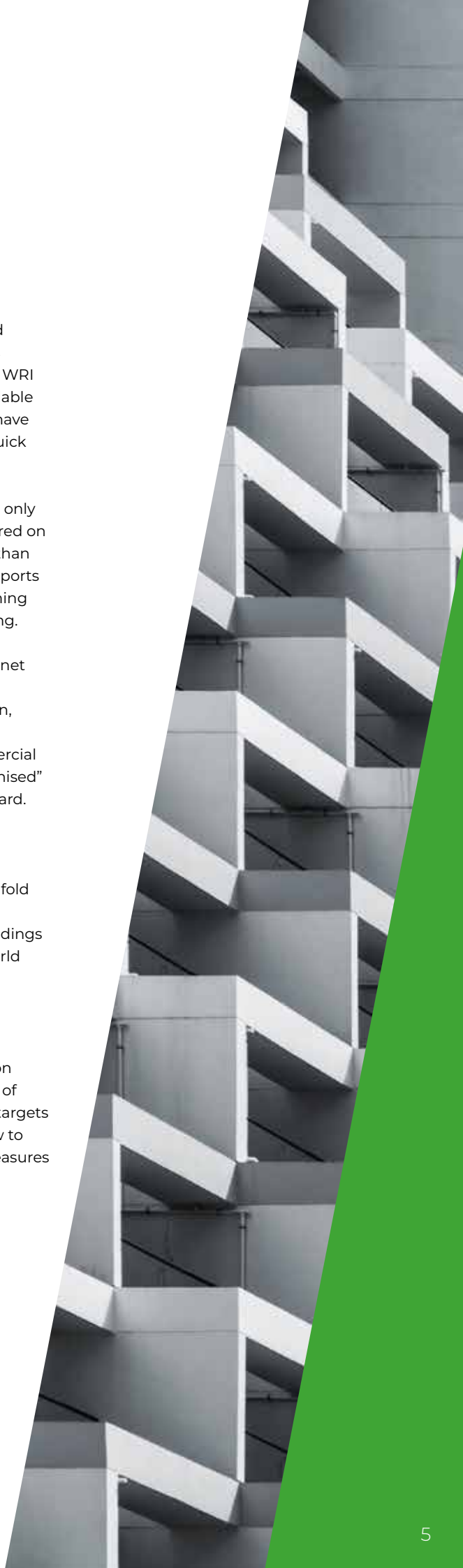
The World Resources Institute defines zero-carbon buildings (ZCBs) as "structures that meet all their energy needs by being highly efficient and totally powered by zero-emissions energy, either on-site or off-site". ZCBs eliminate GHG emissions and increase resilience to climate impacts. The WRI says "energy efficiency and renewable energy technologies are now available just about everywhere, though in many places, policies and regulations have not caught up with technological advancements or the imperative for quick adoption in all buildings".

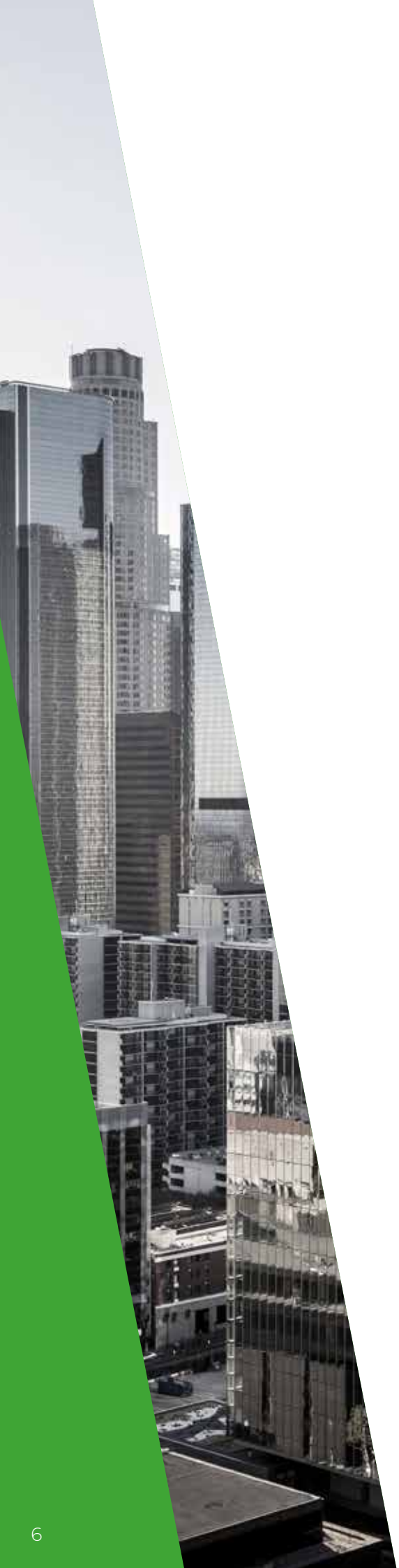
UNEP, in its 2019 Emissions Gap report, says: "The buildings sector shows only scattered policy action at high levels of mitigation ambition, mainly centred on policymaking in the European Union." Although six countries and more than 20 cities have committed to zero targets in the buildings sector, UNEP reports a general lack of targets worldwide for achieving zero emissions, performing deep retrofits of existing structures and phasing out fossil fuels for heating.

To meet the goals of the Paris Climate Agreement, all buildings must be net zero carbon by 2050. But the building sector faces a difficult road ahead: less than one per cent of today's buildings are considered net zero carbon, according to a WRI report on accelerating decarbonisation. In 2017, only 2,500 net zero energy buildings existed worldwide, including 500 commercial buildings. And these estimates cover only the structures "officially recognised" through green building certification or adherence to a recognised standard.

An IPCC report claims that cost-effective technology solutions to reduce energy use and emissions are available. Advances in technology, design practices, knowledge and behavioural changes can achieve a "two to tenfold reduction in energy requirements of new buildings and a two to fourfold reduction for existing buildings", according to the report. "In existing buildings 50 to 90 per cent energy savings have been achieved throughout the world through deep retrofits." However, barriers hinder the adoption of these opportunities which – in the absence of aggressive policy interventions – remain untapped.

Even when progressive building designers and smart city leaders focus on energy use and its consequent carbon footprint, they confront a scarcity of strict, well-defined building codes. Attempts to establish tighter energy targets at local government levels are constrained by a lack of consensus on how to design codes which specifically address zero energy and zero carbon measures or how to ensure buildings actually achieve the targets.





The Global Climate Community

The world does not suffer from a shortage of organisations tackling global emissions and carbon neutrality challenges. Numerous government bodies, alliances, institutes, leadership groups and other entities offer a wide range of policy recommendations, legislation, research, targets and mandates on climate change and building emissions.

The global climate community includes:

- C40 Cities Climate Leadership Group
- Climate Technology Centre and Network (CTCN)
- European Commission
- European Environment Agency (EEA)
- Global Covenant of Mayors for Climate and Energy
- Intergovernmental Panel on Climate Change (IPCC)
- International Council for Research and Innovation in Building and Construction
- International Finance Corporation (IFC)
- International Energy Agency (IEA)
- International Renewable Energy Agency (IRENA)
- Leadership in Energy and Environmental Design (LEED)
- National Institute of Building Sciences (NIBS)
- Programme for Energy Efficiency in Buildings (PEEB)
- The Climate Group
- UN Global Alliance for Buildings and Construction (GlobalABC)
- UN Economic Commission for Europe (UNECE)
- UN Environment Programme (UNEP)
- U.S. Department of Energy (DOE)
- U.S. Energy Information Administration (EIA)
- U.S. Environmental Protection Agency (EPA)
- World Economic Forum (WEF)
- World Green Building Council (WorldGBC)
- World Resources Institute (WRI)

In 2011, the European Commission released a roadmap for advancing to a competitive low-carbon economy and reducing GHG emissions by 80 per cent by 2050 (compared with 1990 levels). The roadmap called for GHG target reductions of 25 per cent by 2020, 40 per cent by 2030 and 60 per cent by 2040. In Energy Procedia, researchers from the Politecnico di Torino and International Energy Agency (IEA) write: “This essentially means that the carbon-based society of today which took 200 years to develop would need to radically transform to a new low carbon society in less than 40 years.”

Today, most of the international community is committed to a low carbon future, with the Paris Climate Agreement serving as a global framework for change and innovation. More than 200 countries including European Union member states have ratified the treaty and most have established climate laws and policies. National governments and cities are launching climate reduction initiatives, many of them with the built environment as a primary focus and with strategies, subsidies and financial incentives designed to accelerate the transition to net zero energy buildings.

However, the IPCC predicts if the world continues on the current decarbonisation path, it will fall dangerously below the Paris climate targets. An ominous IPCC report in 2018 warned that the world has only 12 years to prevent the planet from warming above 1.5°C and stressed the urgent need for a global low carbon transformation. “By 2050, greenhouse gas emissions must be reduced by 40 to 70 per cent below the levels they were in 2010.”

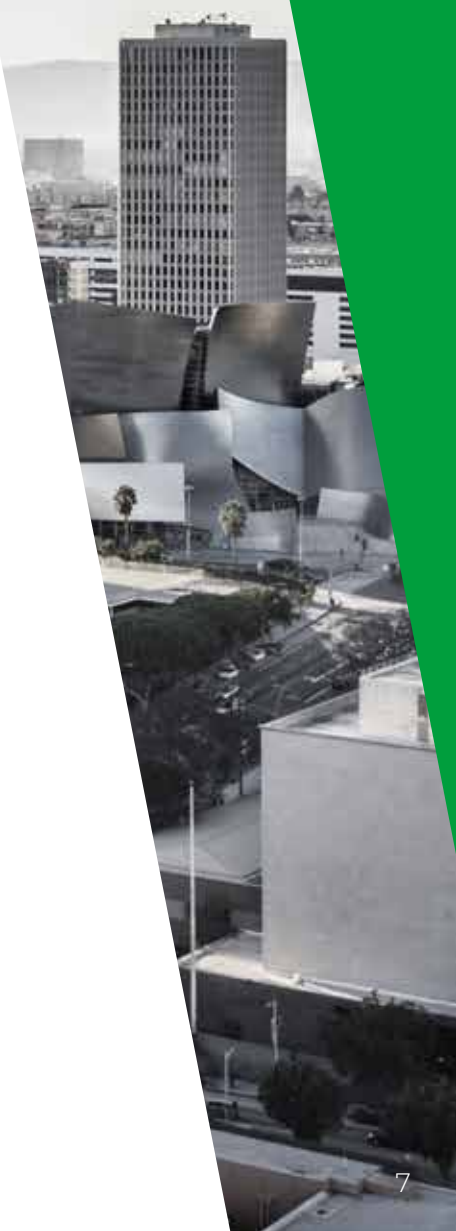
Getting from the current path to a new path and meeting the IPCC targets requires significant changes in energy efficiency in the built environment. To accelerate decarbonisation policies, the WRI created eight pathways — each comprising a mix of basic energy efficiency, exemplary energy performance and on- or off-site carbon-free renewable energy.

Yet another hurdle is that energy-efficient buildings are not the standard in most countries. “Architects and engineers lack information about technologies and building design, and banks and investors are reluctant to invest,” says the Programme for Energy Efficiency in Buildings (PEEB), whose mission includes transforming the building sector by promoting sustainable buildings, providing technical assistance and redirecting investments towards energy efficiency.

GlobalABC claims that “near-zero-energy construction shares are typically less than five per cent in most markets, and typical renovation rates are around one to two per cent of the building stock per year with 10 to 15 per cent energy intensity improvements”. Achieving sustainability targets requires refurbishment rates “to double and to avoid the lock-in of inefficient buildings and their subsequent emissions”.

Adding to the complexity of the challenge, the GlobalABC says the buildings and construction sector value chain is fragmented and lacks stakeholder coordination among national and local authorities, international organisations, companies, civil society and financial institutions.

Because the building sector is one of the major generators of CO_2 emissions, all new buildings in the EU must be designed according to nearly Zero Energy Buildings (nZEB) criteria starting from 31 December 2020. A European directive requires that existing buildings meet the same nZEB targets defined for new constructions.



In March 2020, the European Commission announced its proposed European Climate Law, a legislative mandate for the EU to be climate neutral by 2050. President Ursula von der Leyen says: “We are acting today to make the EU the world’s first climate neutral continent by 2050. The Climate Law is the legal translation of our political commitment, and sets us irreversibly on the path to a more sustainable future. It is the heart of the European Green Deal.”

Current climate and energy policies in the EU could be threatened by the coronavirus pandemic. Although the pandemic impact and lockdown measures have led to reduced carbon emissions, governments in coal-intensive countries believe the EU should revisit its European Green Deal targets as national leaders focus on the pandemic and economic recovery. Fazlun Khalid, a UN adviser, says that “scientists have long warned of the inevitability of a pandemic” due to our encroachment on natural ecosystems. Climate change amplifies the risks. Khalid thinks that “if the EU fails to transform its economic priorities, we will be unable to avoid not only the next pandemic, but also an unprecedented climate disaster”.

The Financial Times reports that global emissions have plunged during the coronavirus crisis. “Yet despite the potential short-term dip in emissions, there is a risk that the pandemic – which is likely to dominate debate for months or even years to come – will overshadow environmental concerns. Climate talks have already been delayed and new policy initiatives postponed.”

Francesco La Camera, Director-General of the International Renewable Energy Agency (IRENA) says pandemic recovery policies should support and accelerate low-carbon development. “COVID-19 does not change the existential path required to decarbonise our societies and meet sustainability goals. By making the energy transition an integral part of the wider recovery, governments can achieve a step change.” La Camera believes recovery measures should include investments in sustainable energy infrastructure and clean energy technologies – not in fossil fuels.

The U.S. version of a Green New Deal – proposed by Representative Alexandria Ocasio-Cortez and Senator Ed Markey – might change the way America builds. Implementing this controversial proposal requires a transformation of America’s buildings and construction industry, including the country’s existing buildings. The Green New Deal calls for retrofitting all of them within a decade. In other pre-pandemic actions, New York City enacted a law with its own citywide green new deal. The Climate Mobilisation Act defines measures that include “forcing the owners of the city’s large buildings – a huge source of its carbon footprint – to make them more efficient”. The new law requires large buildings to cut emissions 40 per cent by 2030 and 80 per cent by 2050.

Strategies for low-carbon innovation

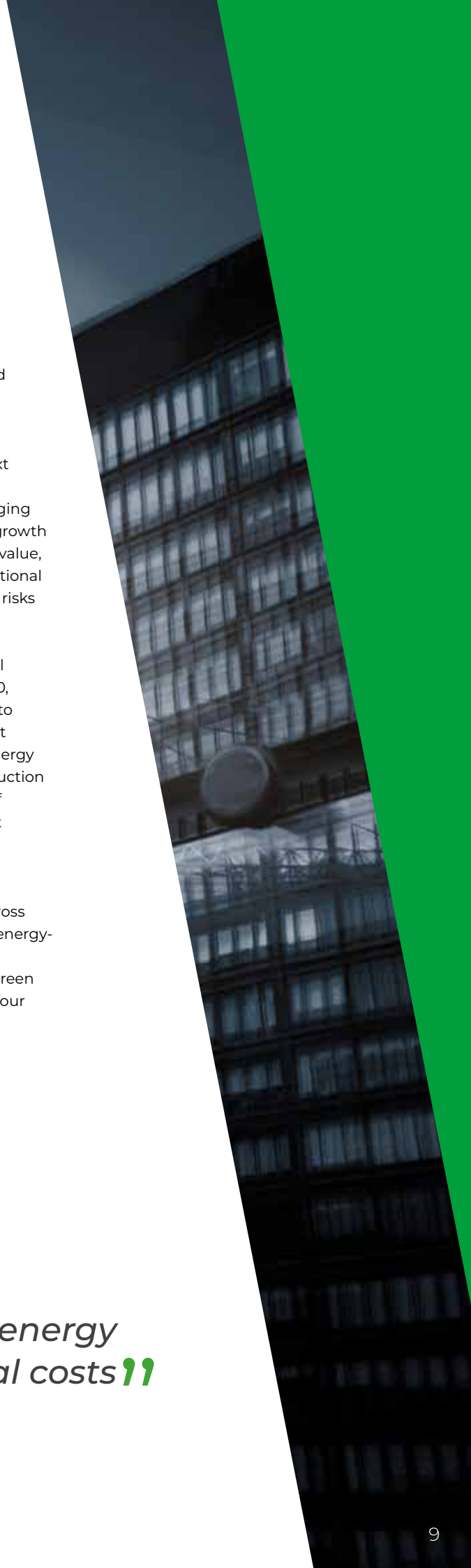
The buildings and construction sector faces major hurdles to make the changes needed to reach international objectives for emissions. These hurdles place a premium on green building initiatives, involving combinations of renewable energy, energy efficiency, electrification and business model innovation. Green buildings are designed to reduce or eliminate harmful impact to the environment.

The International Finance Corporation (IFC) reports that "during the next decade, green buildings represent a significant low-carbon investment opportunity in emerging markets – $24.7 trillion by 2030. Cities in emerging markets are expanding at a fast pace to keep up with high population growth and rapid urbanisation". The IFC says green buildings – typically higher-value, lower-risk assets – consume less energy and therefore yield lower operational costs. Green buildings also enable investors and owners to mitigate the risks associated with a low-carbon transition.

Keeping the global temperature rise below 2°C and toward 1.5°C, annual energy-related CO_2 emissions have to fall more than 70 per cent by 2050, based on IRENA's 2020 Global Renewables Outlook. "A large-scale shift to renewable energy and electrification measures could deliver 75 per cent of the needed reductions or as much as 90 per cent with ramped up energy efficiency measures." IRENA stresses that achieving these emission reduction goals requires accelerated technology measures such as deployment of renewable energy, deeper electrification powered by renewables, direct renewable use (e.g., solar thermal and biomass) and innovation in energy efficiency.

GlobalABC says "clean technology deployment remains unbalanced across building end users and needs further promotion to drive transitions to energy-efficient and low-carbon building technologies". A global study of more than 100 green building experts identified 12 strategies for promoting green building technologies (GBT) and innovation. Survey respondents rated four strategies as most important:

- Financial and other market-based incentives for GBT adopters
- Availability of better information on cost and benefits of GBT
- Mandatory governmental policies and regulations
- Green rating and labelling



"Green buildings consume less energy and yield lower operational costs"

Energy efficiency and its global potential

Researchers at U.S. national laboratories announced the development of a model on the feasibility of cutting emissions from buildings "by almost 80 per cent by 2050, potentially forming a major part of efforts to address climate change". Reaching this target requires the installation of highly energy-efficient technologies. Examples of innovation in energy efficiency include:

- **Energy-saving retrofits and upgrades:** reducing energy loss and emissions by modernising the building envelope
- **Microgrids combined with renewable energy sources:** providing capabilities to achieve a more balanced energy supply
- **Artificial intelligence and machine learning:** enabling rapid alerts of energy waste or loss
- **Energy storage solutions combined with on-site renewables:** helping to reduce the variation in energy caused by a surge in demand
- **Intelligent platforms, sensors and user-centric communications:** enabling energy-efficient behaviour and measurable reductions in energy consumption

Electrification proposed as a "most feasible option"

Megan Mahajan, Policy Analyst at Energy Innovation, believes the most feasible option to decrease building emissions is to increase the share of electric building components. In a Forbes article, Mahajan writes that "decarbonising buildings is challenging because building components take decades to turn over". Setting and achieving key targets to electrify buildings is crucial to reaching net zero emissions by 2050. "Electric building components can already be cheaper than natural gas equipment over component lifetimes, but up-front costs are still higher, requiring smart policy to accelerate the adoption of all-electric equipment," says Mahajan, who stresses that an ambitious all-electric policy mandate should enable the majority of building emissions reductions by 2050.

The Internet of Things (IoT) and its carbon neutrality role

The World Green Building Council (WorldGBC) is coordinating local efforts to ensure that all new buildings operate at net zero carbon. IoT technology supports the WorldGBC main pillars, including reduced energy consumption, generation of renewable energy on-site and measurement of carbon consumption and waste.

The IoT can promote carbon neutrality by overcoming a stumbling block in the adoption of green building practices. Because solar and wind energy vary depending on weather conditions, the use of renewable energy sources does not always deliver a consistent supply of energy. Jonathan Weinert, an IoT thought leader at Signify, says an IoT-enabled demand-driven smart grid addresses this barrier. "In a smart grid, the IoT can facilitate the immediate transfer of energy from a node where it's in surplus to a node that's running an energy deficit, thus smoothing out the system. Or else the IoT can make sure that excess energy is stored up today so that the system can use it tomorrow. In both cases it makes renewable energy sources feasible to use. Variability is no longer an issue." The IoT can also collect data that analytics platforms use in power grid management and facilitation of a grid's response to fluctuations in demand.

Innovation in smart lighting solutions with IoT platforms yields opportunities to reduce the emissions of both new and existing buildings through:

- Monitoring energy consumption
- Managing light sensors and delivering usage-driven luminosity levels of LED lighting
- Collecting data to evaluate and optimise energy usage

Building Information Models (BIMs) is another area where the IoT and sensor networks deliver benefits. In addition to their application in design and construction of new buildings, a BIM – by serving as a digital twin of the structure – can be used after a new building is operational. Data collected by the sensors help to evaluate energy efficiency and identify potential improvements in building performance.

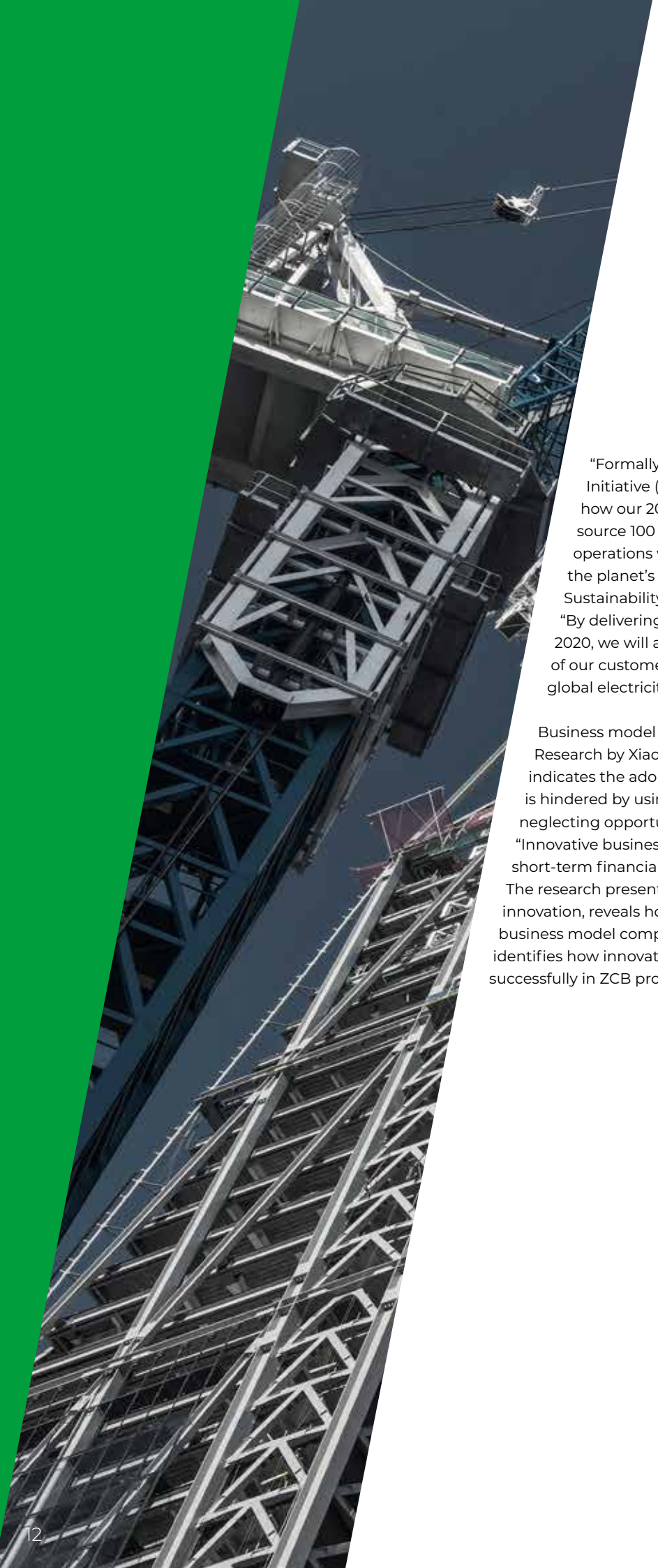
According to Deloitte, "the IoT is already having a significant impact" on the commercial real estate (CRE) sector. "The way in which IoT-generated information creates value represents a fundamental shift for CRE companies." IoT applications and data analytics create value in the sector by improving energy efficiency and opening new opportunities for differentiation and sustainability programmes.

Carbon offsets to compensate for CO_2 emissions

Global crises require leaders with a global perspective. Consider Signify and its sustainability programme "Brighter Lives, Better World" – the company's commitment to carbon neutrality. Signify recognised the company's global reach and resources provided opportunities to take big steps toward corporate carbon neutrality. The company therefore created a strategy to reduce and compensate for emissions generated by fossil fuel use in their businesses worldwide.

Signify compensates for its corporate CO_2 emissions "by preventing the same amount of emissions from entering the atmosphere elsewhere." The company invests in emission reduction projects that issue carbon credits confirming the reduction or avoidance of CO_2 emissions. Signify is highly selective in this process. "We have defined standard requirements to select only carbon offsetting projects that ensure positive impact." The company relies on third party verification to ensure the selected projects deliver the intended reductions, and each carbon offset project must be certified by an established standards-setting body such as the United Nations Clean Development Mechanism (CDM).

As a result of this carbon offset programme, Signify set a corporate target to reach carbon neutrality in 2020. In 2019, the company announced a reduction in its global carbon footprint of 45 per cent (since 2015) and increased its use of renewables to 94 per cent.



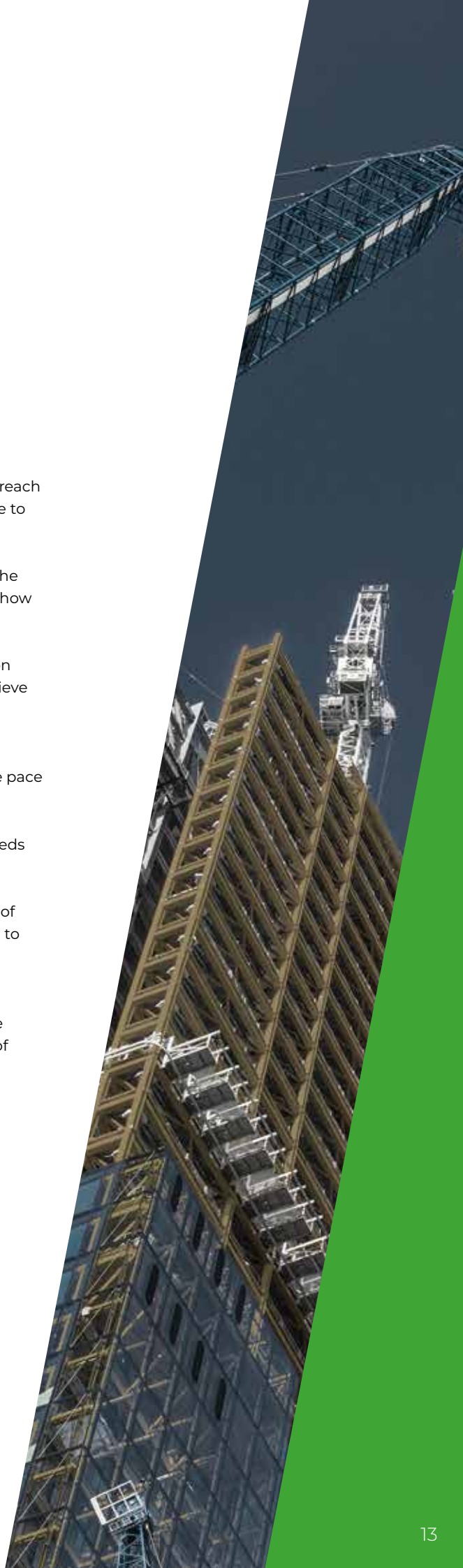
"Formally approved by Science-Based Targets Initiative (SBTI), these commitments demonstrate how our 2020 targets to become carbon neutral and source 100 per cent renewable electricity align our operations with the 2°C pathway needed to live within the planet's limits," says Nicola Kimm, Global Head of Sustainability, Environment, Health & Safety at Signify. "By delivering two billion LED lamps and luminaires by 2020, we will also help limit the environmental impact of our customers, accelerating the transition to decrease global electricity consumption.

Business model innovation for zero carbon projects

Research by Xiaojing Zhao at the University of Hong Kong indicates the adoption of low or zero carbon buildings is hindered by using traditional analytical methods and neglecting opportunities based on business model innovation. "Innovative business models for ZCBs shift the focus from short-term financial returns to long-term value creation." The research presents a framework for ZCB business model innovation, reveals how value is created through interrelated business model components in zero carbon projects, and identifies how innovative business models were applied successfully in ZCB projects in six countries.

Key takeaways

- Pre-pandemic levels of GHG emissions must be cut in half by 2030 and reach net-zero by 2050 to avoid severe climate change and long-term damage to the planet.
- To meet its global responsibilities under the Paris Climate Agreement, the building and construction sector needs to make significant changes in how buildings are designed, built and operated.
- An acceleration of actions in energy efficiency, renewable energy, carbon offsets, electrification and business model innovation is required to achieve the Paris Agreement targets.
- Retrofits of existing buildings offer significant opportunities to reduce emissions, and leaders in government and industry must accelerate the pace of retrofits.
- The building and construction sector value chain is fragmented and needs improvement in stakeholder coordination.
- The building sector's role in creating sustainable cities and its adoption of the IoT and other digital technologies are key elements in the transition to carbon neutrality.
- The pandemic impact on green building policies and decarbonisation is uncertain, but a risk is that socioeconomic recovery concerns will take precedence over measures to meet international targets for reduction of building emissions.



Conclusions

While countries strive to recover from the coronavirus crisis, a big question is how the world can regain momentum in confronting the climate crisis – a looming catastrophe that continues while government attention is focused elsewhere.

A global survey of business leaders and senior government officials indicates coronavirus recovery measures offer "the potential for strong alignment between the economy and the environment. The direction of these measures over the next six months will largely determine whether the worst impacts of global warming can be avoided". However, disruptions on the scale of a global pandemic "rarely make it easier to fight climate change. In some cases, they can make it harder," according to a New York Times article.

In spite of post-pandemic risks and uncertainties in the building sector, Casey Talon and Carsten Petersdorff, research directors at Guidehouse Insights, believe in finding opportunities. In a Greenbiz article, they foresee "an unprecedented opportunity to rethink the entire approach to designing, constructing and managing commercial buildings" and forge a collective effort in defining new practices for electric and digital building infrastructure. The authors believe that developing a building strategy in the post-pandemic era "is an opportunity to make individual buildings cleaner and more efficient".

While national governments focus on coronavirus recovery and socioeconomic issues, cities and local governments can heighten their role in the decarbonisation of buildings through:

- Development of policies which require new government buildings to be constructed as ZCBs
- Introduction of low-carbon building codes that focus on energy efficiency and the use of renewables
- Promotion of technology solutions and financial incentives consistent with low-carbon building codes
- Gradual increases in the price for carbon pollution, as a mechanism to improve the ZCB business case
- Facilitation of partnerships and ecosystems amenable to making changes in how buildings are designed, operated and upgraded

Through active membership in the global climate community, mayors and city leaders have demonstrated their commitment to climate measures. Now is the time for smart cities to lead the way in reducing emissions and achieving carbon neutrality in the built environment.