



Towards a Zero-Emission and Resilient Real Estate Industry:

*Global Outlook
and Asia's Progress*

Credits

Lead Authors: Zhengzhen Tan, Siqi Zheng

Country Chapter co-authors:

Chapter 1: Europe, Vineet Abhishek

Chapter 2: North America, Qiaojun Lai

Chapter 3: Australia, Steven La

Chapter 4: China, Zehao Yu

Chapter 5: India, Himanshu Tiwari

Chapter 6: Thailand, Shawn Hu

Chapter 7: South Korea, Jin Gao

Chapter 8: Singapore, Shao Lan Wang

Acknowledgement:

Lead Authors

Zhengzhen Tan is research scientist, lecturer at Center for Real Estate; director for Asia Real Estate Initiative at Massachusetts Institute of Technology.

Siqi Zheng is STL Champion Professor of Urban and Real Estate Sustainability; faculty director of Center for Real Estate and Sustainable Urbanization Lab at Massachusetts Institute of Technology

The lead authors thank funding provided by Wang Real Estate Innovation Fund. We also appreciate reviewer Fabio Duarte, Denise DeLorey provided comments and feedback for the executive summary.

©2022 Massachusetts Institute of Technology

Designed by Louis Charron

All right reserved. No part of this book may be reproduced in any form or by any electronic or mechanical means, including information storage and retrieval systems, without written permission from the publisher.

Table of content

| | | |
|---------|--------------------------|----|
| Part 1. | Executive Summary | 04 |
| Part 2. | Regional Chapters | |
| | Chapter 1: Europe | 12 |
| | Chapter 2: North America | 19 |
| | Chapter 3: Australia | 29 |
| | Chapter 4: China | 36 |
| | Chapter 5: India | 44 |
| | Chapter 6: Thailand | 53 |
| | Chapter 7: South Korea | 61 |
| | Chapter 8: Singapore | 69 |
| | Notes | 75 |

Zhengzhen Tan, Siqi Zheng

The Intergovernmental Panel on Climate Change (IPCC) Special Report 6 released in August 2021 urged action to maintain a habitable planet for humankind. To avoid the most significant effects of climate breakdown, including limiting the global temperature rise by 1.5°C¹, GHG² emissions must be halved before 2030 and net-zero emissions must be achieved before 2050. The period of 2020 - 2030 is a decisive decade for global economy decarbonization³.

Global political and business leaders are publicly committing their countries, cities, and companies to net-zero emissions and a 1.5°C target. The United Nations' Race-to-Zero campaign has mobilized a coalition of leading net-zero initiatives, representing 733 cities, 31 regions, 3,067 businesses, 173 of the biggest investors, and 622 higher education institutions.⁴ One outcome of the 2021 UN Climate Summit (referred to as COP26) is that 136 countries have pledged to reach net zero, with countries responsible for nearly half of global emissions aiming for a 2050 deadline, while others have target dates further in the future.⁵ The Net Zero Asset Managers initiative, launched in December 2020, aims to galvanize an international group of asset managers committed to supporting investments aligned with the goal of net-zero emissions by 2050 or sooner. As of Dec 2021, this initiative now encompasses 220 signatories globally, thus collectively holding USD \$57.4 trillion in assets under management.

Buildings generate nearly 40% of annual global CO₂ emissions. Across real estate markets globally, building operations are responsible for 28% of total emissions annually, while building materials and construction (typically referred to as embodied carbon) are responsible for an additional 10% of total emissions annually⁶ (Diagram 1). Real estate is

a huge industry. The value of all the world's real estate assets reached \$326.5 trillion in 2020.⁷ As the world's most significant store of wealth, real estate is more valuable than all other global equities and debt securities combined.⁸ Real estate is an extraordinary contributor to carbon emissions. As such, real estate industry players in the construction, development, asset management and investment segments can play a substantial role in finding a solution. Decarbonizing real estate is key to achieving the net-zero economy. The World Green Building Council's Net Zero Carbon Buildings Commitment urges real estate businesses to reach net-zero carbon in operation for all assets under their direct control by 2030, and all buildings to be net-zero carbon in operation by 2050. The real estate industry faces time-sensitive challenges to reduce carbon emissions, while investors and occupiers are making bold commitments at a fast pace, setting ambitious net-zero goals for 2030 or even sooner.

To get the buildings sector on track to achieve net-zero carbon by 2050, all actors across the buildings value chain must increase their decarbonization actions and their impact by a factor of five.⁹ A building does not live a life of its own. The touchpoint of real estate business interacts with many parts of the economy, such as energy, technology, urban infrastructure, finance and investment. Net-zero buildings require systematic change in the economy. In 2019, electricity consumption in building operations represented nearly 55% of global electricity consumption. This underlines the importance of a triple strategy to aggressively reduce energy demands in the built environment while decarbonizing the power sector and implementing materials technology strategies that reduce lifecycle carbon emissions.¹⁰

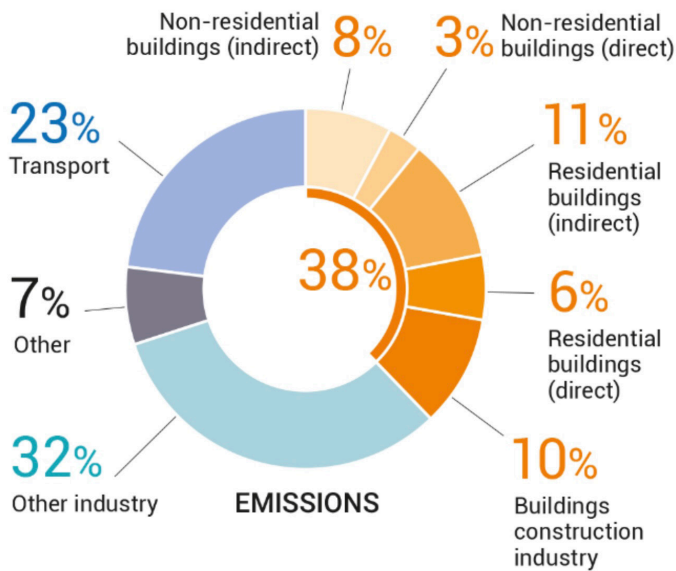


Diagram 1: Global share of buildings and construction emissions, 2019

Source: 2020 Global Status Report for Buildings and Construction. United Nations Environment Program (2020). Dec 16, 2020

With this critical momentum, the MIT Asia Real Estate Initiative 2022 Sustainability Whitepaper focuses on the real estate industry's transition to net-zero emissions. To create a market transition at scale, innovation is inevitable. Academics, scientists and regulators are working hard to calculate carbon externality and hold market players accountable through cost and business risk. Successful market transformation will require a combination of human capital and financial capital with novel solutions wrapped in innovative business models.

COP26, for the first time, had a specific focus on cities, regions and buildings. C40 is a network of mayors of nearly 100 cities collaborating to deliver the urgent actions needed to confront the climate crisis. In 2021, C40's Leadership Standards for 2021-2024 went into effect, setting an ambitious standard for C40 cities to ensure they are on a path to a zero-carbon future.¹¹ C40 cities also played an important role at the COP26, where it was announced that more than 1,000 city and local governments around the world have joined the Cities Race to Zero, committing to limit the global temperature increase to 1.5°C.

Over the next decade, urbanization will continue, particularly in Asia and Africa. According to the most recent estimates from the United Nations, two out of three inhabitants in 2050 will live in urban areas. Most of this urban growth will take place in Asia and the West African urban belt. Cities play an increasingly important role in tackling climate change. Their exposure to climate and disaster risk increases as they grow. Almost half a billion urban residents live in coastal areas, increasing their vulnerability to storm surges and sea level rise. In the 136 biggest coastal cities, there are 100 million people – or 20% of their population – and \$4.7 trillion in assets exposed to coastal floods.¹² Around 90% of urban expansion in developing countries is near hazard-prone areas and built through informal and unplanned settlements. By 2045, the world's urban population will increase by 1.5 times to 6 billion. City leaders must move quickly to plan for growth and provide the basic services, infrastructure, and affordable housing their expanding populations need.

In this white paper, we examine the global real estate market transition that is currently underway, examining eight regions' real estate markets: European Union; North America, Australia; and Asia's China, India, South Korea, Thailand and Singapore. This white paper consists of eight chapters, with each chapter focusing on a new country/region market, we examine 3 key market levers: 1) Public policy; 2) Capital markets; 3) Business innovation in the real estate sector, including real estate technology, i.e. PropTech firms. Each chapter concludes with opportunities and future research questions.

1. Policy

Decarbonization policies are evolving rapidly. Jurisdictions in the EU, US and Canada continue to enact regulations to eliminate carbon emissions. Property owners and investors are facing greater pressure to act.¹³ In 2020, the EU passed its "Renovation Wave" regulations—requiring a 60% reduction of carbon emissions in buildings over the next decade, along with an 18% reduction in heating and cooling demands. Bloomberg New Energy Finance estimates that in Europe alone, this will cost more than \$3 trillion (Coker & Champion 2021). The European Renovation Wave, which followed policy precedents from Los Angeles's 2019 Green New Deal and New York's Local Law 97, pulled the real estate industry into the epicenter of climate change action. Global top cities in all eight countries described here represent the biggest commercial real estate markets in their countries. As such, these cities lead municipal level decarbonization regulations. They are Boston, New York City, Sydney, Melbourne, Seoul, Bangkok, Beijing, Chongqing, Singapore. Their regulation mechanisms are a combination of carrots (incentives) and sticks (mandates), from energy codes, penalties, and mandatory green certification, to tax credit/rebates, subsidies and zoning incentives.

As EU and North America capital markets have been moving from voluntary to statutory ESG reporting requirements, regulations are transitioning towards more stringent, performance based decarbonization mandates. On March 2022 US Securities and Exchange Commission (SEC) proposed that public companies disclose climate-related information in their registration statements and periodic reports 10-k. The most important requirements relate to carbon emissions and physical climate risk exposure. In addition to simply reporting these details, the SEC also expects companies to describe how they're actively managing the associated risks. The new SEC mandate will have significant impacts for publicly traded REITs and knock-on effects for private real estate funds.

European regulation like SFDR (Sustainable Finance Disclosure Regulation), the EU Taxonomy, and US new SEC climate disclosure rules propel the world's two largest real estate markets (US and Europe) into a regulated ESG reality. The era of voluntary disclosures based on arbitrary standards and self-defined approaches will quickly fade away. Market participants will now look to a smaller, legally binding set of prescriptions about what to disclose, when and how. Those real estate firms that adopt outcome-based targets and are able to deliver comprehensive, bottom up, granular, real time, automated and transparent ESG reporting will be those most likely to secure the influx of institutional finance targeting sustainable assets, as capital markets move from voluntary to statutory ESG reporting requirements.¹⁴ Inevitably, such firms which have clear data and PropTech strategies.

2. Capital Market

The Glasgow Financial Alliance for Net Zero (GFANZ) - a group of more than 450 organizations in the financial sector, including banks, fund managers and insurance companies - have pledged to move US\$130 trillion of funds under their control into investments where the recipient is committed to net-zero emissions by 2050. Many organizations are working to establish standards, action plans to implement the net-zero goals. The International Financial Reporting Standards (IFRS) Foundation announced a new International Sustainability Standards Board to develop globally consistent and harmonized climate and broader sustainability disclosure standards for the financial markets. This step has been welcomed by Finance Ministers from more than 50 countries and subsequently received support from the G7 to make climate disclosures mandatory and transparent. The number of ESG regulations has grown over the past decades as more and more governments require green reporting standards. Sustainable Finance Disclosure Regulation (SFDR) became effective on March 10, 2021 as the EU regulatory standard for sustainable investing. SFDR imposes mandatory ESG disclosure obligations for asset managers.¹⁵ Starting from 2025, all fund managers in the UK will be required to adopt the Task Force on Climate-related Financial Disclosures (TCFD), a new international standard for reporting on climate risks. Canada is now considering enacting the standard as well.¹⁶

The capital markets in India, China, Thailand, and South Korea are still in a nascent state compared to the EU, US and Canada. There is little demand for sustainability in real estate investment from domestic capital market investors; however, the trend is catching up. Investors in these Asian markets are gradually warming up to ESG standards. Funding for energy efficiency in the real estate market is primarily driven by government-owned entities and several global financing institutions. A few leading private institutions also have offerings in this segment but their impact has been very limited. Data transparency is also a critical issue in the Asian capital markets in India, China, Thailand, South Korea and Singapore. As one example, although the Thai SEC has stipulated the “One Report” disclosure standard, critics see issues of greenwashing among market participants that use the disclosure as a means of branding rather than taking concrete measures with validated data and performance on emissions and ESG performance.

In China, India, and Thailand, a few green bonds have been successfully issued by infrastructure companies, but no financial products specifically aim to fund net-zero building investments. In India, while several financial institutions have issued green bonds to provide lending for green projects, there has been no specific bond issuance by a real estate developer or by public authorities that earmark the proceeds towards green buildings. China is the second-largest green bond issuer globally. In 2018, China’s internationally aligned green bond issuance reached USD 31.2 billion, accounting for 18% of global volume. These funds invest primarily in green transportation, renewable energy, and clean energy, with only 9% allocated to the building and construction sector. Although green bonds support lower financing costs, extra costs to borrowers are incurred during the process, such as certification expenditures. More green debt instructions and focusing on the building and construction sector and streamlined process is needed.

In China, South Korea, Thailand and Singapore, the national Emissions Trading Schemes (ETS) is considered one of the key financial instruments to achieve emissions targets. **Singapore** is the first Southeast Asian country to implement carbon pricing. The Carbon Pricing Act of 2019 encouraged emissions reductions in all sectors and helped the country transition to a low-carbon economy. In **China**, the national carbon trading market is under development, commercial banks will likely explore a series of financial products and services related to carbon emission reduction indicators and carbon emission quotas. On 1 January 2015, **South Korea** implemented a nationwide emissions trading scheme, the Korea Emissions Trading System¹⁷ in 2015 which was the second-largest energy trading market at that time after EU ETS. **Thailand** has also initiated efforts to establish domestic carbon market mechanisms. Thailand Carbon Neutral Network (TCNN) promote cooperation among government organizations, private sectors, and local communities by creating demands for carbon credit in line with the Thailand Voluntary Emission Reduction Program (T-VER) standards.¹⁸

3. Business Innovation

The EU, US and Canada markets see a booming business case for net-zero buildings. To date, there have been 136 verified and 547 emerging zero energy (ZE) projects in North America, representing over 62.7 million square feet of real estate, a number that has more than doubled in size since 2015. While ZE projects have expanded rapidly to almost every state in the U.S. and every province in Canada, they are largely concentrated in California and the Northeastern United States. Over the past two years, the greatest growth in ZE projects was seen in California, Oregon, New York, and Massachusetts. Publicly- and privately-owned ZE projects have grown at a similar pace, with the public sector continuously leading the market. Government offices, libraries, schools, and universities still account for a large portion of the ZE project list. In EU, US and Canada markets, net-zero energy new construction is becoming mainstream especially in the jurisdictions of Massachusetts; New York City, New York; Austin, Texas, Vancouver, British Columbia; and Toronto, Ontario. In those markets, new net-zero buildings enjoy strong government incentives and can be built with little incremental up-front costs.

As opportunities emerge, there are also challenges. One challenge has been to develop a ZE building in a dense urban context. It is hard for buildings over six stories to generate sufficient electricity onsite from solar photovoltaics (PV) to fully offset their energy usage, no matter how energy efficient. Another challenge is to develop ZE buildings for laboratories, hospitals, data centers, and other high-energy use types. In those situations, building owners must purchase additional renewable energy offsite to reach carbon neutrality.

In Australia, market demand and competition have created a virtuous reinforcement circle to drive change in the private sector. Many private sector players are already ahead of the game and are willing to go down the net-zero path before policy mandates require them to. In the EU, US, Canada and Australia markets, more and more companies are outpacing policymakers in their sustainability ambitions and actions.

Achieving a zero-carbon building for existing buildings requires changes to the operations of and/or retrofitting; for new buildings, it requires new construction methods, with embodied carbon across all

building uses/types. Across the globe, in the earlier green building movement, we saw that the public building segment (also known as MUSH - municipal, university, school and hospital) had the greatest number of early adopters and pioneers in building sustainability. This segment consists of long-term owner occupiers. As a result, it's easier for them to work out financial structures for long-term investments. Commercial real estate, on the other hand, has extra challenges, including meeting short-term return targets, different lease structures, split incentives, etc. In China, India, South Korea, Thailand, and Singapore, few private developer-led net-zero commercial real estate projects exist. Almost all net-zero buildings are funded by the public sector, such as governments or universities, with exemplary projects currently underway in China, India and South Korea.

Leading real estate firms across the globe are investing capital into the technology (i.e. Proptech) solution, such as IOT, AI, Digital Twins to advance energy efficiency, ESG goals and decarbonization. When the real estate industry transition into a low-carbon emission paradigm, environment sustainability expertise, technology and data skills, will become as important as real estate skills and capital-market skills. Any firm that tries to decouple those skills will not only face severe consequences from regulators, but also significant barriers to fulfilling the ESG goals of future investors and raising the capital.

4. Challenges and Opportunities

In 2017, the United Nations Environment Program estimated that the global building floor area is expected to double by 2060, adding more than 2.48 trillion sq ft to the planet in new buildings construction.¹⁹ Asia is driving the global urban development boom. By 2025, more than half of the world's urban population— 2.5 billion people—will live in Asia. In India, 70% of the commercial and high-rise residential buildings that will exist in 2030 are yet to be built in the next 10 years.²⁰ China, the largest building construction market in the world with up to 21.5 billion sq ft constructed annually, will account for nearly 50% of new construction globally in the coming decade.²¹ South Korea is proposing new city development across its nation, bringing large-scale infrastructure and real estate development outside the existing city center.

Asia will also be a big part of the net-zero solution. In COP26, several Asia economies formally committed to a net-zero economy: 2070 (India), 2065 (Thailand), 2060 (China), 2050 (South Korea). Real estate owners, operators, and developers will continue to see opportunities in innovative financial mechanisms that can advance net-zero new construction and net-zero building retrofitting. The first financial lever is an ESG mandate from equity capital. Second is the green financing mechanism from debt investors. Thirdly, carbon credits are one powerful tool to offset the emissions from buildings. Reliable carbon measurement technology and procedures may provide a foundation to launch building decarbonization credits for building sector players. As a result of rapid urbanization, population growth and infrastructure needs, China's estimated climate-smart business investment potential will be \$15 trillion by 2030.²² This includes \$773 billion in new renewable energy, \$12.9 trillion for low-carbon buildings. This creates significant opportunities for generating renewable energy, improving green buildings, and building sustainable cities.

According to the Global Alliance for Buildings and Construction, to achieve the global decarbonization target, net-zero energy and carbon-neutral buildings must become the primary form of new building construction across all economies by 2050. This means prioritizing performance-based, mandatory building energy codes. It also means collective action by all actors along the real estate industry value chain to reduce the demand for material and lower embodied carbon and to adopt nature-based solutions that enhance building resilience. Proptech startups across China, India, South Korea, and Thailand primarily offer brokerage and transaction-based services, with little focus on real estate sustainability. Future opportunities in sustainability-focused Proptech will unfold as the region's real estate industry transitions towards zero-emission buildings.

In urbanized regions such as the EU, US, and Canada, opportunities are focused on accelerating action on building retrofits; developing and implementing decarbonization strategies for refurbishment and retrofits; increasing renovation rates and depth; and encouraging investment. The market transformation at scale can only be achieved when the private sector players have both incentives and capability. The emerging private sector net-zero buildings signal that older assets and new building decarbonization can be financially feasible. Market leaders have already validated the value proposition of decarbonization investment via green premiums and competitive advantage. Investors are creating social and financial returns with sustainability. However, for in-between assets, decarbonization will require that perfectly functioning assets be retired and then replaced with something more efficient, a goal that may not be financially feasible. A 2020 McKinsey Europe report highlighted that 80% of all required retrofits do not yield financial benefit. Spending on energy efficient buildings increased in 2019, the first time since 2016, with investments in energy efficient buildings across global markets increasing to USD \$152 billion. However, this remains a miniscule proportion of the USD \$5.8 trillion spent in the buildings and construction sector.²³ Therefore, the speed of change lags behind overall building construction investment.

Profit of decarbonizing the building sector is not enough to drive change at scale. The real issue is to spur faster and more scalable action. The decarbonization of buildings must rapidly increase in scale and pace to stay on track of the Paris Agreement goal. To support the decarbonization of new and existing buildings, effective policies and regulations are being launched across jurisdictions in the US and the EU to cover the entire building life cycle, including the design, development, operation and decommissioning stages, and also to act beyond site boundaries through neighborhood planning and renewable energy development. To accelerate action, greater collaboration is required across a range of stakeholders, including policy makers, urban planners, architects, construction companies, material suppliers, utility companies, developers and investors.

Highlights of the eight country chapters

Europe

- The European Green Deal 2019 laid out a concrete strategy for reducing the greenhouse gas emissions by at least 55% by 2030 from the 1990 levels. The European Commission formulated and passed the Climate Law 2021 which included a legally binding target of net-zero greenhouse gas emissions by 2050.

- Individual countries, guided by the Paris Agreement mandate as well as the European Union directives and other legislation, are formulating policies to achieve specific goals. The UK, France, Germany and the Scandinavian nations are at the forefront of enabling legislation and implementing programs and funds for the net-zero real estate sector, with the goal of reaching the EU target. The UK has announced that from April 2020 onwards, all privately-rented homes in England and Wales which are required to have an Energy Performance Certificate must have EPC band E as minimum energy performance rating unless a valid exemption has been secured. Wales launched the Optimized Retrofit Programme with £20 million budget and a novel 'whole-building approach' towards decarbonization of homes and social housing.

- 94% of real estate entities (institutional investors, listed property companies, non-listed real estate fund management companies) have defined an ESG policy for their real estate investments. 48% use the GRESB. The main drivers of ESG policies are investor demand, the opportunity to mitigate short- and medium-term risks, and the potential to increase asset value.

- Europe is at the forefront of ensuring the adoption of ESG regulations into business decisions in the commercial real estate sector. Projects have been undertaken to achieve net-zero targets. For example, Aviva Investors announced plans to reach net-zero emissions across its £47.3 billion real estate platform over the next 20 years. Hines European Core Fund (HECF) is another market leader in ESG at the global level. In the River Green Finance deal, Goldman Sachs Group Inc's unit promoted the first-ever European green commercial mortgage-backed securities deal, structured around a €196.2 million loan for an office property in a Paris suburb.

North America

- The policy goal of the United States and Canada is to reach net-zero emissions economy by 2050. In Canada, many major cities like Vancouver and Toronto, as well as provinces such as Quebec, Newfoundland, and Labrador have pledged to decarbonize. In the United States, 23 out of 50 states have created emission-reduction targets and 12 have developed carbon-pricing guidelines, with concentrations in California and the Northeastern United States.

- Approximately 76 percent of American investors have already adopted or are considering adopting ESG criteria. The value of ESG in real estate includes enhanced returns, risk management, and compliance with ESG regulations. The United States, led by the government-backed mortgage giant Fannie Mae, is the largest source of green bonds in the

world. There are 21 green banks across the United States. These financing vehicles have generated \$1.69 billion in 2020 to reach \$7 billion in cumulative green bank investment, growing at their fastest pace in years.

- In recent years, more than a dozen real estate companies, including office REIT, Boston Properties; industrial REIT, Prologis; data center REIT, Equinix Inc.; real estate services, Colliers International Group Inc., etc., have made net-zero pledges and aligned their sustainability strategies with the objective of achieving net-zero emissions by 2050.

- Emerging PropTech sectors are catalyzing the transition to net-zero buildings. These include: energy-as-a-service; building management and automation; heating and cooling technologies; advanced building materials; distributed energy solutions; carbon reporting; smart facades and windows; and lighting technologies.

- A 2019 RMI report finds the cost increase to build a zero-energy or zero-energy-ready home is modest—far less than consumers, builders, and policymakers realize—and highlights methods builders and policymakers can use to drive increased market penetration. Costs are expected to continue to decline over time as this market matures.²⁴ Federal tax credits and other local incentives are available in both Canada and the United States to offset the cost for energy saving features. Massachusetts is a national leader in affordable zero-energy buildings. Zero-energy buildings being built in Massachusetts bear zero additional up-front costs given today's incentive structure.

Australia

- At COP26, Australia released the Long-term Emissions Reduction Plan to reach net-zero carbon emissions by 2050. At the forefront of the public sector initiatives are local municipalities such as the City of Sydney or City of Melbourne, both of which have the highest degree of control through Local Environmental Plans that guide land use and management. The Commercial Building Disclosure (CBD) Program requires that landlords or agents obtain a Building Energy Efficiency Certificate (BEEC) before any commercial building goes on the market for sale, lease or sublease.

- ESG investing is on a strong upward trajectory, with investment in environmentally sustainable properties showing substantial growth. Investors and portfolio owners are starting to adhere to more stringent green strategies with many equity investors in the real estate sector; in particular, the Australian Stock Exchange (ASX) listed real estate developers and owners to recognize the value of investing in sustainability, with many investors committing to net zero.

- Lenders within the Australian debt market are recognizing the value of incorporating ESG criteria in their lending decisions as this can lead to cheaper wholesale funding through the issuance of green bonds. Such investments mitigate risk given that the value of sustainable loan collateral is more resilient and of higher value. Furthermore, green investments help lenders achieve internal ESG targets within their own organizations. There is however a shortage of sustainable financing in the Australian market. This shortage may be attributable to issuers not knowing what assets qualify.

- According to the latest Global Real Estate Sustainability Benchmark (GSREB), the Australia and New Zealand real estate market is the wor-

ld's greenest, with Australia topping the GSREB rankings for an 11th consecutive year. Much of its' success can be attributed to the private sector already being ahead of the game as they recognized the value of sustainability early on and were willing to pursue net-zero goals before these elements the public sector push.

- As a growing market with strong competition and high demand, the real estate sector has responded in new and innovative ways through the development and implementation of newer technologies with a focus on sustainability. Examples include the use of digital twins, cross-laminated timber, glue-laminated timber, green walls, heliostats, trigeneration and district cooling plants.

- There is a growing interest in the use of timber in building construction to tackle the issue of embodied carbon. The commercialization of timber as a key resource for achieving net-zero carbon buildings can be accelerated especially for high rise construction

China

- In 2021, China's State Council issued the "Action Plan for Carbon Dioxide Peaking Before 2030", which proposed to accelerate updates to the energy efficiency of buildings, municipal infrastructures, and other standards to improve energy savings and carbon reduction requirements. According to the Action Plan, by 2025, green building standards will be fully implemented in new buildings in urban areas.²⁵ Since 2010, China's central government has carried out 87 low carbon pilots, comprising 81 cities and six provinces. More than 60 of these pilots have committed to peak carbon emissions before 2025. Beijing has stated it will maintain a steady decline in carbon emissions after peaking in 2021–25. Various provinces and cities have also rolled out measures and regulations to attain decarbonization goals.

- China has gradually required listed companies to disclose ESG information. However, quantitative information appears insufficient in most real estate companies' ESG reports: only 31% of them released an independent ESG report, with only 3.36% of the ESG reports have been assured by an independent third-party auditor.

- China is the second-largest green-bond issuer globally. In 2018, China's green-bond issuance reached US\$31.2 billion, accounting for 18% of global volume. However, only 9% is allocated to the building and construction sector. Green bonds show less flexibility than conventional corporate bonds and require greater building specifications, reducing the number of potential issuers. Ample opportunity remains for Chinese real estate companies to issue green bonds to achieve green development targets.

- China is implementing significant policies to address climate change, including restricting coal consumption. The cumulative investment potential for the construction of new green buildings in China may be around \$13 trillion by 2030. As carbon reduction is mostly driven by the public sector, China's current exemplary net-zero building projects are primarily public buildings, with minimal engagement by high-quality private developers. Market leader firms include Hang Lung Properties, Link REIT, and Swire Properties. Mainland real estate companies are gradually focusing on reducing carbon emissions, while still in search of an action plan and pathway.

India

- With the recent net-zero commitment by the Indian government at COP26, the fine print for net-zero buildings is still awaited and is expected to be rolled out over the course of the next few years. Current policies focus on net-zero energy buildings through energy conservation and the use of renewable energy. The Energy Conservation Building Code 2017 governs compulsory and optional energy-saving measures during the design, construction, and operation of commercial buildings. Green building and net-zero energy building ratings have been emerging across the country.

- Equity financing options for green and net-zero buildings are limited. Venture capital is available through the Bureau of Energy Efficiency and capital subsidies are available through the Indian Renewable Energy Development Authority. There are few investments by the International Finance Corporations in equity of Banks for onward lending for green real estate projects. Debt financing is available primarily from government institutions and public sector banks with early interest by some private banks. The recent emergence of REITs and green bonds suggests the possibility of future growth. The Reserve Bank of India is likely to issue licenses for Green Banks in the near future.

- Business innovation in net-zero buildings is primarily dominated by government-sponsored projects. Examples include Indra Paryavaran Bhawan, New Delhi, and the Indian Institute of Technology, Jodhpur. Early interest has been exhibited by private players such as Godrej Group and Infosys. These buildings are financed through internal company accruals. Developers such as Godrej Properties, DLF, Lodha Group, etc. have voluntarily disclosed their ESG initiatives in their annual ESG reports. Godrej Properties is the leading developer with a GRESB score of 95/100.

- Despite having a significant number of proptechs, there is a limited presence of proptechs addressing construction and property management sustainability and net-zero buildings.

- The real estate sector will require a huge infusion of capital over the next decade in order to achieve growth in green bonds, green banks, and sustainability-focused REITs. The capital requirement is high for both developers as well as proptechs. There is great potential for collaboration with local players in terms of technology and capital.

Thailand

- Climate change is currently addressed at the highest policy level under the National Strategy, and a plethora of regulations, acts and plans have been promulgated by the Thai government. Thailand has a large network of governmental bodies that focus on its climate change issues; energy consumption in the building sector is one of the key elements of the bigger picture. The Bangkok Climate Change Master Plan specifically aims to reduce GHG, including many FAR incentives and tax rebates for green-certified real estate projects.

- While the Thai SEC has stipulated some renewed reporting standards, Thailand lacks pragmatic financial instruments and sophisticated financial markets to support the development of green buildings. Thailand is, however, on track to establish carbon pricing, trading and offsetting scheme, as well as environmental taxation.

- Two private real estate developers and construction material manufacturers have taken the UNFCCC Race to Zero campaign pledge: Charoen Pokphand Group and Siam Cement. Several real estate firms, including Central Group, AWC, LPN, and Pruksa Real Estate have taken initiatives to reduce the carbon footprints of their projects.

- There are many exemplary projects, new and retrofitted, that demonstrate Thailand's endeavor toward sustainable urbanization, but they're by and large focused on green-certified buildings. Thailand currently has no net-zero buildings. Thailand, and especially Bangkok, is highly vulnerable to climate change impacts. But its real estate sector has not yet focused on adapting to climate change. Electricity consumption in the building sector almost doubled in the past decade, becoming the most rapidly increasing sector in terms of electricity consumption. Few case studies suggest Thailand's real estate sector is adapting to climate change except flood-prone areas.

- PropTech startups in Thailand are mainly centered around brokerage and transaction-based services, with little focus on real estate sustainability. Thailand also lags in terms of real estate climate-tech (i.e., solar energy and geothermal harvesting, next-gen building materials and novel construction methods, technologies to enhance existing buildings' resilience to climate change). Future investment opportunities lie in green building construction/management, and also nascent renewable energy applications in real estate. Further research is needed regarding the development and market acceptance of green technology.

South Korea

- There are robust policy frameworks on both the national level and in big cities in South Korea. The Paris Agreement is a transition point in the country's policy setting. After the Paris Agreement, policies were enacted more frequently and goals became stricter and more ambitious. Key policies include: Korean New Deal and The 2050 Carbon Neutral Strategy of The Republic of Korea.

- South Korea implemented the Zero Energy Building (ZEB) Standard in 2017. According to the Mandatory ZEB Implementation Roadmap, ZEB will become a compulsory certification for new public buildings in 2020. By 2030, all new buildings with a total floor area of more than 5380 sqf will comply with the zero energy building code. A limited number of ZEB certifications were implemented before it became a mandatory standard. The mandatory ZEB certification will substantially affect the development of the Korean real estate market.

- Established in 2019, The Smart City Act regulated city development and provided a sandbox for developers to try out new technologies for green city development. It is another driving force to accomplish city-level emissions reduction through infrastructure improvement, energy monitoring and management through technologies and building regulations.

- While sustainability is always a philosophy embraced by big developers, ESG is a new concept. Few developers have established ESG strategies. This is likely to change as capital market investors are actively adopting ESG in their investment strategies. Other finance mechanisms have been promoted by the government to advance real estate sustainability. These include green debts, the emission trading system, and the Green Growth Trust Fund.

- Zero energy projects are mostly driven by the government. Government-owned development corporations play an important role in developing pilot projects. Private developers are actively pursuing zero energy developments, but the overall number is limited. One public sector led new city example is the zero-energy city development known as OCEANIX City. The city of Busan, UN-Habitat and OCEANIX have partnered to build the world's first sustainable floating city prototype off the coast of Busan. OCEANIX City will house 10,000 residents across 75 hectares and is poised to become the world's first resilient and sustainable floating community.

- South Korea has leading information technologies but its proptechs in energy and sustainable development sectors are still limited. ICT technologies and infrastructure bring zero-energy sector innovation opportunities. New public-private cooperation will accelerate the implementation of zero energy policies as well as investment in sustainable material, construction, supply chain, new and renewable energy.

Singapore

- Singapore published a Long-Term Low Emissions Development Strategy in April 2020, with the goal of halving emissions from their peak in 2030 to 30 Mt CO₂e by 2050. Singapore is the first Southeast Asian country to implement carbon pricing. In the Singapore Green Plan's Greener Infrastructure and Buildings, Singapore agrees to: 2025 targets:

- Reduce energy consumption of desalination process from current 3.5kWh/m³ to 2kWh/m³
- Integrate waste and used water treatment facility to be 100% energy self-sufficient (Tuas Nexus)

2030 targets:

- Green 80% of Singapore's buildings (by gross floor area) by 2030
- Ensure 80% of new buildings (by gross floor area) to be super low energy buildings from 2030
- Build best-in-class green buildings to see an 80% improvement in energy efficiency (over 2005 levels) by 2030

- The Monetary Authority of Singapore (MAS) announced in 2021 that it will spend US\$1.8 billion (about S\$2.4 billion) in climate-related investment opportunities. Singapore Budget 202 will issue green bonds for S\$19 billion worth of infrastructure projects, bolstering the nation's ambitions to transition to a low-carbon economy and become a leading green finance hub in Asia and beyond.

- Singapore is taking action in three main areas in order to counteract greenwashing and, as a result, improve the credibility of the green finance sector. From 2023, the Singapore Exchange (SGX) proposes that obligatory climate reporting be implemented in (i) financial, (ii) agriculture, food and forest products, and (iii) energy sectors. From FY 2024, the (iv) materials and buildings and (v) transportation sectors must follow suit.

- In 2017, SGX began voluntarily recommending the Task Force on Climate-related Financial Disclosures (TCFD) framework for sustainability reporting. SGX is the first Asian exchange to propose enforcing climate disclosures in accordance with the TCFD recommendations.

- So far, Singapore has only two zero-energy buildings. One was developed by the National University of Singapore and the other is Keppel Bay Tower by Keppel Land. It's Singapore's first Green Mark Platinum (zero energy) commercial building. Keppel Land took advantage of a BCA grant to test five new and emerging energy-efficient technologies in Keppel Bay Tower. These technologies aim to significantly reduce the building's energy consumption and improve its energy efficiency by 20% compared to other BCA Green Mark Platinum buildings. Keppel Bay Tower was certified as a Green Mark Platinum (zero energy) skyscraper by the Building and Construction Authority (BCA) in 2020. It is Singapore's first commercial building to receive this honor.

Notes

1. STATUS REPORT: BUSINESS AMBITION FOR 1.5° C RESPONDING TO THE CLIMATE CRISIS, <https://sciencebasedtargets.org/resources/files/status-report-Business-Ambition-for-1-5C-campaign.pdf>
2. In this report, as we quote literature from various industrial, governmental and cultural contexts. "Carbon", "CO2" and "Greenhouse gas (GHG)" are used interchangeably. The term "carbon" is sometimes used as a shorthand expression to refer to either just CO2 or to greenhouse gases in general. There are different GHGs and carbon is one of them. We acknowledge converting CO2 to carbon does not allow comparisons between different GHGs, in the way that converting to CO2e does. It is less and less common to see CO2 emissions reported in terms of "carbon", though shorthand terms such as "carbon accounting" and "low carbon economy" are still used as popular proxies for "GHG accounting" or "low GHG economy".
3. Decarbonizing the Built Environment, JLL, June 2021
4. The United Nations Framework Convention on Climate Change: <https://unfccc.int/climate-action/race-to-zero-campaign>
5. <https://zerotracker.net/>
6. 2020 Global Status Report for Buildings and Construction. United Nations Environment Programme (2020). Dec 16, 2020
7. Source: The total value of Global Real Estate. Savills, from <https://www.savills.com/impacts/market-trends/the-total-value-of-global-real-estate.html>, Paul Tostevin, September, 2021
8. Source: The total value of Global Real Estate. Savills, from <https://www.savills.com/impacts/market-trends/the-total-value-of-global-real-estate.html>, Paul Tostevin, September, 2021
- 9 & 10. 2020 Global Status Report for Buildings and Construction. United Nations Environment Programme (2020). Dec 16, 2020
11. Statement by the C40 Cities Steering Committee on the organisation's new Leadership Standards. C40. January 6, 2021
12. World Bank: <https://www.worldbank.org/en/topic/urbandevelopment/overview#1>
13. Global status report for buildings and construction 2019, IEA from <https://www.iea.org/reports/global-status-report-for-buildings-and-construction-2019>, December 2019
14. Pi Labs. 2021. Transparency Through Technology.
15. Source: Why real estate investors can make a real difference to climate change, from <https://www.schroders.com/en/middle-east/professional-investor/insights/markets/why-real-estate-investors-can-make-a-real-difference-to-climate-change/>, Kristina Foster, August 16 2021
16. Source: ESG and Real Estate: The top 10 things investors need to know, CBRE, from <https://www.cbre.com/insights/reports/esg-and-real-estate-the-top-10-things-investors-need-to-know#environmental>, October 18, 2021
17. ets.krs.co.kr
18. <https://enviliance.com/regions/southeast-asia/th/th-ghg>
19. Towards a zero emission, efficient, and resilient buildings and construction sector, Global Status Report 2017, https://www.worldgbc.org/sites/default/files/UNEP%20188_GABC_en%20%28web%29.pdf
20. Role of Green Buildings in Sustainable Constructions, Tathagat & Dod, 2015
21. Analysis of the Chinese Market for Building Energy Efficiency, US Department of Energy, 2014, https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22761.pdf
22. Climate Investment Opportunities in Emerging Market, An IFC Analysis, 2016
23. 2020 Global Status Report for Buildings and Construction. United Nations Environment Programme (2020). Dec 16, 2020
24. The Economics of Zero-Energy Homes, 2019, RMI, <https://rmi.org/insight/economics-of-zero-energy-homes/>
25. Action Plan for Carbon Dioxide Peaking Before 2030. The State Council, China's cabinet. 2021

Part 2. Regional Chapters

Chapter 1. European Union

Real Estate Industry Overview

The European Union (EU) with its 27 member countries (Diagram 2), has been at the forefront of taking actions to achieve net-zero carbon emissions per the United Nations Framework for Climate Change (UNFCCC) protocols. The EU, whose GDP of US\$18,736.85 billion, is one of the largest and most advanced real estate markets. The composition of the real estate investment sector is 42% offices, 15% retail, 14% residential, 12% industrial, 10% hotels, and 7% other.¹ Cumulatively, the commercial real estate market is valued at US\$8119.49 billion, of which US\$513.25 billion derives from 530 listed companies. Among these companies, the market cap for real estate investment trusts (REIT) is US\$243.55 billion among 225 companies. The non-REIT market cap is \$269.70 billion and consists of 305 companies. The overall stock market size of the EU is US\$13 trillion. Leading REITs in Europe, shown in Diagram 1 for the year 2019, by market size,² include Venovia SE, Segro REIT PLC, GE CINA REIT, Covivio SA, and Klepierre REIT SA. The leading real estate investment managers (see Diagram 1) in Europe by assets under management are Swiss Life Asset Managers, AXA IM-Real Assets, Blackstone Group, Credit Suisse, and the CBRE Global Investors.³

Leading real estate investment managers in Europe as of 2019, by assets under management (USD billion)

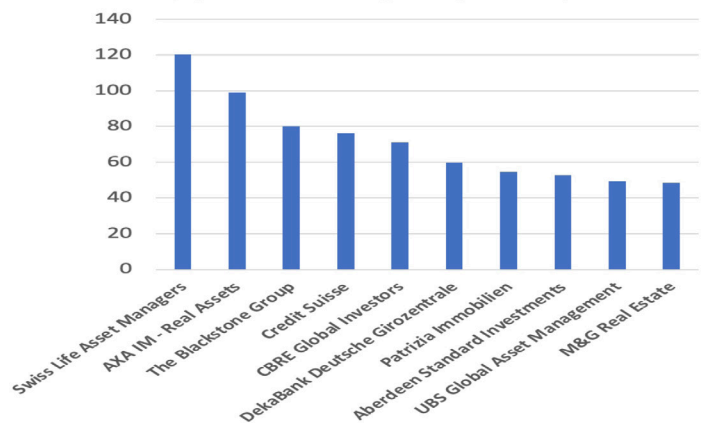


Diagram 1: Investment Managers in Europe

Source: <https://www.statista.com/>

European cities have consistently been at the top in almost all sustainability ranking indexes worldwide. In the 2018 Arcadis' Sustainable Cities Index, among the top 50 cities, more than half (27) are European cities. Thirty-five percent of the EU's buildings are older than 50 years. Seventy-five percent of the buildings are energy inefficient. Of these old buildings, hardly 1% are renovated every year.⁴ Although the renovation rate is very low as of now, the building renovation and refitment sector can play a major role in emission reduction, because renovation of existing buildings can reduce the EU's total energy consumption by 5%–6% and lead to reduced CO₂ emissions of approximately 5%.

Distribution of property investment in Europe in 2019, by sector (in billion GBP)

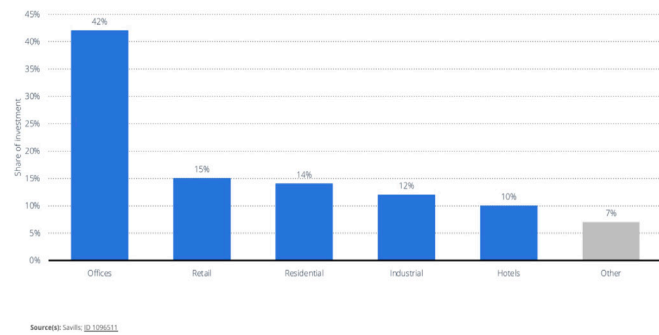


Diagram 2: Property Investments in Europe

Because of the direct relationship between investments in energy efficiency and the consequent stimulus in the economy, a business case exists for energy-efficient building. The construction industry provides 18 million direct jobs and contributes 9% of Europe's GDP. The significance of the refitment and renovation market for the economy becomes all the more salient with the acknowledgment that it can boost the SME sector, which contributes more than 70% of the value-added works in EU's real estate sector.⁵

1. Policy

1.1 EU Policy Landscape and governance

After the 2015 Paris Agreement, the European Commission announced the European Package 2016, aimed at integrating the internal energy market of the EU, focused on energy efficiency, and planned to take climate action through eight new laws by the respective member states. The 2019 European Green Deal laid out a concrete strategy for reducing greenhouse gas (GHG) emissions by at least 55% by 2030 from the 1990 levels, ensured review of each of the existing climate laws, and intended to introduce new legislations.⁶ The European Commission formulated and passed the Climate Law 2021, which included a legally binding target of net-zero GHG emissions by 2050, including measures to track the progress of member states and provisions to review all the climate laws every five years.⁷

1.2 Policy Highlights

Post 2000, the first major initiative toward regulating and minimizing the energy usage of buildings was the directive passed by the European Parliament in 2002 on the energy performance of buildings. The directive aimed to give impetus to more efficient energy performance of buildings in the EU through the following five aspects:

- 1) A general methodology framework to arrive at the total energy performance of buildings;
- 2) Requirements for the energy performance of new buildings;
- 3) Requirements for the energy performance of already built stocks that were undergoing major renovation;
- 4) Energy certification; and
- 5) Regular inspections and assessments of heating installations, boilers and air-conditioning systems.

Energy Performance of Buildings Directive (EPBD) (2003, 2010, 2016, under review) → Renovation Wave Strategy, 2020

Energy Efficiency Directive (EED) (2012, 2018, 2021) ↔ Renewable Energy Directive (RED) (2009, 2018, 2021)

↕
 • Emission Trading Scheme (ETS)
 • Social Climate Fund

Diagram 3: EU Legislative Framework for Buildings

Regarding the real estate sector, as shown in Diagram 3, EU has three mutually reinforcing directives⁸: the Energy Performance of Buildings Directives (EPBD - 2003, 2010, 2016, 2022), the Energy Efficiency Directive (EED - 2012, 2018, 2021), and the Renewable Energy Directive (RED - 2009, 2018, 2021). These three broad directives are aided by the EU's Renovation Wave Strategy, which was passed in October 2020, as well as the Emission Trading Scheme (ETS) and the Social Climate Fund (SCF). Together, the five directives and the strategy aim to achieve a highly energy-efficient and decarbonization building stock by 2050, create a stable environment for investment decisions, and enable consumers and businesses to make more informed choices to save energy and money.

Energy Performance of Buildings Directives (EPBD)

directs all EU member countries to establish a strong multi-year long-term renovation strategy that aims to decarbonize the building sector by 2050 and requires each member state to indicate milestones for 2030, 2040, and 2050, with the strategies to be aligned with the energy-efficiency targets set under the respective countries' National Energy and Climate Plans. As per the directive, all new building buildings must be nearly zero-energy buildings (NZEB) from December 31, 2020, with the same criteria for new public buildings already in place since December 31, 2018. Also, issuing energy performance certificates (EPC) whenever a building is sold or rented out.

Energy-Efficiency Directive (EED)

EU countries should ensure energy-efficient renovations for at least 3% of the total floor area of buildings that are owned and occupied by the central government departments. The directive also recommends that the concerned national governments only purchase highly energy-efficient buildings. The directive after the 2021 revisions introduces higher targets for reducing primary (39%) and final (36%) energy consumption by 2030, which are now binding at the EU level, in line with the climate target plans, and introduces a system of benchmarking for member states so that they can set their national indicator contribution to the binding EU target. In the UK, the heating of buildings, which is primarily done with natural gas, is responsible for nearly 25% of emissions in the UK. Much of it comes from homes, and the UK is considered to have the oldest and least efficient housing stock in Europe, with almost two thirds of homes ranked at the bottom of EPC ratings (as mentioned in Diagram 7).⁹ Further, the Energy Efficiency (Private Rented Property)

(England and Wales) Regulations 2015 mandates from April 2020 onwards that all privately rented homes in England and Wales that are required to have an EPC must have EPC band E as a minimum energy-performance rating unless a valid exemption has been secured.

Renewable-Energy Directive (RED)

aims to increase the current EU-level target of renewable-energy sources in the overall energy mix from at least 32% to at least 40% by 2030, which also means the current renewable-energy share of 19.7% shall be doubled in just a decade. As per this directive for buildings, a new benchmark of 49% renewables to be ensured by 2030, and for the industry, a new benchmark of a 1.1-percentage-point annual increase in renewables use, and for heating and cooling, the existing indicative 1.1-percentage-point annual increase becomes binding on member states

1.3 Regional Policy Highlight

The directives mentioned in the above section mandate each member state to come up with their own legislation for defining the specific procedures for calculation and the bare minimum requirements for energy performance, as well as the scale of certification. At the same time, the European Commission mandates the European Committee for Standardization (CEN) for developing and adopting various methodology standards as well as calculation frameworks for integrated energy performance of buildings.

The City of Vienna has created climate-protection areas where new buildings can only be built with a climate-friendly energy-supply system, and 80% of new buildings' heating and cooling system shall be built in climate-friendly manner.

In November 2020, Wales launched the £20 million Optimised Retrofit Programme based on a "whole-building approach" aimed at decarbonization of homes and social housing.¹⁰ Wales also mandated energy-efficiency rules for new social home,s with the target of building 20,000 high-quality, low-carbon homes over the next five years.

In 2019, the UK issued the Future Homes Standard for England by 2025, which ensures new homes are future-proofed with low-carbon heating and high levels of energy efficiency. The UK also came up with the £1 billion Public Sector Decarbonization Scheme, which provides funds for decarbonization of public sector buildings. Similarly, the UK's Social Housing Decarbonization Fund (£800 million) and the Home Upgrade Grant (£950 million) make funds available toward the energy performance of low-income households. The £60 million Net Zero Innovation Portfolio (NZIP) Heat Pump Ready Programme aims to promote innovation in the heat pump sector.

The city of Oslo has come up with the novel concept of promoting district heating using biofuels and the city's carbon-free electricity.

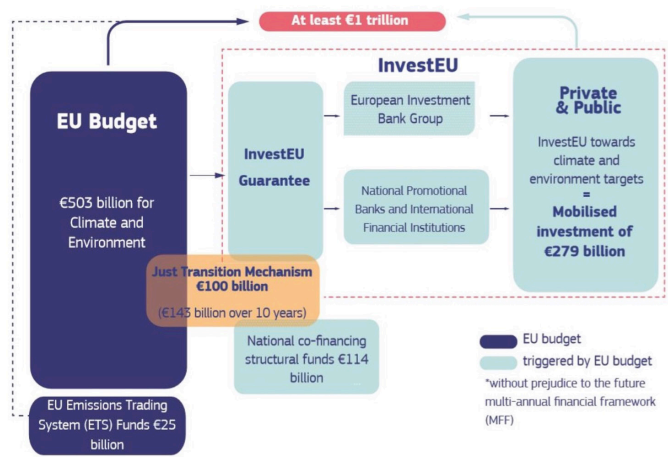
The city of Berlin has initiated a broad shift in its heating program by improving the energy mix as well as energy efficiency through the **Energy Saving Partnership** program, in which private companies are involved for improving the energy efficiency of public buildings.

The Netherlands has pledged to stop its reliance on natural gas for residential heating by 2050. It is the first country to commit to such a goal.

2. Capital Market

The EU has put in a financial framework (see Diagram 4) to achieve the net-zero targets and has come up with multiple building blocks for the sustainable financial framework to transform the real estate industry. These building blocks are as follows:

WHERE WILL THE MONEY COME FROM?



*The numbers shown here are net of any overlaps between climate, environmental and Just Transition Mechanism objectives.

Diagram 3: EU Legislative Framework for Buildings

1. Disclosure framework for non-financial and financial companies: It is a mandatory-disclosure regime providing investors with information to make informed sustainable investment decisions. Disclosure requirements under this regime consider not just the effect of a company's work on the environment and society, but also the business and financial risks owing sustainability exposures (also known as the "double materiality" concept). In this context, the European Commission has adopted a delegated act under the Taxonomy Regulation specifying the information to be disclosed by financial and non-financial undertakings concerning their environmental performance based on the EU Taxonomy.

2. Investment tools, including benchmarks, standards, and labels: These elements enable financial market participants to align their investment strategies more easily with the EU's climate and environmental goals. They provide greater transparency to market participants. These goals are the objectives of both the EU Climate Transition Benchmarks and the EU Paris-aligned Benchmarks, created by the EU Climate Benchmarks Regulation.

3. International Platform on Sustainable Finance (IPSF): Article 20 of the Taxonomy Regulation creates a "platform on sustainable finance." Launched in October 2019, the platform is an advisory body composed of experts from the private and public sector. It advises the European Commission on the various technical screening criteria under the EU taxonomy. In addition, this platform also monitors and gives reports on the quantum of capital used for sustainable investments. IPSF aims to upscale private capital mobilization in the direction of environmentally sustainable investments.

Private building renovation program financing models in Europe:

- **Renovation loan program:** Under this program, the banks are invited to lend funds for energy-efficiency renovations in buildings and are mainly provided to housing associations, with guarantees issued by a public financial institution alongside financial incentives in the form of grants to incentivize energy savings. Starting this loan program requires the creation of a fund and public sourcing of equity to test the concept. Public guarantees to financial institution may be needed to attract financiers. Funds can also be complemented or replenished with the issue of specialized bonds, such as green bonds, as well as by ETS allowances or similar carbon trading instruments.

- **Urban development fund:** This fund selects and finances projects based on public objectives, and it can focus on a single area of investment or fund projects in several areas simultaneously.

- **Energy Services Company:** This company uses EPC to offer energy-efficiency services.

Within the overall broad classification mentioned above, the following is an overview of the various funds that have been made available for the undertaking of various projects:

- **European Structural & Investment Fund (ESIF):** These funds are the main policy tools for investment, under which six main funds work together across all EU countries. Under ESIF, €17.6 billion has been granted towards energy efficiency projects and improvements to public and residential buildings.

- **Horizon 2020 program:** This program is a major funding source for research and innovation projects. It provides grants for energy-efficiency research and can cover the costs of testing new technologies as well as new business models. Under this program, €101 million was made available in 2017.

- **Project Development Assistance:** This program is a funding source for supporting public authorities in developing robust and reliable sustainable-energy projects. It has two components:

a) **European Local ENergy Assistance (ELENA)** for large-scale sustainable energy investments. Under these investments, different sub-projects exist, which are managed by either the European Investment Bank (EIB), KfW (the German development bank), the Council of Europe Development Bank (CEB), or the European Bank for Reconstruction and Development (EBRD).

b) **Mobilising Local Energy Investments—Project Development Assistance (MLEI-PDA)** aims to help public- and private-project promoters come up with sustainable-energy investment projects valued between €6 million and €50 million.

c) **Fi_compass** is a platform which delivers advisory services to assist agencies in setting up financial instruments that are provided jointly by the European Commission and EIB.

- **Finance mechanisms:**

d) **Energy Service Companies (ESCOs)**, under which the remuneration is dependent on the quantum of energy savings generated for the clients. As a result, users invest in energy-efficiency strategies without paying for the whole investment. A mature ESCO landscape

is found in countries such as Austria, the Czech Republic, France, and Germany.

e) **Energy-Performance Contracting**, under which an external organization executes the energy-efficiency project and uses the stream of income from the reduction in energy consumption to repay the up-front costs of the project. The energy-using company only receives payment if the measures implemented deliver the expected energy savings.

2.1 Equity and Debt Schemes

- **European Fund for Strategic Investments (EFSI):** This fund is the most important mechanism for investment plans in Europe and provides guarantees for first loss to enable the EIB group to undertake investment decisions in risky projects. This guarantee-assurance encourages the inflow of private finance in sustainable real estate projects. This fund has so far mobilized €546.5 billion in investment, benefiting over 1.4 million SMEs.

- **Private Finance for Energy Efficiency:** This joint collaboration between EIB and the European Commission makes available a financial instrument that can provide debt financing for energy efficiency. This instrument has two key components—the Risk Sharing Facility and the Expert Support Facility—that can be combined with an EIB loan and can still avail the low refinancing costs of EIB.

- **European Regional Development Fund (ERDF):** This fund offers grants, equity, and debt instruments for various energy-efficiency projects and programs.

- **European Social Fund (ESF):** This fund focuses on softer aspects such as education and training to build competencies for undertaking energy-efficiency projects.

- **European Regional Development Fund (ERDF):** This fund provides grants as well as indirect funding. The grants can be used to subsidize the costs incurred in the operations of energy-efficiency buildings. This subsidization helps the direct beneficiaries of the project by reimbursing part of the renovation costs. Its flagship Joint European Support for Sustainable Investment in City Areas was started in 2011 to assist urban areas in initiating regeneration programs. Under the indirect funding component of ERDF, agencies can take advantage of risk capitals, loans for setting up revolving funds, or seed funding.

- **Green Energy Finance Facilities (GEFF):** This organization helps local partner financial institutions as well as homeowners take advantage of credit lines for energy-efficient as well as green building projects. Along with credit lines, those using this fund are also provided technical assistance and low-intensity grants. As of now, the GEFF program is available through a network of more than 120 local financial institutions in 24 countries, and it focuses on the industrial, municipal, residential, and commercial sectors. One of the showcase projects under this funding mechanism is the **Residential Energy Efficiency Credit Line** for Bulgaria. It gives loans to homeowners associations, utility companies, and banks for undertaking initiatives for energy-improvement projects in residential buildings.

- **Latvian Baltic Energy Efficiency Facility:** This fund is supported by the EBRD and was set up with the aim of purchasing receivables from

completed and certified ESCO. Under it, resident associations and public building managers can engage with ESCOs to undertake energy-efficiency upgrades by accessing requisite financing.

2.2 Green Bonds

The European Green Deal Investment Plan (2020) led to the establishment of a green bond standard and initiated the process for a legislative proposal by the European Commission. The European Green Bond Standard is a voluntary standard to help scale up and raise the environmental ambitions of the green bond market.¹¹ Once it is adopted by co-legislators, this proposed regulation is expected to set a gold standard for how companies and public authorities can use green bonds to raise funds through capital markets to be able to finance large-scale investments, all while meeting strict sustainability requirements as well as protecting investors.

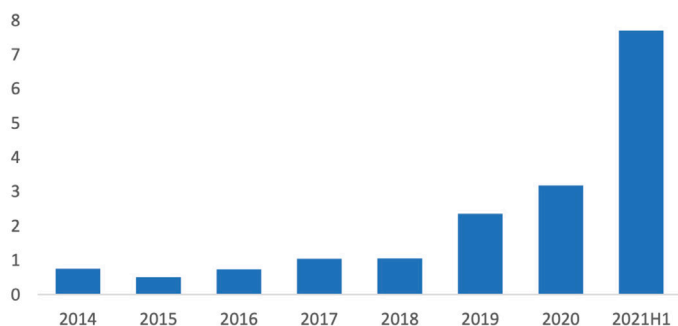


Diagram 5: Total Issued Green Bonds by Country (EUR, billion)

Source: EPRA, Bloomberg, TR-Eikon and S&P

The EU is on the path to becoming the largest green bonds issuer after announcing its target of reaching 30% of the **NextGenerationEU recovery plan** using green bonds. The targeted sectors are renewable energy, energy efficiency, clean transportation, and R&I supporting green transition.¹² The economy will see an interjection of €250 billion investments in green bonds being facilitated through the recent legal-framework policies of the EU Climate Taxonomy and the European Green Bond Standards, which are encouraging the financial markets to go for more sustainable financial products, as well as ensuring greater information and clarity on the companies' sustainable economic activities for the benefit of investors and companies.¹³

One study conducted by EPRA shows the green bonds landscape in the listed real estate (LRE) sector has grown significantly in recent years, from €0.8 billion in 2014 to almost €7.7 billion (first half of 2021; see Diagram 9). The study highlights that the main goal of green issuance is to enable further investments in renovation and upgrades, along with achievement of decarbonization targets. In fact, a total of €17.3 billion in green bonds were issued between 2014 and the first half of 2021. The most active companies belong to the Nordic countries, representing 41% of total green bonds issued during this period. As Diagram 10 shows, "twelve Swedish companies have issued green bonds valuing EUR 4.6 billion representing 27% of the total amount of issued green bonds, followed by four French companies (EUR 3.5 billion, 20%). The other countries active in green bonds issuance (over EUR 1 billion) are the Netherlands (15%), Germany (9%), Finland (8%) and the UK (6%) (as can be seen in Diagram 10)."¹⁴

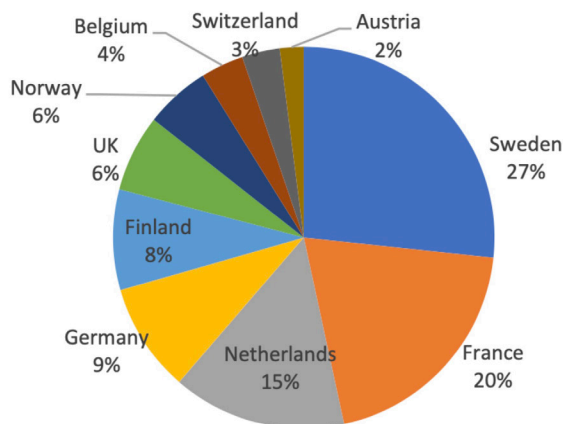


Diagram 6: Total Issued Green Bonds by Country (EUR, billion)

Source: EPRA, Bloomberg, TR-Eikon and S&P, based on FTSE EPRA Nareit Ground Rules for nationality definition

In the **River Green Finance** deal, Goldman Sachs Group Inc's unit promoted the first-ever European green commercial mortgage-backed securities deal, structured around a €196.2 million loan for an office property in a suburb of Paris.

Green Investment Banks

To create a high impact from relatively limited public resources, a new form of financial institutions, often termed green banks or green investment banks (GIBs), have been created by over a dozen national and sub-national governments. These financial entities use innovative transaction structures, risk-reduction, and transaction-enabling techniques, in addition to local knowledge and market expertise, to lead private and institutional investments toward a domestic low-carbon, climate-resilient infrastructure. The most prominent GIBs in Europe follow:

- **UK Green Investment Bank:** This bank was conceived as a means to meet ambitious emissions targets and became operational in 2012. It was supported by a £3 billion fund from the UK. The bank's agenda was to lead UK's transition to a green and sustainable economy through the creation of an institution that was independent of the government. Currently, it is owned by the Macquarie Group Limited.
- **Technology Fund Switzerland:** This fund aims to ensure funding for projects in the environmental and low-carbon technologies landscape that might be facing a deployment gap due to fund constraints.
- **Nefco:** Nefco is an international financial institution that finances the initial scale-up of Nordic green solutions on international markets. Founded in 1990, it is considered the world's first green bank. Nefco serves the financial investment needs of Iceland, Denmark, Finland, Norway, and Sweden.

3. Business Innovation

Europe is at the forefront of ensuring the adoption of ESG regulations into business decisions in the commercial real estate sector. Multiple projects have been undertaken to achieve net-zero targets:

Net-Zero Projects

Gare Maritime, Brussels¹⁵: Conversion of an old rail transit station into a mixed-use building

Extensa, a Belgian real estate company, renovated and remodeled the Gare Maritime railway station in Brussels into an energy-efficient, sustainable state-of-the-art mixed-use building. The project aimed to incorporate the highest sustainability standards while utilizing the land value of the building that was located at the center of an up and coming district. The project underscores the strategic impact created due to bundling and aggregation of decarbonization technologies. The renovation was done using 10,000 cubic meters of alternative building materials such as wood, which led to a saving of 3,500 tonnes of CO₂. The structure was then fitted with complementary energy-efficient and renewable technologies, such as 10,000 solar PV panels, 10 geothermal energy wells, 21,300 cubic-meter rainwater collection tanks, and 3,000 square meters of indoor gardens.

Enel X's San Mauro Torinese Municipality Project¹⁶

Enel X led a project along with the municipality of San Maru Torres to retrofit and digitalize the various municipality buildings with the objective of reducing operating expenses of the municipality and enhancing the energy efficiency of the various buildings. The buildings included those of public offices, Townhall and sports facilities. Multiple emission-reduction and renewable technologies were employed, such as building insulation, retrofit solutions, LED lighting, on-site renewable generation, gas boiler hybrid heating systems, and so on. IoT platforms were used to integrate multiple data sources such as weather forecast environmental data of temperature and humidity, as well as hardware performance and energy consumption. The platform enabled efficient energy usage through fixed temperature set points and early detection of operating anomalies and malfunctions.

Multiple Net Zero Projects in London, UK

The Forge, a new office block in London, is the first office building in the UK to adhere to the UK Green Building Council's net-zero buildings framework. Similarly, Paradise, which is a timber frame office, is a net-zero carbon building because it sequesters the carbon of the timber which it has used. Another project in London, called the Gherkin¹⁷, attempted to recreate sea sponges in the built environment to enhance its structural strength and reduce ventilation, cooling, and heating energy requirements. It created shafts to enable heat exchanges as well as sunlight penetration deep inside the building.

Hamburg's Bio-Intelligent Quotient House¹⁸

Just like the Gherkin in London, the Bio-Intelligent Quotient House in Hamburg, Germany, took inspiration from nature for its building design, and it generates passive energy using algae biomass present on the buildings' façade, where algae habitate on the water-filled windows. The façade absorbs the light not used by the algae to generate energy for hot water and heating.

Freiburg, Germany's Solar Settlements¹⁹

Freiburg, Germany, has several settlements that power their energy usage completely from solar. They require very little energy for heating, and many of them are energy-plus homes and generate more renewable energy onsite than what they need and are able to sell the energy back to the municipal utility.

4. Opportunities

Electricity storage: Europe supports the development of a domestic green battery value chain consisting of high-performant, safe, and sustainable battery cells with the lowest environmental footprint possible. An example is the **TILOS island project**, winner of two EUSEW 2017 awards (EUSEW=EU Sustainable Energy Week) for a hybrid power plant, combining the use of sun and wind together with big battery systems and introducing a smart energy management system on the island. Additionally, **BATCircle project** (Finland) focuses on the up-scaling of metallurgical and chemical processes and improvement of current commercial processes recovering metals.

The EU currently imports more than half of its energy, mainly in the form of oil and gas. With an external energy bill averaging €300 billion over the last two years, the EU has enormous potential to significantly reduce its imports of fossil fuels and increase its energy sovereignty. The new electricity market design resulting from the **Clean Energy for all Europeans package** will also ensure a more stable EU energy market in future, by making the electricity market in the EU better suited to variable and intermittent renewable energies. With these new rules, the trading of electricity can be done almost in real time. Through a wide range of structural investments—notably, those identified as **Projects of Common Interest** (which are eligible for EU funding)—cross-border connection projects have increased significantly over the past decade. Some other initiatives dealing with pan-regional net-zero innovations are the following:

- **Sero – Zero-Carbon Buildings²⁰**—Sero, a sustainable real estate company, provides home technology solutions that cover “whole-life solutions for Net Zero’ covering buildings, energy, construction and financing. It aims to create homes which can support themselves intelligently supporting the wider energy system, with a vision for “comfort-as-a-service offerings that cover heat, power and transport for consumers.”

- **The Nordic Swan Ecolabel** scheme is available for around 60 product groups and 200 different product types and more than 25,000 different products, from detergents to buildings and real estate. The label helps and guides the consumers and professional buyers to make procurement decisions based on environmental considerations. The scheme sets life-cycle-based environmental requirements, as well as requirements for chemical usage in the products.

- **The Smarter Tariffs**—Smarter Comparisons project, UK, has developed an open-source, smart-tariff comparison tool that, along with supporting research and development findings, is available to consumers and industry. This tool gives precise and independent tariff recommendations that are based on actual usage data that are recorded by consumers' smart meters (or from the household information). These tools give consumers the information they need to switch to the

best deals and, at a system level, integrate new technologies with renewable-energy sources.

Although the EU has been at the forefront of sustainable real estate regulatory mechanisms, funding, financial instruments, and innovation, much of the development is happening in Western Europe. Further research into the disconnect within the European market between Eastern and Western Europe in terms of their robustness and proactive approach is needed, particularly regarding regulations, initiatives, and frameworks. Although the EU acts as the nodal agency for many of the developed countries, non-EU members seem to be getting left behind in funding, coordination, and knowledge.

About the Author



Vineet Abhishek

Vineet Abhishek is a first-year Master of City Planning candidate at the Massachusetts Institute of Technology and is focusing on integrated transportation, infrastructure, and municipal financing. He is an urban rail transport professional with more than nine years of experience managing the commercial and operational aspects of railway services in Mumbai, India.

Real Estate Industry Overview

The US ranks as the second most valuable residential market after China and accounts for 11% of the global residential value, or \$28 trillion. The global commercial real estate value in 2020 reached \$32.6 trillion. As the largest commercial property market, the US accounts for 27% of global commercial real estate value, or \$8.8 trillion.¹

In the US, the real estate industry provided the largest GDP (Q1 2021), at more than \$4 trillion, according to the Bureau of Economic Analysis.² In Canada, the Real Estate and Rental and Leasing (RERL) industry accounted for more than 13% of GDP growth,³ reaching a level of \$266.09 billion as of October 2021, up from \$261.66 billion the prior year.⁴ The recent housing boom has driven the sector to surge 20% faster than GDP, with residential investment hitting a record high at \$247.9 billion in Q1 2021, a 42.4% increase from previous year.⁵

According to MSCI's report, the size of the professionally managed global real estate investment market in 2020 grew to \$10.5 trillion from \$9.6 trillion in 2019, with the US and Canada constituting 38% of the market size. On a year-over-year basis, the market size of the United States and Canada increased by 6.8% and 0.8%, respectively, to \$3,650.6 billion and \$363.9 billion in 2020, totaling \$4 billion, while EMEA (Europe, Middle East, Africa) and Asia Pacific increased by 13.4% and 8.3% to \$3.6 trillion and \$2.8 trillion, respectively (Diagram 1). However, the US continued to be the largest market, and Canada moved up to the seventh position.⁶



Diagram 1: Change in National Market Sizes between 2019 and 2020, USD Billion

Source: Real Estate Investment Market 2020/21, MSCI from <https://real-estate-find.com/combining-as-part-of-real-estate-enterprise/>

In the face of climate risk, investing in the real estate market today may require adoption of decarbonization strategies. To achieve the global decarbonization target, net-zero-energy and carbon-neutral buildings must become the building standard across all economies by 2050. To date, North American has 136 verified and 547 emerging zero energy (ZE) projects, representing over 62.7 million square feet of real estate, which is more than double in size in 2015. ZE projects have expanded rapidly to almost every state in the US and every province in Canada, with concentration in California and the Northeastern US (refer to Diagram 2). In the past two years, the greatest growth in ZE projects has occurred in California, Oregon, New York, and Massachusetts (refer to Diagram 3). Publicly and privately owned ZE projects are growing at a similar pace, with the public sector continuously leading the market. Government offices, libraries, schools, and universities account for a large portion of the ZE project list. In the private sector, several conglomerates, such as Google, Apple, and Amazon, have entered the ZE market (refer to Diagram 4). More than 100 distinct building types incorporate

ZE projects, with the education and office sectors accounting for 58% of all projects (refer to Diagram 5). In terms of building size, larger ZE projects are becoming more popular, with over 35% having more than 50,000 square feet (refer to Diagram 6).⁷

A rapid increase in the number of ZE project is critical to avoid a global climate crisis. According to Grand View Research Inc., the global ZE building market is projected to grow to \$78.8 billion by 2025.⁸

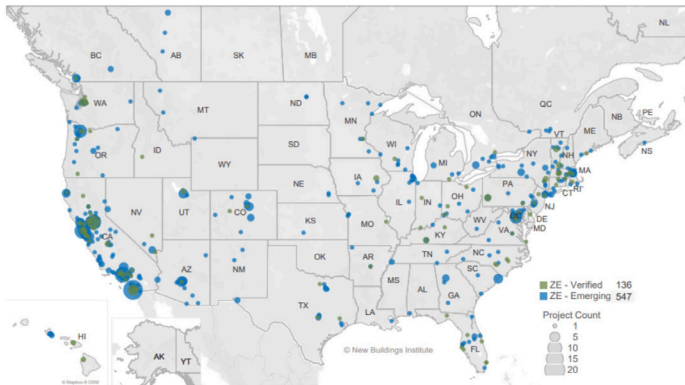


Diagram 2: 2020 Zero Energy Project Locations

Source: 2020 getting to Zero buildings list, New Buildings Institute, from https://new-buildings.org/wp-content/uploads/2020/09/NBI_GTZ-List_2020.pdf

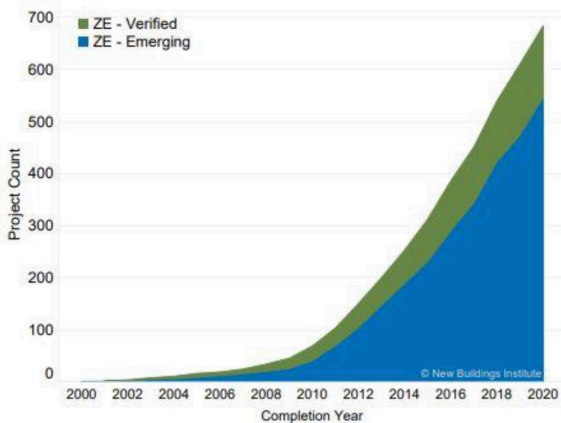


Diagram 3: Zero Energy Project Growth

Source: 2020 getting to Zero buildings list, New Buildings Institute, from https://new-buildings.org/wp-content/uploads/2020/09/NBI_GTZ-List_2020.pdf

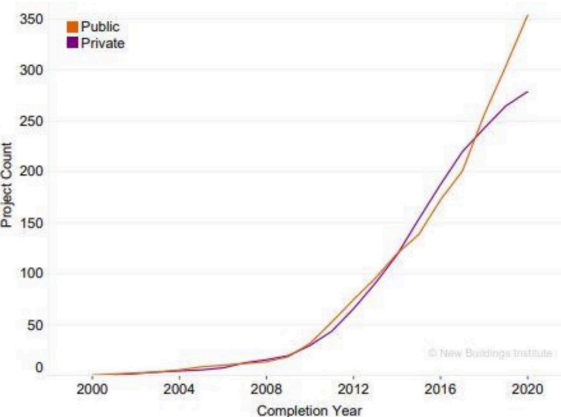


Diagram 4: Zero Energy Project Growth by Sector

Source: 2020 getting to Zero buildings list, New Buildings Institute, from https://new-buildings.org/wp-content/uploads/2020/09/NBI_GTZ-List_2020.pdf

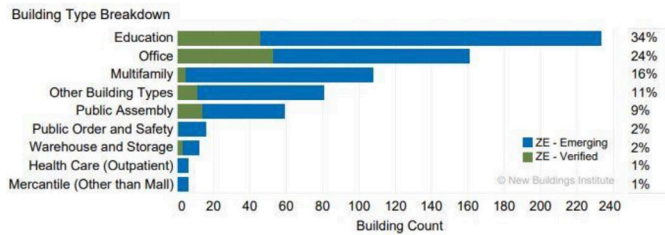


Diagram 5: Zero Energy Building Types

Source: 2020 getting to Zero buildings list, New Buildings Institute, from https://new-buildings.org/wp-content/uploads/2020/09/NBI_GTZ-List_2020.pdf

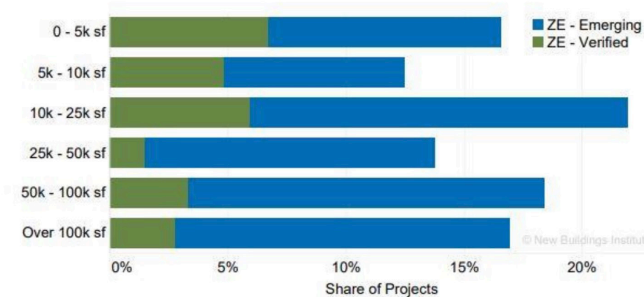


Diagram 6: Size Distribution of Zero Energy Projects

Source: 2020 getting to Zero buildings list, New Buildings Institute, from https://new-buildings.org/wp-content/uploads/2020/09/NBI_GTZ-List_2020.pdf

1. Policy

The US and Canada aim to reach net-zero emissions as an economy by 2050. In Canada, many major cities such as Vancouver and Toronto, and provinces such as Quebec and Newfoundland and Labrador, have pledged to decarbonize. The National Energy Code of Canada for Building (NECB) was adopted on November 1, 2016, as part of the commitment to reduce greenhouse gas (GHG) emissions and improve the energy efficiency of Canadian buildings. The NECB directly impacts the design and construction of numerous building components and systems, including building envelope, electrical, and mechanical systems.⁹

In the US, the International Code Council updated its building energy codes to meet the requirements of the 2021 International Energy Conservation Code (IECC), which incorporates crucial improvements for both commercial and residential buildings over the 2018 edition, including ZE appendices, to align with the global goal of reducing GHG emissions and increasing energy efficiency. Since 2006, the IECC has achieved 40% energy-efficiency improvement. Because the Biden Administration set the goal of ZE building for new buildings by 2030 and all buildings by 2050, national, state, and local governments must enact energy codes to meet their GHG reduction targets.¹⁰ As of 2021, 23 of the 50 states had created emission-reduction targets and 12 had developed carbon-pricing guidelines.¹¹ Emission trading systems (ETS) are one of the main forms of carbon pricing initiatives. State-based emission trading programs include California's Cap-and-Trade Program (California's key strategy to cut greenhouse gas emissions) and the Regional Greenhouse Gas Initiative (RGGI), whose collaborating jurisdictions

include Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont, and Virginia (refer to Diagram 7).¹²

| State | Requirements, Goals, and Commitments |
|---------------|---|
| Connecticut | Public Act 18-82 (2018) added a mandatory emissions-reduction target of 45% below 2001 levels by 2030 to a mandatory emissions-reduction target of 80% below 2001 levels by 2050. |
| Delaware | GHG emission reduction target is a 26% to 28% reduction by 2025 from 2005 levels. |
| Maine | Legislation (2019) requires GHG emission reductions of 45% by 2030 and 80% by 2050 (from 1990 levels). Executive order signed to make state carbon neutral by 2045. |
| Maryland | The Department of the Environment's 2030 Greenhouse Gas Emissions Reduction Act Plan (2021) would achieve a 50% reduction by 2030 without accounting for anticipated new federal government policies to reduce emissions. |
| Massachusetts | Legislation (2021) requires the state to achieve net-zero emissions by 2050. In addition, the law stipulates two interim benchmarks: by 2030, emissions must be 50% lower than they were in the state in 1990, and by 2040, they need to be 75% lower. |
| New Hampshire | The state's economy-wide aspirational goal is to reduce GHG emissions 80% below 1990 levels by 2050. |
| New Jersey | The state's economy-wide emissions goal (NJ PACT) and the Global Warming Response Act (2019) require the reduction of economy-wide emissions to 1990 levels by 2020 and 80% below 2006 levels by 2050. New Jersey has achieved its 2020 emissions target. |
| New York | The Climate Leadership and Community Protection Act (2019) sets GHG emissions limits of 40% below 1990 levels by 2030 and 85% below 1990 levels by 2050, as well as a goal of net-zero emissions across the economy by 2050. |
| Rhode Island | The 2021 Act on Climate established economy-wide GHG emissions-reduction targets of 45% below 1990 levels by 2030, 80% below 1990 levels by 2040, and net-zero emissions by 2050. |

| State | Requirements, Goals, and Commitments |
|----------|---|
| Vermont | The Global Warming Solutions Act, Act 153 (2020), requires the state to reduce GHG pollution to 6% below 2005 levels by 2025, 40% below 1990 levels by 2030, and 80% below 1990 levels by 2050. |
| Virginia | The Virginia Energy Plan established a goal for the Commonwealth to reach net-zero emissions by 2045. |

Diagram 7: Climate Goals and Commitments of the RGGI Participating States

Source: Climate goals and commitments of the RGGI participating States, from https://www.rggi.org/sites/default/files/Uploads/Climate-Commitments/RGGI_State_Climate_Commitments.pdf, The Regional Greenhouse Gas Initiative, September 2021.

Major incentives are given to homeowners as well as building owners to shift to efficient electric appliances such as electric space and water heating systems. The municipal governments also regularly update building codes to require the use of any energy-efficient and emission-reducing technologies as they become readily available and more affordable.

Listed below are some of the cities with significant zero-emission efforts and policies:

1. In **Sacramento, California**, the city council adopted a framework for existing building electrification (Resolution No. 2021-0166) on June 1, 2021, requiring the existing structures to be transitioned to carbon-free electricity by 2045.¹³ On the same date, the council also adopted the New Building Electrification Ordinance, requiring new constructions to be fully electric no later than January 1, 2026¹⁴. These plans signify a significant commitment by the city to achieve carbon neutrality by 2045.

2. In **Davis, California**, the city council set a goal of carbon neutrality by 2040, which is five years ahead of the state of California's target. Davis City Council passed a new Residential Energy Reach Code in October 2019, which provides incentives for all-electric homes, and a new Non-residential Energy Reach code in April 2019, which requires solar photovoltaics on all new non-residential construction, any high-rises, multi-family homes, and electric vehicle charging on new developments.¹⁵

3. **Portland, Oregon** launched a Zero Cities Project in 2017, aiming to help the city implement equitable strategies to reach a net-zero-carbon building sector by 2050. The Zero Cities Project has evolved into a larger movement, "Building Community, Shifting Power" (Build/Shift), which prioritizes improving rental housing and collaborates with the Bureau of Planning and Sustainability (BPS) to make progress toward building decarbonization.¹⁶ The City also enacted HR 2180 EV-ready building codes for new construction in multi-family, mixed-used, and commercial properties.¹⁷ The city has seen a 42% decrease in carbon emissions per person, while population and job growth have increased at a similar rate since 1990, showing a city can experience significant growth while drastically decreasing emissions.¹⁸

4. **New York, New York** has a pending legislation that will prohibit natural-gas usage in new buildings starting in 2023 for smaller buildings and in 2027 for buildings over seven stories tall. By 2027, energy-efficient emissions-free sources such as electricity must be used for appliances, space heaters, and water boilers. According to a study by RMI, this bill will reduce carbon emissions by around 2.1 million tons by 2040, equivalent to 450,000 cars' worth of annual emissions.¹⁹

5. **Boston, Massachusetts** prides itself as the most energy-efficient city in the US, as rated by the American Council for an Energy-Efficient Economy.²⁰ In September 2022, the city passed a new ordinance, requiring all buildings 20,000 square feet and larger to reach zero carbon emissions by 2050. The ordinance is applicable to 4% of the properties, representing 60% of the building emissions in Boston.²¹

6. **Austin, Texas** has set a target of net-zero emissions by 2040, with some short-term plans of, by 2030, (i) achieving net-zero carbon emissions for all new buildings, (ii) diminishing carbon emissions of existing buildings by 25%, (iii) reducing all natural gas emissions by 30% in Austin-based buildings, (iv) reducing construction carbon emissions by 40%, and (v) requiring 80% of new non-residential construction to be built within the city's central activity centers.²²

7. **Vancouver, British Columbia** has set a target of zero emissions for new buildings by 2030. Vancouver's city council outlined four strategies to achieve this goal: Limits, Leadership, Catalyse, and Capacity Building. The first strategy aims to categorize thermal energy limits and GHG by building type and lower them to zero. The second strategy of leadership is displayed when City-led building projects show zero emission building tactics. The third one creates tools that catalyze major private builders and developers to display effective methods to construct net-zero-emission buildings. Lastly, Centre of Excellence for Zero Emissions Building is created to increase the building capability of the entire industry by using information distribution and skills-development tools to share how to accomplish this target. Ideally, these four strategies will result in most new buildings in Vancouver having no operational GHG emissions by 2025 and all new buildings having no GHG emissions by 2030.²³

8. **Toronto, Ontario's** city council has set a target of reducing the city's 2050 GHG emissions to 20% of the 1990 levels. Renewable and district energy generation will be increased to curb emissions and reduce demand on the existing energy-production infrastructure. The city's Zero Emissions Building Framework outlines three goals to diminish the environmental footprint of buildings and develop their adaptability to climate change: (1) decrease the general energy requirement from the developed ecosystem to reduce energy expenditures for consumers by improving buildings' energy efficiency; (2) shrink GHG emissions by utilizing lesser carbon energy sources to incorporate district energy structures when applicable; and (3) increase the thermal longevity of buildings in the face of both natural and man-made adverse events. If successful, the city's framework will allow new buildings in Toronto to produce zero emissions by 2030.²⁴

2. Capital Market

Institutional investors have continued to focus on ESG when making investment decisions, and investment managers are repositioning their strategies in response. According to CBRE's 2021 Americas Investor Intention Survey, approximately 76% of investors have already adopted or are considering adopting ESG criteria (refer to Diagram 8), although the adoption level is still behind EMEA's. Institutional investors allocate 25% to 30% of their capital to ESG, inspiring other types of investors to follow the trend (refer to Diagram 9).²⁵ Obviously, ESG has now moved from a "nice to have" to "have to have" for managers and their institutional clients.

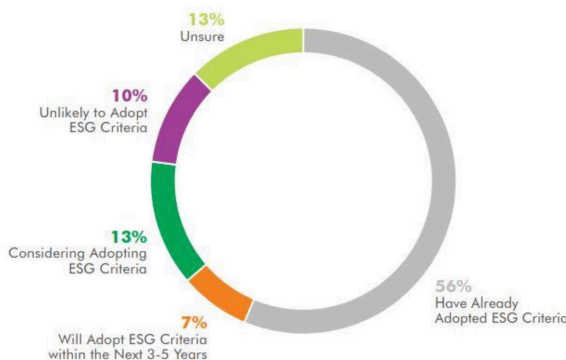


Diagram 8: ESG Investing

Source: Americas Investor Intention Survey 2021, CBRE, from http://cbre.vo.llnwd.net/grgservices/secure/AMS%20IIS%202021_Report.pdf?e=1641576428&h=76e1512169fdf95fdc63d047c6fe0e90

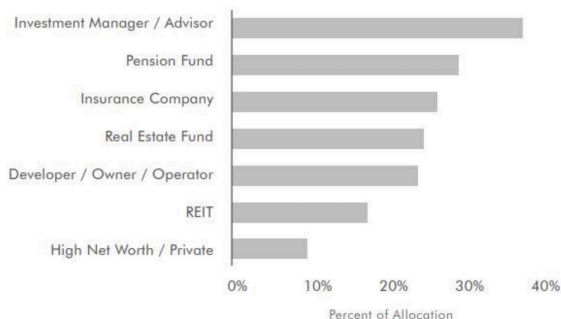


Diagram 9: Capital Allocation to ESG

Source: Americas Investor Intention Survey 2021, CBRE, from http://cbre.vo.llnwd.net/grgservices/secure/AMS%20IIS%202021_Report.pdf?e=1641576428&h=76e1512169fdf95fdc63d047c6fe0e90

Responses to ESG investing vary by region. Institutions based in the Americas (i.e. North America and South America) have lagged behind some of their global peers in having ESG policies. However, the Hodes Weill & Associates' report showed a year-over-year jump in formal ESG policies from 36% in 2020 to 39% in 2021. EMEA-based institutions have led the industry in ESG, with 72% of institutions reporting they have a formal policy in place (refer to Diagram 10).²⁶

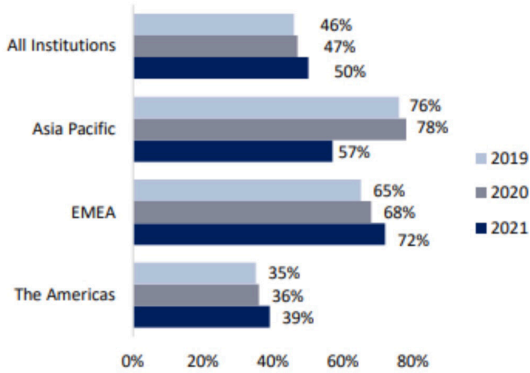


Diagram 10: Formal ESG Policies by Location of Institution

Source: 2021 Institutional Real Estate Allocations Monitor, Hodes Weill & Associates and the Cornell Baker Program in Real Estate, https://5f4e89a9-4c6c-44a4-b3f3-9fb-2b125ff9e.filesusr.com/ugd/abfec0_0576c6d1cc264004aef377252ff4f068.pdf

Although slower to adopt formal ESG policies, the North and South America-based institutions made significant progress in ESG implementation in 2021, with 37% of institutional investors reporting that their investment process was influenced by ESG policies—a 15% increase from 2020. The increasing importance of the role of ESG policies in decision-making has been recognized globally, with 49% of all institutions reporting their investment decisions are influenced by ESG, compared with 36% in 2020. As in the prior year, EMEA-based institutions have continued to be industry leaders in turning policies into practice, with 79% of institutions reporting being influenced by their ESG policies (refer to Diagram 11).²⁷

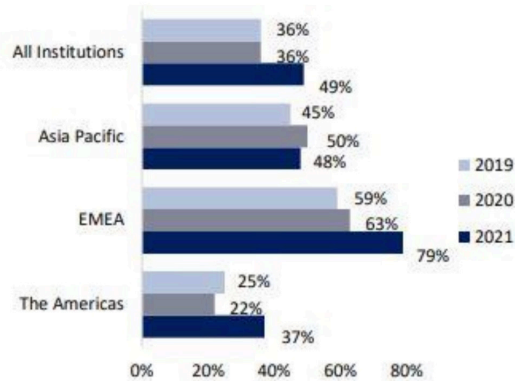


Diagram 11: Investment Process Influenced by ESG Policies by Location of Institution

Source: 2021 Institutional Real Estate Allocations Monitor, Hodes Weill & Associates and the Cornell Baker Program in Real Estate, from https://www.origoinvestments.com/files/pensionfund-cre-article_bisnow_05.21.pdf

ESG objectives are fully aligned with investor incentives, and a sustainable investment strategy can achieve a wide range of benefits during the investment cycle. Below are three main factors that can explain the value of ESG in real estate in the US and Canadian market:

1. Enhanced returns: Tackling carbon emissions from real estate will increase building efficiency, resulting in higher rents, lower costs, and more interest from tenants, which can lead to overall better returns for investors.

2. Risk management: The current trend of shifting toward sustainable investment has made “doing nothing” not an option. Increased obsolescence or the vacating of properties that do not meet sustainability standards will affect asset value. For example, extreme heat in many regions (one of the results of climate change) is driving demand for air conditioning and contributing to higher operating costs for buildings. The longer-term consequences of climate-related risks can lower the value of unsustainable assets. Older properties with poor energy efficiency are particularly vulnerable, leading to a “brown discount” in property value. ESG investment can protect future value and liquidity as occupiers increasingly shy away from properties with subpar environmental performance.

3. ESG regulations: The number of ESG regulations has grown over the past several decades as more and more governments require green reporting standards. Sustainable Finance Disclosure Regulation (SFDR) became effective on March 10, 2021, as the EU regulatory standard for sustainable investing. SFDR imposes mandatory ESG disclosure obligations for asset managers, and both private and institutional investors have fully embraced the need for action to limit the worst impact of climate change and to overcome growing inequality globally.²⁸ In addition, starting from 2025, all fund managers in the UK will be required to adopt the Task Force on Climate-related Financial Disclosures (TCFD), a new international standard for reporting on climate risks. Canada is considering enacting the standard as well.²⁹ Because of the tendency toward tightening compliance, investors have to guarantee they have the knowledge to remain in control of a rapidly shifting regulatory environment.

Several real estate investment trusts (REITs), led by Boston Properties, Equinix, and Prologis, have prioritized ESG:

1. Office REIT Boston Properties is a front-runner in green buildings. It has earned an overall ESG rating of A from MSCI and recently received a top ESG rating in the 2021 Global Real Estate Sustainability Benchmark. The highest scores have been attained by the Company in numerous areas, including data monitoring and review, targets, policies, reporting, and leadership. The highest LEED certification levels of Gold and Platinum have also been achieved across its 27-million-square-foot portfolio. Additionally, Boston Properties has executed several energy-conservation projects, including solar-panel installation in its office buildings, as a step toward achieving carbon-neutral operations by 2025. All these efforts have helped diminish GHG emissions by 70% while reducing site energy-use intensity by 27% since 2008.³⁰

2. Perhaps surprisingly, data center REIT Equinix is also a leader in ESG given how much water and energy data centers consume. However, the Company has put great effort into designing, building, and operating data centers with high energy-efficiency standards. It has also established a long-term goal of utilizing 100% clean and renewable power on its global platform. Equinix is considered a leader in human capital development, privacy and data security, and has received an AA rating from MSCI.³¹

3. Industrial REIT Prologis earned an AA rating from MSCI as well, partially because it's a leader in human capital development. Its Community Workforce Initiative allows the Company to partner with a non-profit organization to train employees for jobs in transportation, distribution, and logistics. One of several ESG goals Prologis has set is

to train 25,000 individuals by 2025. In addition, the Company aims to achieve zero-carbon construction globally and diminish its overall emissions by more than 15% by 2025. To meet the target, Prologis plans to implement 400 megawatts of solar capacity on its buildings and adopt 100% LED lighting for its global portfolio by 2025.³²

Green bonds serve as another main tool to finance green initiatives, such as green buildings. Since their debut in 2007, global green-bond issuance has grown dramatically, reaching \$1 trillion in December 2020, and cumulative market size is projected to hit \$5 trillion by 2025. Various global initiatives, such as the Paris Agreement and the United Nations Sustainable Development Goals, have resulted in extraordinary growth.³³

The US, led by the government-backed mortgage giant Fannie Mae, has the largest source of green bonds in the world (refer to Diagram 12).³⁴ In 2020, Fannie Mae, the largest green-bond issuer, offered \$13 billion in green bonds, bringing its total to \$88 billion since 2012. Its green bonds have contributed to total resource savings of 9.5 billion Kilo British Thermal Units of energy consumption, 8.5 billion gallons of water, and 634,000 metric tons of GHG emissions.³⁵ Freddie Mac, another government-sponsored enterprise, also provides green bonds, and its volume reached \$3.3 billion in 2020. Its five-year-old initiative, Green Advantage, was created to serve older housing stock (mostly affordable and workforce housing properties) in need of energy-efficient upgrades. Through September 2020, the program had achieved a total of \$60.7 billion in volume over 596,000 units, per government-sponsored enterprise (GSE).³⁶

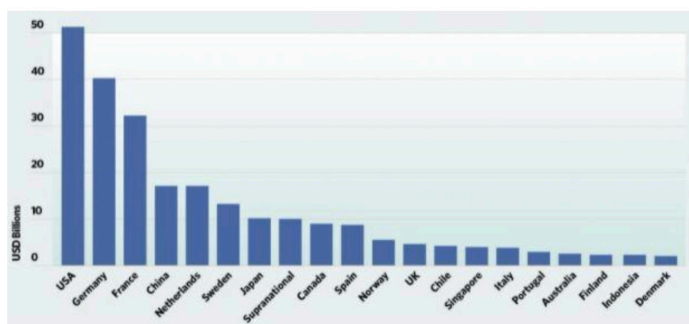


Diagram 12: Top 20 Countries for Annual Green Bond Issuance

Source: Record \$269.5bn green issuance for 2020: Late surge sees pandemic year pip 2019 total by \$3BN, Climate Bonds Initiative, from <https://www.climatebonds.net/2021/01/record-2695bn-green-issuance-2020-late-surge-sees-pandemic-year-pip-2019-total-3bn>, Liam Jones, January 24, 2021

Green banks emerged as another form of “green lending” to finance CRE sustainability projects. Connecticut launched the first American green bank in 2011. To date, the US has 21 green banks, according to the 2021 U.S. Green Bank Annual Industry Report by American Green Bank Consortium. These financing vehicles generated \$1.69 billion in 2020 to reach \$7 billion in cumulative green-bank investment, growing at their fastest pace in years.³⁷

3. Business Innovation

3.1 Leading Real Estate Companies

More and more commercial real estate companies in the US and Canada are joining the race to carbon neutrality in the aftermath of the COVID-19 pandemic. Driving forces to transition to net-zero CO2 emissions include increasing pressure from institutional investors to address ESG issues, employees of real estate companies pushing management to develop sustainability approaches, and tenants increasingly picking buildings that have sustainability features. In recent years, more than a dozen real estate companies have made net-zero pledges and aligned their sustainability strategies with the objective of achieving net-zero by 2050.³⁸ Below is a list of leading real estate companies in each sector.

1. **Office REIT Boston Properties**, the global leader of Class A office properties, aims for carbon-neutral operations by 2025. To achieve its goal to reach net zero, the company has adopted four main strategies: (i) One-third of its total carbon emissions are expected to be reduced through more energy-efficient operations by 2025; (ii) the company will create onsite renewable-energy systems, offsite renewable-energy procurement, and voluntarily transition to 100% renewable green tariffs and community choice aggregation programs; (iii) the company will fully electrify onsite gas-fired systems; and (iv) carbon will be offset to the extent necessary, with the remaining emissions being offset during the transition to carbon-free energy.³⁹

2. **Data center REIT Equinix Inc.**, the world’s digital infrastructure company, has set a science-based target (SBT) for emissions reduction across its global operations and supply chain by 2030. Aligned with the Paris Climate Agreement, its commitment to carbon neutrality is crucial to ensuring Equinix continues to invest in innovations that curb GHG emissions and keep global warming to 1.5 degrees Celsius. Equinix set a goal of 50% reduction in absolute Scope 1 and 2 emissions by 2030 from a 2019 baseline. The Company is also targeting 100% climate neutrality by 2030 across its Scope 1 and 2 emissions. As part of its goals, Equinix aims to achieve 100% renewable energy by 2030. Migration to net zero includes strategies such as energy efficiency, reducing refrigerant loss, phasing out high global warming potential (GWP) refrigerants, and investigating the replacement of diesel generators with cleaner on-site generation technologies. As of today, the Company has offered \$3.7 billion in green bonds to promote sustainability-related projects such as green buildings, renewable energy, and energy and water efficiency.⁴⁰

3. **Hotel Marriott International Inc.**, which operates and franchises hotels and licenses vacation ownership resorts globally, has committed to a reduction in GHG emissions across all scopes and net-zero value-chain GHG emissions by 2050. To achieve the goal, the Company has adopted several initiatives, including increasingly using renewable energy, building electrification to maximize renewable electricity, continuously modifying design standards to develop efficient buildings, installing automation systems, and upgrading energy efficiency (e.g., smart thermostats).⁴¹

4. **Multifamily REIT Equity Residential**, one of the largest publicly traded owners and operators of rental apartment properties, is aiming for a 30% reduction in Scope 1, 2, and 3 GHG emissions by

2030. Equity Residential's Energy and Sustainability Management Team is dedicated to planning and executing energy conservation initiatives throughout its portfolio and is responsible for seeking investment opportunities in capital projects that conserve energy or generate clean energy. Since 2012, the Company has advanced over \$85 million in investments in environmentally sustainable projects, which has generated average returns of approximately 23.0%. Equity Residential constantly assesses on-site renewable-energy viability and installs on-site clean and renewable energy wherever it sees fit. The combination of reduction initiatives and renewable-energy initiatives has reduced the Company's carbon footprint and increased the resiliency of the new buildings.⁴²

5. **Industrial REIT Prologis**, the global leader in logistics real estate, has set goals for 100% carbon-neutral construction and 100% LED lighting globally by 2025. The Company continuously reduces the carbon footprint of its buildings by adopting energy-efficient technologies, such as LED and cool roofing, as well as environmentally sustainable technologies, such as heat pumps and thermal energy storage. Two customer-facing programs are remarkable in significantly reducing carbon emissions: (i) Prologis SolarSmart—a program that allows its customers to access the financial, operational, and sustainability benefits of solar without upfront capital costs. In 2020, 40 MW of new rooftop were installed. (ii) Prologis Essentials LED—The Company added 108 million square feet of LED coverage to its portfolio in 2020, the most active year for LED installation. This program has realized 60%–80% savings for customers who incur zero upfront capital costs, retain 100% of energy cost savings, and benefit from safety as well as productivity.⁴³

6. **Shopping Center REIT Kimco Realty Corp.**, one of the largest publicly traded owners and operators of open-air shopping centers in North America, has set the target of lowering Scope 1 and 2 GHG emissions by 30% to 2030 from 2018, with the goal of reaching carbon neutrality by 2050.⁴⁴ Across its national portfolio, the Company strives to maximize operational efficiency and protect its assets from disruption. Over 300 properties have been upgraded to LED lighting since 2014, when the Company launched the Illumi-Nation program. Kimco has also put great effort into developing standards and definitions regarding green leasing and is regarded as one of the 14 initial Green Lease Leaders. Additionally, Kimco has secured a \$2 billion green credit facility—the first of its kind among retail REITS. To reduce the cost of borrowing, the Company targeted an incremental 1% reduction in GHG emissions each year for five years.⁴⁵

7. **Healthcare REIT Ventas Inc.**, specializing in owning and managing health-care facilities in the US, Canada, and UK, is committed to reducing GHG emissions by 30% (from their 2018 levels) by 2030 (2.5% annually). Ventas has organized its ESG strategy to align with the United Nations Sustainable Development Goals (UNSDG) and has set SMART (Specific, Measurable, Achievable, Relevant and Time-Bound) goals against its ESG strategy. Since 2018, the Company has reduced total Scope 1 and 2 emissions by 13.5% and Scope 3 emissions by 12.1% (4.9% and 7.4% reductions, respectively, achieved in 2020).⁴⁶

8. **Real estate investment firm Dream**, one of Canada's most innovative real estate companies, set a goal of net-zero emissions for operations and new developments by 2035, 15 years ahead of Canada's 2050 target. To support Dream's ambitious goal of building decarboni-

zation, the Canada Infrastructure Bank (CIB) issued a \$136.6 million loan to finance Dream's 19 building retrofits in Ontario and Saskatchewan. Dream also joined the Net Zero Asset Managers Initiative to bring its ambition to reality.⁴⁷

9. **Real estate services Colliers International Group Inc.**, a leading diversified professional services and investment management company, has committed to achieving net-zero carbon emissions for all buildings across 66 countries by 2030. Additionally, the Company will develop a net-zero program to help building owners, investors, and occupiers eliminate their building-related emissions. Colliers recently replaced the aging natural-gas-fired hot-water system with a modern heat-pump system for a 26-story office tower at 1075 West Georgia Street in Vancouver. The new heat-pump system is powered by electricity and uses carbon dioxide as the refrigerant. With British Columbia's low-carbon hydroelectricity system, this replacement allows the building to reduce approximately 40 tons of GHG emissions every year. The upgrade is an example of what has become a global trend toward carbon-neutral operation.⁴⁸

10. **Specialty REIT Iron Mountain Inc.**, a global leader in innovative-storage and information-management services, aims to reduce Scope 1 and 2 GHG emissions by 25% by 2025 from a 2019 base year and committing to net-zero emissions by 2040, 10 years ahead of the Paris Climate Accord. The Company outlined its transition to electric vehicles and its commitment to decarbonize the world's electricity supply by setting a goal of powering its facilities with 24/7 clean electricity, working toward zero waste across operations.⁴⁹

11. **Timber REIT Weyerhaeuser Co.**, one of the largest private owners of timberland in the world, is aiming for a 42% reduction in absolute Scope 1 and 2 GHG emissions and a 25% reduction in Scope 3 GHG emissions by 2030 from a 2020 base year. These goals put Weyerhaeuser on the path to net-zero emissions by 2050. Weyerhaeuser is the first company from its sector in North America to make these ambitious commitments. These reduction targets are expected to be achieved primarily through energy-efficiency projects, increased renewable-energy usage, and supplier engagement.⁵⁰

3.2 PropTech: Market trends and Recent Achievement

The global decarbonization target will bring on the most substantial technological shift in modern buildings. Both traditional real estate investors and proptech investors not only have the greatest power to directly catalyze the inevitable transition to net-zero buildings, but also profit the most from its realization. For example, in 2019, the best-performing public REIT, Hannon Armstrong (HASI), which is dedicated to energy-efficient retrofits for the real estate market, has experienced a stock price appreciation of 2.5 times since 2019, outpacing any traditional REIT.⁵¹

Real estate owners' capital investments in high-risk and high-reward technology R&D are considered the highest and best use of a landlord's capital expenditures when a longer-term investment horizon is taken. For example, proptech investors can safely assume large-scale office buildings with on-site power and storage are capable of selling additional power back to the grid or to nearby buildings, turning what was previously an operating expense into a revenue stream.

The real estate and climate technology can be categorized into eight distinct sectors:⁵²

1. The Energy-as-a-Service (EAAS) sector includes companies such as Carbon Lighthouse, which relies on taking a fraction of utility savings as its source of revenue, thus allowing the Company to raise \$70 million in project funding from prominent investors and to secure a \$65 million project finance from Generate Capital. Companies in this sector use a variety of software management, internet, sensors, and automation tools to diminish a building's energy imprint on the environment.

2. The Building Management & Automation category includes companies such as Enertiv that digitize and simplify routine operational systems to decrease capital expenditures and running costs. Companies in this category usually implement systems automation, forecasting, billing, energy auditing, property and equipment management, and demand response.

3. The Heating & Cooling Tech industry centers around technologies such as ground-source geothermal heat pumps and air-source heat pumps that assist buildings in moving from fossil-fuel usage to electrification. For instance, technology start-up Dandelion, funded by Google, and the largest single-family homebuilder, Lennar, invest in geothermal technology, whereas Andreesen Horowitz-backed Bloc Power provides heat pumps to multifamily dwellings in the US without the need for a down payment. This sector is garnering substantial consideration for investment, because fossil-fuel-centred structures account for 10% of worldwide emissions.

4. The Advanced Building Materials sector consists of companies such as Boston Metal, which focuses on electrifying primary steelmaking using its patented MOE process to solve the carbon-emissions challenge facing the steel value chain.

5. Distributed Energy Solutions refers to electrical generation or storage at the local building level, such as solar panels or lithium-ion batteries.

6. The Carbon Reporting industry includes companies such as Hannon Armstrong, which was the first REIT to join the Carbon Accounting Financials partnership in September 2020, demonstrating that a future with audited carbon-emission scoring requirements for REITs is a strong possibility.

7. The Smart Façade & Windows industry decreases lighting requirements during the highest sunlight hours by using automated windows that implement a combination of smart tinting, indoor lighting connection, and blinds control.

8. Lighting tech: 17% of all building electricity in the US is consumed by lightbulbs; therefore, this industry will become more carbon free as clean-energy penetration on the electric grid increases. Next-generation lightbulbs, such as Lifx, SORAA, Nanoleaf, and Sva-rochi, are lower energy intensive.

4. Opportunities

4.1 Regional Collaboration

International attention has moved toward how individuals, businesses, and governments work together to lessen the impact of climate change. The trending term “net zero” leads the headlines. In the real estate sector, the World Green Building Council (WGBC) and its Advancing Net Zero (ANZ) project are the drivers for the transition to net zero. To achieve the Paris Agreement and UN Global Goals for Sustainable Development, the WGBC collaborates with governments, businesses, and NGO to drive the building and construction sector toward a net-zero-emissions and resilient built environment. WGBC's ANZ is a worldwide initiative to decarbonize the built environment globally by eliminating both operational carbon and embodied carbon emissions.

At a regional level, green building councils are working together on plans to produce solutions to address specific regional issues. For instance, the Asia Pacific region created a foundational Embodied Carbon Primer document; the BUILD UPON2 project in Europe embraced decarbonization strategies to further its capabilities in national deep-energy-efficient renovation; and the Americas adopted the Cities Climate Action project. To encourage and accelerate the speed of decarbonization, the Net Zero Carbon Buildings Commitment recognizes organizations as well as regions that lead the way toward net-zero for new buildings by 2030 and for all buildings including existing ones by 2050. To date, 6 states, 28 cities, and 122 businesses have joined the commitment. Beyond commitments, organizations are also creating frameworks for their goals toward net-zero emissions. For example, the United Nations Economic Commission for Europe (UNECE) recently updated its Framework Guidelines for Energy Efficiency Standards in Buildings to reflect the urgency for efficient and thorough design methods to reach carbon neutrality. It is a critical step to ensure energy needs are sufficiently decreased to allow renewable energy to satisfy the remaining needs for space-conditioning energy.⁵³

4.2 Business Opportunities and Future Research Questions - Affordability and Net-Zero Homes

Affordable and net-zero homes have become a hot topic. The perception that increased upfront costs are the primary barrier to zero-energy buildings is a myth; the reality is that zero-energy buildings are a smart investment. A growing amount of evidence suggests, with state and utility rebates for energy-efficiency strategies, net-zero projects can be delivered today at no added upfront cost, making them both affordable and cost comparable to standard homes built to code. Federal tax credits, such as tax credits for residential renewable-energy products, and other state and local incentives are available across the US to offset the cost for energy-saving features. Additionally, local banks offer energy efficient mortgages (EEM) to help homebuyers finance their energy-efficient homes.⁵⁴

Zero energy is ready for the mainstream. Massachusetts is a national leader in affordable zero-energy buildings. As part of the Affordable Access to Clean and Efficient Energy Initiative, the Massachusetts Department of Energy Resources launched a grant program, Zero Energy Modular Affordable Housing Initiative (ZE-MAHI) in 2018. Vermont Energy Investment Corporation earned a \$1.05 million reward to launch

a program that supports the development of 10 affordable zero-energy modular homes in the Commonwealth community. The grant program is designed to replace inefficient manufactured homes with efficiency measures, improving indoor air quality and stabilizing energy costs. Homeowners who make the decision to join the program and are approved will obtain a grant to lower the cost of the zero-energy housing.⁵⁵

Currently, zero-energy buildings being built in Massachusetts bear zero additional upfront costs given today's incentive structure. For both existing and new ZE ready office buildings, return on investment can be achieved within one year. And all other building types can break even in less than eight years in the absence of additional upfront costs (refer to Diagram 13). Diagram 14 also shows slightly higher upfront costs will be recouped in future energy savings. As the costs of energy-efficiency improvements technologies, such as solar systems, are trending down, affordability will be further improved. Additionally, across all building types with technology that's readily available, building energy demand can be reduced 44%–54%.⁵⁶

Nevertheless, ZE projects are feasible today in Massachusetts without added upfront costs. In addition, ZE buildings are the winners when we evaluate the performance across the useful life of the building. Spreading the construction costs over the entire building life cycle, ZE buildings can start saving money from the first day and can achieve both affordability and profitability.

In Canada, the government and the Federation of Canadian Municipalities (FCM) are also investing in sustainable affordable housing to help housing providers retrofit existing units for higher energy performance or build new affordable housing to net-zero standards. The 2019 budget included the \$300 million Sustainable Affordable Housing (SAH) initiative as part of an additional investment of nearly \$1 billion in FCM's Green Municipal Fund (GMF), which provides funding for Canadian municipalities to increase energy efficiency in buildings. The SAH initiative offers grants, loans, and resources to municipal providers, not-for-profit organizations, and housing cooperatives to meet ambitious energy-efficiency standards in the new development and retrofitting of affordable housing. In 2020-2021, year one of funding, the SAH initiative invested in 33 projects, including more than 3,000 units. "Canadians expect all levels of government to work together to tackle climate change and the housing crisis," said Dominic LeBlanc, the Minister of Intergovernmental Affairs. "The Sustainable Affordable Housing initiative, an expansion of the Green Municipal Fund, helps housing providers retrofit existing units or build new affordable housing for higher energy performance. By improving the energy efficiency of our housing stock, we build cleaner communities and put more money back in the pockets of Canadians."⁵⁷

Although incorporating affordability and net-zero homes is possible, several research questions remain whose answers could further promote net-zero buildings without compromising housing affordability.

Net-zero homes generally adopt efficient HVAC and lighting technology as well as well-insulated walls to achieve net-zero energy bill. Harnessing solar power, implementing insulation coverage, and maintaining indoor air quality for a large-scale project is challenging. Thus, some future research questions are "How can the technical difficulties be addressed?" and "What are the costs to deliver large-scale net-zero energy projects?"

Cost is the number one cited limitation to deliver such projects, followed by regulations. Research is needed to understand how can policies and government funding support make the large-scale buildings affordable. According to Emerson, a zero-energy home costs 5%–10% more than a conventional home, but will large-scale ZE projects bear a much higher cost premium? And what incentive program / regulations should governments develop to advance ZE projects?

The last question we would like to look at concerns changing norms. Most ZE homes generate energy through solar power, but not all homebuyers embrace the idea of solar panels installed on roofs. Therefore, more innovations are expected to meet different purchasers' preferences.

Again, affordable net-zero homes can be built all over North America. Builders and designers along with governments will continue to cooperate and innovate to make these homes even more affordable.

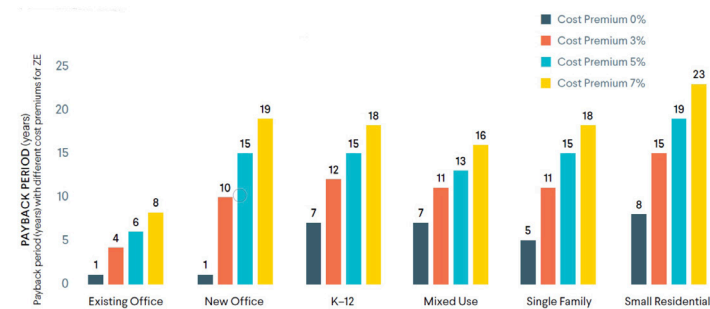


Diagram 13: Payback Periods for Different First-Cost Premiums

Source: Zero energy buildings in Massachusetts: Saving money from the start, Built Environment Plus, from <https://builtenvironmentplus.org/zero-energy-buildings/>

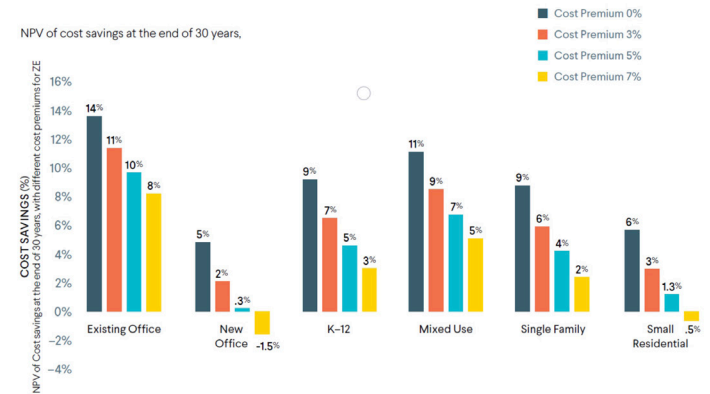


Diagram 14: Percent Cost Savings for Different First-Cost Premiums

Source: Zero energy buildings in Massachusetts: Saving money from the start, Built Environment Plus, from <https://builtenvironmentplus.org/zero-energy-buildings/>

However, as opportunities emerge, challenges arise. One of them is to develop a ZE building in a dense urban context. In general, buildings over six stories have difficulty generating sufficient electricity from solar PV on-site to fully offset their energy usage, regardless of how energy efficient they are. Another challenge is the need to develop ZE buildings for laboratories, hospitals, data centers, and other high-energy-use types. Therefore, in most situations, building owners have to purchase additional renewable energy off-site to reach carbon neutrality.

About the Author



Qiaojun Lai

Qiaojun Lai is a candidate for the Master of Science in Real Estate Development at MIT. With a CPA designation in Canada, she has over six years of experience in real estate accounting and asset management. Her ambition stretches beyond profits; she partnered with multiple non-profit organizations to launch education and real estate projects, aiming to support underprivileged communities. She believes real estate has the power to transform lives and hope to one day affect people's experience in positive ways.

Real Estate Industry Overview

Australia's real estate industry is one of the largest sectors in its economy. The Property Council of Australia reports that in 2015–16, property represented 13% of Australia's overall GDP, amounting to approximately \$202.9 billion.¹ In particular, the property sector is estimated to have contributed approximately \$87.9 billion in combined revenue through taxes, rates, fees, and charges, which equates to 18.2% of total Australian and state/territory taxes and local government rates, fees, and charges revenues in 2015–16.²

According to Statista, the Australia real estate industry by product typology:

- Value of work completed on new residential buildings in Australia in 2020 alone was approximately \$63.78 billion.³
- The value of commercial building activity in Australia in 2019 was estimated at \$43.33 billion AUD.⁴
- The share of investment in commercial real estate in Q1 of 2021 was split by 59% in office, 14% in retail, 9% in industrial, and 18% in other categories.⁵

Australia has six states and two territories. New South Wales, Australia's most populous state, accounts for the largest share of the total national real estate industry's economic activity. This share was estimated by the Property Council of Australia through the state's economic contribution in 2015–16 to be approximately 30% of Australia's total real

estate industry, followed by Victoria at approximately 23%, Queensland at approximately 20%, and Western Australia at approximately 15%, with the remaining percentage attributed to South Australia, Tasmania, the Northern Territory, and the Australian Capital Territory.⁶

The Australian residential sector has grown so drastically that, as a comparison, the median house prices in the main cities in Australia (Sydney and Melbourne) are higher than that in Boston.

| Location | Median House Price in Q3 2021 | Comments |
|----------------|-------------------------------|---|
| Sydney, Aus | \$1,096,692 USD | Data provided by Domain, calculated by using a stratified median price for September 2021. An exchange rate of \$1 AUD = \$0.7315 USD was used as the average of the closing rate as of September 2021. |
| Melbourne, Aus | \$759,297 USD | |
| Boston, US | \$696,083 USD | Data provided by Zillow only include the middle price tier of homes as of October 2021. |

Source: <https://www.domain.com.au/research/house-price-report/september-2021/?pin=26d75e1cb315cd79966c256a00f4dfba> and <https://www.zillow.com/boston-ma/home-values/>

The Australian real estate industry has been remarkably resilient through the recent COVID-19 pandemic. A survey released in July 2021 of 166 senior industry figures had 85% of respondents indicating COVID-19 has had zero impact on their projects,⁷ with many executives in leading real estate firms describing Australia as a “market of opportunities.”⁸ In particular, the residential sector, which is the real estate sector’s greatest economic contributor in Australia, saw substantial growth through the pandemic, rising a record annual rate of 21.7% to surpass the \$9 trillion value.⁹

Australia has historically been a coal-fueled nation and one of the world’s largest coal exporters.¹⁰ The recently held COP26 marked a shift in the country’s energy usage, when Australia, on October 26, 2021, released its long-term emissions-reduction plan, which included a commitment to reach net-zero carbon emissions by 2050.¹¹ The plan acknowledges that “residential and commercial buildings contributed around a quarter of Australia’s emissions in 2019 and account for just under half of Australia’s electricity consumption.” This move is the first real step that the Australian federal government has taken to acknowledge the growing environmental concerns regarding climate change. Even so, this goal has not been legislated into domestic force; rather, it relies on the private sector to drive this emissions reduction.¹²

1. Policy

1.1 Federal Level

The National Construction Code is the regulatory framework that establishes the basic requirements for design and construction purposes.¹³ However, although these requirements cover a minimum degree of energy efficiency for certain types of buildings, they do not cover the path to net zero. Until the 2021 release of Australia’s Long-Term Emissions Reduction Plan prior to COP26, the country had no consistent national plan with mandates that focused specifically on net-zero emissions.

However, even with the release of this plan, large questions still loom regarding the contents of the plan, especially the details on how it would reach net zero. Specific to real estate industry, the plan identifies that:

- The Nationwide House Energy Rating Scheme (NatHERS) provides voluntary energy ratings for residential buildings, and the Your Home guide provides information.
- The National Australian Built Environment Rating System (NABERS) provides voluntary energy ratings for many commercial building sectors.

Much of the plan provides for just a high-level overview and has been criticized for not having a detailed implementation plan to reaching net-zero emissions, with a lack of quantified targets from now until 2050. Although a national-level policy establishing a high-level policy that enables implementation is not uncommon, commentators have flagged the vague nature of the plan in comparison with other first-world countries within the G20.¹⁴ Considerable discretion is left to states and local municipalities to implement their own policies and in particular introduce state specific changes to the National Construction Code. The states in fact provide the relevant legislation to adopt the minimum requirements of the National Construction Code, which NABERS and NatHERS fall under.¹⁵

1.2 State Level

States provide a more detailed framework for implementing sustainability initiatives, achieving net-zero objectives and responding to climate change. To date, each state has, in absence of action by the national government, established its own set of strategies and policies for dealing with climate change within its own planning framework. For example, New South Wales has a Climate Change Policy Framework that outlines its objective to cut 2005-level emissions in half by 2030 en route to achieving net-zero emissions by 2050.¹⁶ Other states, such as Victoria, have legislated their commitment to net zero.¹⁷ Diagram 1 shows a map of Australia with the commitment for net-zero emissions by each state and territory in Australia.

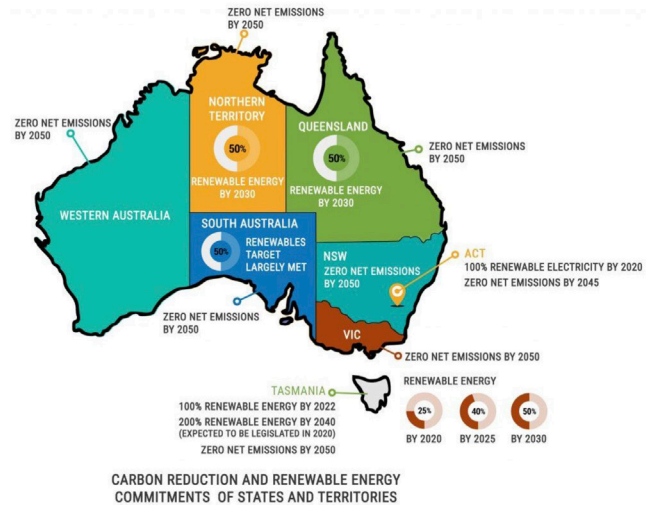


Diagram 1: Map Showing Commitments by Each State and Territory

Source: <https://100percentrenewables.com.au/ambitious-climate-action-commitments-local-governments-states/>

Examples of such policies for different states within each respective planning framework are listed out below:

| NSW | Description |
|---|--|
| NSW Climate Change Policy Framework | The NSW Climate Change Policy Framework outlines NSW’s long-term objectives to achieve net-zero emissions by 2050. The framework defines the NSW government’s role in reducing carbon emissions and adapting to the impacts of climate change. |
| Sustainable Property Guide | The NSW Department of Environment and Climate Change worked with industry to establish a sustainable property guide for commercial properties. |
| NSW Government Resource Efficiency Policy | The aim of the NSW Government Resource Efficiency Policy (GREP) is to reduce the NSW Government’s operating costs and lead by example in increasing the efficiency of its resource use. The policy aims to drive resource efficiency by NSW government agencies in all of its activities and operations. |

| Victoria | Description |
|---|---|
| Victoria's Climate Change Framework | Victoria's Climate Change Framework sets out Victoria's long-term vision for climate-change action. The framework sets out the commitment for net zero by 2050 and the steps the Victorian government is taking to commence the transition, including the legislated Climate Change Act 2017. |
| Victoria's Climate Change Strategy | Victoria's Climate Change Strategy is a roadmap to net-zero emissions and a climate-resilient Victoria by 2050. Under the Victorian Climate Change Act (2017), every five years, the State Government of Victoria is required to publish a new strategy setting its interim targets for achieving the state's legislated long-term target of net-zero emissions by 2050 and outlining how it will meet these targets. |
| Environmentally sustainable development of buildings and subdivisions | A roadmap establishing standards to be introduced to the Victoria Planning Provisions and planning schemes to improve sustainability of building and subdivision developments across Victoria. |

1.3 Local Municipality

At the forefront of the public-sector initiatives are local municipalities, which are able to have the highest degree of control through Local Environmental Plans that guide the way land is used and managed. The 537 different councils in Australia use a wide spectrum of approaches. Out of Australia's 537 local governments, 89 have committed to net-zero emissions by 2050 as of December 2021.¹⁸ Of these, the City of Sydney and the City of Melbourne are two of the most progressive councils, as they are the local municipalities of the capitals of the two most populous states, namely, New South Wales and Victoria, respectively.

The City of Sydney has recently released a document titled "planning for net zero energy buildings" that outlines the performance standards that are proposed to apply to reach net-zero emissions. This document provides for a first target reduction in 2023, followed by a second target

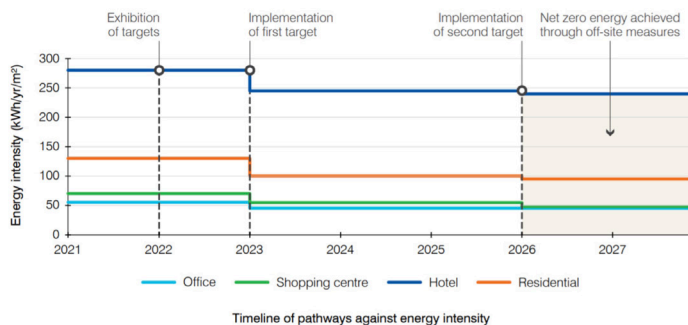


Diagram 2: Target Reduction Established by City of Sydney

Source: <https://www.cityofsydney.nsw.gov.au/surveys-case-studies-reports/planning-for-net-zero-energy-buildings>

in 2026, to achieve net-zero emissions by 2035 as shown in Diagram 2. These minimum standards are proposed to apply to new developments and proposed redevelopments of existing buildings within its jurisdiction and allows the use of a mix of measures including optimum building energy efficiency, on-site renewable energy, and off-site renewable energy.¹⁹

A summary of the minimum standards that are proposed to apply is included in Diagram 3. The plan was released for public consultation in mid-2021 and is currently under review.

The City of Melbourne has committed to reaching net-zero emissions by 2040 and seeks to do so by introducing a set of minimum performance standards. The City of Melbourne in 2018 released a Climate Change Mitigation Strategy²⁰ that initially set out the strategy for reaching the city's emissions-reduction target by the following:

1. 100% renewable energy,
2. zero-emissions buildings and precincts,
3. zero-emissions transport, and
4. reducing the impact of waste.

This strategy was subsequently amended with Melbourne's climate and biodiversity emergency declaration committing to reaching a zero-emissions target for the municipality 10 years earlier, by 2040, with 10 strategic priorities for accelerated action.²¹

One aspect of the 10 strategic priorities was to mandate greening and zero-emissions buildings through the Planning Scheme. This mandate has led to the proposed Sustainable Building Design Amendment C376, which requires a minimum 5 Star Green Star Design and As Built rating for buildings over 5,000 square meters.²² This proposed standard will apply to both new developments and retrofits over the minimum threshold area to improve the energy efficiency of buildings. This proposal was endorsed by the City of Melbourne in September 2020 and is currently in the process of being released for public exhibition and consultation.

| Asset class | First target (2023) | Second target (2026) |
|--|--|--|
| Office (base building) | Maximum 45 kWh/yr/m ² , or equivalent NABERS Energy or Green Star Buildings credits, or equivalent | Maximum 45 kWh/yr/m ² , or equivalent NABERS Energy or Green Star Buildings credits, or equivalent, and renewable energy procurement to net zero |
| Shopping centre (base building) | Maximum 55 kWh/yr/m ² , or equivalent NABERS Energy or Green Star Buildings credits, or equivalent | Maximum 45 kWh/yr/m ² , or equivalent NABERS Energy or Green Star Buildings credits, or equivalent, and renewable energy procurement to net zero |
| Hotel (whole of building) | Maximum 245 kWh/yr/m ² , or equivalent NABERS Energy or Green Star Buildings credits, or equivalent | Maximum 240 kWh/yr/m ² , or equivalent NABERS Energy or Green Star Buildings credits, or equivalent, and renewable energy procurement to net zero |
| Multi-unit residential (whole of building) | | |
| 6-10 storeys | Basix Energy 40 | Basix Energy 45 and renewable energy procurement to net zero |
| 11-20 storeys | Basix Energy 35 | Basix Energy 40 and renewable energy procurement to net zero |
| 21-30 storeys | Basix Energy 30 | Basix Energy 35 and renewable energy procurement to net zero |
| Mixed use | Individual asset component targets identified above | Individual asset component targets identified above |

Diagram 3: Minimum standards proposed to apply to each asset class

Source: <https://www.cityofsydney.nsw.gov.au/surveys-case-studies-reports/planning-for-net-zero-energy-buildings>

1.4 Data and Standards

The Commercial Building Disclosure (CBD) Program in Australia requires landlords or agents to obtain a Building Energy Efficiency Certificate (BEEC) before the building goes on the market for sale, lease, or sublease for commercial properties. This program was legislated by the Building Energy Efficiency Disclosure Act 2010 by the Commonwealth of Australia and requires the energy rating as rated by the NABERS scheme to be published. Studies conducted on the effect of this mandatory disclosure indicate these disclosure requirements have contributed to the reduction in energy usage and carbon emissions within the real estate sector.²³

However, such disclosure requirements currently only apply to commercial buildings over a threshold size of 1,000 square meters. They do not apply to other real estate assets, including residential, which make up two-thirds of all real estate in Australia.²⁴ Although requirements are localized at the state level (e.g., the Australian Capital Territory has mandated that all sales or leases as of 1999 must disclose the modeled energy efficiency of a home), no national standard requirement is in place for disclosure of energy-efficiency performance of a home in Australia. The National Energy Efficient Building Project released a report in 2015 that proposed an electronic building passport to be trialed in subsequent phases of the project; however, this proposal has not been adopted yet.²⁵ Rather, how to introduce the requirements of mandatory disclosure of energy-efficiency data in assets beyond commercial offices is the subject of ongoing investigation and trials at both state and local levels.²⁶ For example, the City of Sydney in its “planning for net zero energy buildings” document identifies a recommendation for government agencies to “investigate developing a rating tool and process that supports the disclosure of energy performance of multi-unit residential buildings at point of sale.”²⁷

2. Capital Market

2.1 Equity Investment

Within Australia, ESG investing is on a strong upward trajectory, with investing in environmentally sustainable properties experiencing a substantial amount of growth in the market.²⁸ Real estate equity investors have recognized that developing environmentally friendly portfolios with a focus on ESG is one of the best ways to protect future value and returns.²⁹ CBRE, in its Capital Markets Outlook Report for 2021, identified a larger percentage of investors that have adopted ESG criteria in their investment portfolios compared with 2020.³⁰ As such, investors and portfolio owners are starting to adhere more and more to stringent green strategies. Many equity investors in the real estate sector, and particularly ASX (Australian Stock Exchange) listed real estate developers and owners, are cognizant of the value in investing in sustainability, with many making their own commitment for net zero. This trend has also been driven by international investors, whereby offshore buyers in the past 10 years have been driving a stronger push toward ESG as part of their investment criteria.³¹ A few examples follow:

- Vicinity Centres as one of Australia’s largest retail REITs has adopted a target of net-zero carbon emissions by 2030 for common areas of its wholly owned retail assets.³²

- AMP Capital is committed to all of its real estate funds and assets becoming net-zero carbon by 2030 through phasing out fossil fuels, running on 100% renewable energy and improving the energy efficiency and resilience of their buildings.³³

- Lendlease’s Australian funds have committed to being net-zero carbon by 2025 for projects and assets covered under Scope 1 and 2 of their program.³⁴

- GPT Group’s Wholesale Office Fund delivered and exceeded its carbon-neutral commitment in December 2020, with each of its assets certified as carbon neutral.³⁵

As a highly developed market, Australia operates on a significant scale where ESG performance is deeply scrutinized and highly valued by equity investors. Although no mandatory disclosure rules on the management of financial risks in relation to climate change are in place, the Australian Prudential Regulation Authority (APRA) has, as of April 2021, released draft guidelines designed to assist entities in managing climate-related risks and opportunities as part of their reporting frameworks.³⁶ The proposed climate-risk reporting framework establishes the disclosure and reporting requirements within APRA’s existing risk-management and governance requirements and provides guidance to institutions regulated by APRA. It aligns with the framework established by the Financial Stability Board’s Task Force on Climate-Related Financial Disclosures (TCFD).

2.2 Debt Market

Lenders within the debt market in Australia are also recognizing the value of incorporating ESG criteria within their lending decisions. Leading Australian law firm Pinsent Mason reports that lenders are embracing ESG considerations as part of their business planning, because doing so can provide cheaper wholesale funding through the issuance of green bonds, mitigate risk where the value of sustainable loan collateral is recognized to be more resilient and of higher value, and achieve internal ESG targets within their own organization.³⁷ The debt market for ESG lending is emerging quickly in Australia, with the four main banks declaring targets for green lending portfolios.³⁸

Examples of some recent debt raising in the capital markets for real estate include the following:

- Lendlease raised \$500M AUD in its green-bond debut in October 2020, which at the time was one of the largest issued by an Australian non-financial corporate. The proceeds of the green bond will be used to support the delivery of green buildings within Lendlease’s \$110 billion global development pipeline, such as Sydney’s Barangaroo, the UK’s International Quarter London, and Chicago’s Southbank. The delivery of these buildings will help achieve Lendlease’s environmental targets and commitment to net-zero carbon for Scope 1 and 2 emissions by 2025 and absolute-zero carbon across all operations by 2040s.³⁹

- Frasers Property Australia secured a syndicated green loan for \$600M AUD for a five-year term, refinancing under the Green Loan Principles in March 2019, which provides a reducing pricing structure with interest cost savings if the Fraser maintains its 5 Star Global Real Estate Sustainability Benchmark ratings.⁴⁰

- Investa Commercial Property Fund (ICPF) approved Australia's first certified green loan in January 2019 for a \$170M AUD loan whose proceeds are used for eligible real estate assets. ICPF has established a Green Debt Framework to guide the management and use of the proceeds in line with the Green Bond Principles and Green Loan Principles, such as only deploying funds for low-carbon building projects that meet the criteria set out in the CBI standards.⁴¹

Although this market is growing, Westpac, as one of Australia's largest institutional lenders, reports a shortage of sustainable financing in the Australian market. Much of this shortage is attributed to issuers both not knowing what assets qualify and not having enough assets to qualify.⁴² CBRE similarly notes green lending is still at an embryonic stage in the Pacific region, citing the ability to track fund flows and a lack of knowledge of the requirements to comply with green-lending principles as the main impediments.⁴³

3. Business Innovation

According to the latest GRESB (Global Real Estate Sustainability Benchmark), the Australia and New Zealand real estate market is the world's greenest.⁴⁴ Much of this finding can be attributed to the innovation and leadership of the private sector as world leaders in this space. As of 2021, Australia had topped the GSREB rankings for an 11th consecutive year, with several Australian real estate companies topping many category assessment rankings.⁴⁵ These companies include major developers and managed real estate, funds such as Lendlease, Frasers, Cromwell, Dexs, Growthpoint, Scentre Group, ISPT, and AMP Capital.

One reason of private sector's leadership in real estate sustainability is that sustainability is inherent in how the private sector operates. Lendlease Australia Chief Executive Dale Connor noted that "strong sustainability targets, along with net zero carbon commitments, are critical in continuing to attract both capital partners and quality tenants."⁴⁶ Much of the private sector was already ahead of the game and was willing to go down the path of net zero before these elements were pushed by the public sector.⁴⁷ The private sector has understood a premium is associated with greener buildings, with Knight Frank estimating that green-rated office buildings in Sydney and Melbourne with a NABERS rating of 5 or more could command premiums up to 18% higher.⁴⁸

3.1 Leading Real Estate Companies

A snapshot of some of the leading real estate companies within Australia are shown below. Many of these companies operate on both a national and global scale.



Lendlease is a globally integrated real estate and investment group with expertise and capability as builder, owner, developer, and investor. Founded in Sydney, Australia, in 1951, it has expanded on a national and international scale and is one of the world's leading developers for sustainable and cutting-edge developments. It is a 1.5oC aligned company and seeks to reach net-zero emissions for its entire portfolio by 2040. Several of Lendlease's major projects include

- Barangaroo South – Sydney, Australia,
- Darling Quarter – Sydney, Australia,
- Salesforce Tower – Sydney, Australia,
- Southbank – Chicago, United States, and
- 277 Fifth Avenue – New York, United States.



Mirvac is an Australian property group with operations fully across the property investment, development, and retail services landscape. It was founded in 1972 and is one of the leading developers in Australia across commercial, industrial, retail, build to rent, and residential. Key projects include

- 200 George Street, Sydney, Australia,
- The Federick – Sydney, Australia,
- LIV Indigo – Sydney, Australia,
- Olderfleet, 477 Collins Street – Melbourne, Australia, and
- 664 Collins Street, Melbourne, Australia.



GPT is a vertically integrated diversified property group that owns and actively manages its \$25.3 billion portfolio of Australian office, logistics, and retail assets. GPT was launched as Australia's first-ever property trust in 1971. The trust originally was launched and managed by Lendlease until 2005, when a proposal was approved to split into a separate independent company.



Charter Hall is a listed REIT on the ASX that was founded in 1991 and is one of Australia's largest integrated property investment and fund management companies. Its capabilities span investment management, property leasing, property development, asset management, property management, and portfolio integration.



Dexus is an Australian Real Estate Investment Trust managing an Australian property portfolio valued at \$42.5 billion. Dexus was first listed on the ASX in 1984 under the Deutsche Bank's externally managed funds, which split off in 2004. Dexus is one of the largest commercial landlords in all of Australia including

- 1 Bligh Street – Sydney, Australia,
- Governor Phillip & Macquarie Tower – Sydney, Australia, and
- 100 Mount Street – Sydney, Australia.



Stockland is one of the largest diversified property groups in Australia. Founded in 1952, Stockland develops, owns, and manages a large portfolio of retail town centers, workplace and logistics assets, residential communities, retirement living villages, and land lease communities. Key properties include

- Macquarie Technology Park – Sydney, Australia,
- Stockland Shellharbour – Sydney, Australia, and
- Bellevue Gardens – Sydney, Australia.



TOGA was founded in 1963 in Sydney, Australia, and develops, owns, and manages residential and mixed-use developments. It is a fully integrated developer with a hotel operator component. Key properties include

- Adina Apartment Hotel – Sydney, Australia,
- A by Adina – Sydney, Australia, and
- Wicks Place – Sydney, Australia.

3.2 Leading Projects

Australia has been at the forefront of leading real estate technology. As a growing market with strong competition and high demand the real estate sector has responded in new and innovative ways through the development and implementation of newer technologies with a focus on sustainability. These new technologies have facilitated the improvement of all elements of real estate including design, development, construction, and asset management to create more sustainable real estate assets.

Below is a sample of the latest real estate technology being employed across the real estate sector.

| | | |
|---|---|---|
| Technology: Digital Twin | Willow provides a digital twin for the built environment and has been successfully implemented in several projects, including The Ribbon, 567 Collins Street, and Barrack Place, 60 Martin Place. |  |
| Use: Hotel | The digital-twin technology as a representation of physical assets has created efficiencies in the design, construction, and operations phase of each respective project. | The Ribbon (Under Construction – Scheduled for Completion in 2022) |
| Size: 60,000 sqm | | |
| Key players: Developer – Grea- ton Development Digital Twin Provider - Willow | | |

Technology: Cross Laminated Timber (CLT) / Glue-Laminated Timber (Glulam) / Hybrid Towers

Use: Commercial

Size: 7,900 sqm

Key players:
Developer – Lendlease

Developed by Lendlease as the “front door” to Barangaroo South, International House Sydney is a 6-story commercial building built entirely on CLT and Glulam. Through the use of CLT and Glulam materials, the 6-story building has delivered a range of economic, social, and environmental benefits, including reduced construction time and less air, noise, and waste pollution. An estimated 3,500 cubic meters of sustainably grown and recycled timber, which has a 60% lower carbon footprint than traditional materials of concrete and steel and has a faster construction time, were used in this project. The building has been able to achieve a 6 Star Green Star for Office Design.



International House, Barangaroo (Completed in 2017)

Technology: Cross Laminated Timber (CLT) / Glue-Laminated Timber (Glulam) / Hybrid Towers

Use: Commercial and hotel

Size: 80,000 sqm


Key players: Developer – Dexus
Anchor Tenant – Atlassian

Atlassian is proposing to develop Australia’s tallest commercial hybrid timber tower at 40-stories high. Atlassian has recently engaged Dexus to develop the tower where Atlassian will position itself as the anchor tenant.

The use of timber throughout the tower enables a target of 50% reduction in embodied carbon and energy compared with conventional construction. The proposed asset is intended to operate on 100% renewable energy with net-zero emissions by using natural ventilation through mechanically controlled louvres and solar panels integrated into the building’s façade.



Atlassian HQ (Development Application Approved in 2021 – Target completion in 2025)

| | | |
|--|---|--|
| Technology: Green Walls & Trigen & Heliostat | One Central Park has a green wall as a hydroponic system that in effect hangs off the building and has its own irrigation system. The development also contains a trigeneration plant expected to reduce greenhouse gas (GHG) emissions by 190,000 tonnes over the 25-year design life of the plant through the provision of efficient electricity generation, heating, and cooling. The development also includes a heliostat to provide additional natural light to the inner park. |  |
| Use: Residential | | |
| Size: 32,000 sqm | | |
| Key players: Frasers | | One Central Park (Completed in 2014) |

| | | |
|--|---|--|
| Technology: District cooling Plant | The Barangaroo South development uses a centralized district cooling plant with a harbor-water cooling system to save both on energy and water. It provides the entire cooling capacity to approximately 540,000 square meters of GFA and relies on harbor heat rejection in place of typical cooling towers to save on potable-water demand. |  |
| Use: Mixed use – commercial, residential, hotel, retail | | |
| Size: 540,000 sqm | | |
| Key players: Lendlease | | Barangaroo South International Towers – International Towers were completed in 2015-2016. The rest of the precinct is anticipated to be completed by 2026 |

Note: Real Estate technology related to PropTech is covered in a separate paper

4. Opportunities

4.1 Regional Collaboration

Australia has established good regional relationships and collaboration across all levels of government. For example, Australia has a regional agreement to collaborate with the ASEAN Council on achieving the UN Sustainable Development Goals (2030) and specifically to focus on smart and sustainable city developments.⁴⁹ In addition, several cities and businesses within Australia have signed up for the Net Zero Carbon Building Commitment under the World Green Building Council's ambitions⁵⁰:

- Cities: Melbourne & Sydney
- Businesses: AMP Capital, Atelier Ten, Built, CBUS, CBA, Dexus, Frasers, GPT, ISPT, Lendlease, Monash University, QIC, Nightingale Housing, Stockland, Sydney Opera House

4.2 Innovation Opportunities

An area of growing interest is the use of timber for construction in buildings to tackle the issue of embodied carbon. The WorldGBC highlighted timber usage in its report *Bringing Embodied Carbon Upfront* the design of Lendlease's 25 King Street commercial tower in Brisbane, which at the time was the world's tallest engineered-timber office building that used prefabricated cross-laminated timber to develop a high-quality, sustainable project.⁵¹

Since then, we have seen major developments, including the 40-storey hybrid timber tower proposed by Atlassian⁵² and the subsequently proposed KingsGreen tower that has the goal of creating Australia's tallest and largest engineered timber office building in exceeding the benchmark set by Atlassian.⁵³

4.3 Research Questions

Further opportunities for research for sustainability within Australia include the following:

- How can the commercialization of timber as a key resource for achieving net zero carbon buildings be accelerated especially for high rise construction?
- How can redevelopments of existing buildings, including retrofits of existing buildings, be implemented in a more sustainable manner?
- How is sustainable development being carried out in rural and regional Australia or areas outside of the main capital cities?
- What is the future projection on the next wave of sustainable developments in response to Australia's specific risks on climate change in context of the 2019/2020 black summer bushfires?
- How can the public sector take a more progressive approach to driving sustainability in line with the private sector to create better synergies in public-private partnerships?

About the Author



Steven La

Steven La is a qualified professional with over 8 years of professional working experience in the Australian market. Steven holds a Bachelors of Civil Engineering (First Class Honors) from the University of Sydney, as well as a Masters of Construction Law (First Class Honors) from the University of Melbourne, and is currently enrolled in the Masters of Science in Real Estate Development at the Massachusetts Institute of Technology. Steven is passionate about transit-oriented development and has worked on several high-profile projects, including the Victoria Cross Integrated Station Development as part of Sydney Metro City & Southwest and the Central Precinct Renewal Program.

Real Estate Industry Overview

China, with a population of 1.4 billion, houses one-fifth of the world's population.¹ It has more than 160 cities with a population of over 1 million, as well as five of the world's top 10 largest cities: Beijing, Shanghai, Hong Kong, Shenzhen, and Guangzhou.² Since 2008, China has topped the annual list of the largest emitters of greenhouse gas (GHG) CO₂.³ In 2019, China emitted 10.2 billion metric tons of CO₂—nearly twice as much as the US, representing almost 28% of global emissions (Diagram 1). But net emissions alone are not enough to get the whole picture. When looking at CO₂ emissions per capita, the US is in 14th place with over 16 tons of CO₂ per capita. China emits less than half of that amount per capita, tallying 7.1 tons, putting the country in 48th place.⁴

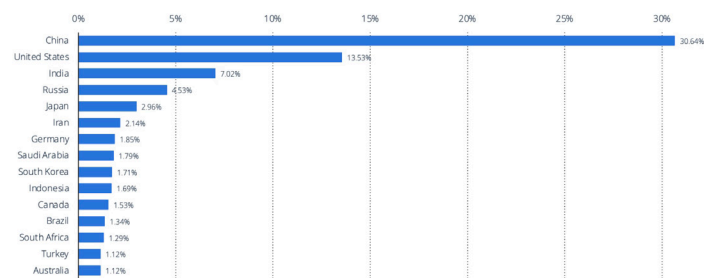


Diagram 1: CO₂ Emissions by Country 2020

Source: Global Carbon Project (Global Carbon Atlas); Expert(s) (Friedlingstein et al. (2021)); ID 271748

China's real estate market is vast and is considered the most crucial sector in the world economy.⁵ According to Goldman Sachs, it is valued at about US\$55 trillion—twice the size of its US equivalent and four times China's GDP. The annual housing activity, including construction and other property-related goods and services, accounts for about 29% of China's GDP, far above the 10%–20% typical of most developed nations. Chinese cities are growing rapidly, as indicated by a 60% urbanization rate in 2019.⁶

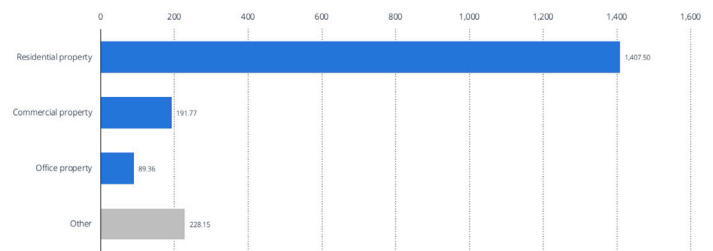


Diagram 2: Real Estate Developer Investments in China in 2019, by Building Use (in billion US\$)

Average exchange rate in 2019: 1 RMB = 0.145 US\$

Source: National Bureau of Statistics of China, 2019

The homeownership rate in China is significantly higher at over 90% compared to 65% homeownership in the US market.^{7,8} However, rental yields are below 2% in major cities like Beijing, Shanghai, Shenzhen, and Chengdu. About 21% of homes in urban China were vacant in 2017—a very high proportion relative to international standards—equating to

65 million empty units.⁹ Among families who owned two properties, the vacancy rate reached 39.4%, and among those who owned three or more, 48.2% were vacant. Nonresidential makes up approximately 30% of China's real estate investment. The China commercial real estate market accounted for US\$357.32 billion in 2019.¹⁰ Driven by solid economic growth, the commercial real estate market revenue is forecasted to grow at an annualized rate of 3.5% over five years through 2026, to \$362.5 billion.¹¹

China's Building Energy Consumption Research Report shows that in 2018, total carbon emissions of the whole building process totaled 4.93 billion tons, accounting for 51.3% of national carbon emissions. The proportion of carbon emissions in building-materials production was 28.3%; the ratio of carbon emissions in building construction was 1%; the proportion of carbon emissions in buildings' operation phase was 22%.¹²

Estimates suggest around 50% of the world's construction will occur in China over the next 10 years.¹³ According to the BBC's Future Planet Series, from 2001 to 2016, primary energy consumption in China's building sector more than doubled to around 1 billion tons of coal. The carbon cost of building construction, including the raw materials and energy utilized throughout the supply chain, contributes to around one-fifth of China's carbon emissions. According to the Special Committee on Energy Consumption Statistics of the China Building Energy Conservation Association (2019), carbon emissions from China's building sector will continue to increase, peaking by 2039. It's almost nine years later than the national peak year and may become the last major sector to achieve carbon neutrality in China. In the future, energy efficiency will no longer be a measure of green building, and more exploration and practice will be related to "zero-carbon."¹⁴

1. Policy

After a long period of uneven economic development, China is gradually taking steps to reduce energy intensity, boost enforcement of environmental laws and regulations, and reduce coal usage, by expanding cleaner energy usage. China has become a major global producer and user of clean and renewable energy. Meanwhile, carbon-emission control has been highlighted at the national level as a primary goal. The real estate industry has enormous potential to contribute to this goal.

1.1 National policy and regulations

In September 2020, President Xi of the Chinese government announced at the United Nations General Assembly that China plans to reach peak carbon emissions by 2030 and carbon neutrality by 2060. The Chinese economy is expected to grow at a fast pace of approximately 5% annually in the next 10–15 years. Energy consumption will inevitably rise with the nation's economic growth. China will have to expedite its engagement rate in sustainable development sufficiently fast to decrease carbon emissions.

In 2021, China's State Council issued the "Action Plan for Carbon Dioxide Peaking Before 2030," which proposed to accelerate the update of building energy efficiency, municipal infrastructure, and other standards to improve energy saving and meet carbon-reduction requirements. According to the Action Plan, the green building standards will

be fully implemented in new buildings in urban areas by 2025.¹⁵

To better promote the green development of the real estate industry, the Chinese government has adopted a series of preferential economic policies to encourage developers to invest in the construction of green buildings. In 2012, the Ministry of Finance, the Ministry of Housing, and the Urban-Rural Development (MoHURD) jointly issued implementation opinions on accelerating the development of green buildings in China. It proposed rewarding green building projects according to the building area, offering an incentive of RMB 45 and RMB 80 for each square meter of 2- and 3-star green building projects, respectively. In September 2018, the green financial standards working group of the China Financial Standardization Technical Committee deliberated and passed the articles of association and promoted the development of green real estate projects by providing financial support for green real estate projects.

At the implementation level, the government has issued mandatory regulations to promote green development. China's green real estate industry officially started when the Green Building Evaluation Standard "GB/t50378-2006" was issued in 2006. In 2015, The 13th Five-Year Plan (FYP) for the construction industry issued by MoHURD required all new city buildings to meet 20% higher energy efficiency than that of 2015 and expected green buildings in urban areas would account for at least 50% of new construction by 2020. MoHURD further issued a National Standard for Building Emission Calculation in 2019. The new calculation standard factors in each phase of a building's life cycle, including the emissions intensity of the production and transportation of building materials and emissions during construction and demolition.

In the 2020 14th FYP, China continued to increase its non-fossil energy share, reducing the percentage of coal in total energy consumption and striving to build a clean, low-carbon, safe, and efficient energy system. The CO₂ emissions per unit of GDP will be cut by more than 65% from the 2005 level, and non-fossil energy will account for about 25% of primary energy consumption by 2030. In the urban and rural development section, the plan stressed the actions of electrification of the public transportation system, expanding urban green spaces, building green corridors, mandating green building materials, and so on. The plan also called for the "elimination" of major demolition and construction (a significant source of energy consumption and carbon pollution) by facilitating the renewal of older communities instead. A noticeable gap between China's carbon-reduction policies and related regulations exists because the 2019 Green Building Evaluation Standard contains little content on carbon-emissions reduction and carbon neutrality.

1.2 Regional Policy

China has carried out 87 low carbon pilots since 2010, comprising 81 cities and six provinces. More than 60 of these pilots have committed to peak carbon emissions before 2025. Beijing has stated it will maintain a steady decline in carbon emissions after peaking in 2021–25. Various provinces and cities have also rolled out measures and regulations to attain the goals, which can be categorized as follows:

| Policy area | Policies | Provinces |
|---|---|--|
| Energy conservation | <ul style="list-style-type: none"> Reduce or limit the production capacity of polluting industries such as steel, stainless steel, cement, methanol, etc. Post stringent measurements to approving extra manufacturing capacity of above industries | Guangdong, Zhejiang, Inner Mongolia, Shandong, Guizhou |
| Electricity price discrimination | <ul style="list-style-type: none"> Higher electricity price for high emission companies | Shandong, Hebei, Jiangxi, Liaoning, Tibet |
| Energy replacement | <ul style="list-style-type: none"> Encourage the development of new energy and associated infrastructures (wind, solar, hydrogen) Promote alternative fuel vehicles and related infrastructures | Shanxi, Guangdong, Zhejiang, Jiangsu, Liaoning |
| Technology advancement | <ul style="list-style-type: none"> R&D on carbon sequestration, carbon capture and storage capability Develop energy internet to better integrate energy saving with Big Data, AI and other digital platforms | Inner Mongolia, Shanxi, Tianjin, Hainan |
| Carbon sink | <ul style="list-style-type: none"> Increase total forest, lakes, wetland areas to enhance natural ecosystems | Beijing, Liaoning, Sichuan, Tianjin, Anhui |
| Carbon trading market | On trial | Nation-wide |

Beijing's Interim Measures for the Management of Ultra-Low Energy Building Demonstration Projects and Subsidies, released in June 2017, provides subsidies for privately invested ultra-low energy building demonstration projects. Once a project is confirmed as a demonstration project in Beijing, a subsidy of no more than 50% will be given, and the rest will be given after the project is verified. This plan will largely overcome developers' concerns about costs and encourage more developers to invest in ultra-low energy buildings.

Chongqing City proposed reaching 70% of green building area in new buildings in cities and towns by 2022, and the proportion of new construction of assembled buildings in the city will not be less than 20%. Jiangsu Province proposed striving for the lowest carbon-emissions intensity of buildings in the country. Jiangsu, Zhejiang, Ningxia, Hebei, Liaoning, Inner Mongolia, Guangdong, and seven other provinces (regions) promulgated local green building regulations, however, mainly for the old version of green building evaluation standards. In the context of "carbon neutrality," regional-characteristics legislation on green building is imminent. Provinces, cities and districts that have issued local green building development regulations and rules keep pace with the national goal and revise the relevant content accordingly.

Many places have launched corresponding incentives to encourage building energy efficiency: Hebei's special funds for high-quality development of key industries are tilted toward manufacturers of high-performance doors and windows, special materials, and other proprietary parts and components for ultra-low-energy-consumption buildings; Heilongjiang proposes to introduce preferential policies in land supply, industry management, taxes, and fees to guide the construction of subsidized housing to adopt assembly-type construction; Guangdong conducts incentives such as financial support, floor-area-ratio rewards, tax benefits for the construction, acquisition, and operation of green buildings, and the green retrofits of existing buildings.

So far, China has not issued a document that regulates CO2 emissions, and only some laws stipulate standards for the use of water resources and electricity resources.

The U.S. Leadership in Energy and Environmental Design (LEED) certification is prevalent in China. In 2018, LEED-certified Grade A office buildings exceeded 523 million square meters across greater China,

accounting for over 27% of the total market share in 10 prominent cities. According to the CBRE, the average occupancy of premium LEED projects in China is 10% higher, and the rental fee is 25% higher than comparable non-LEED buildings.

2. Capital Market

China's capital market plays an essential role in addressing climate change and achieving carbon targets. It has brought in funds and resources to develop China's low-carbon economy. The funding for energy efficiency in the real estate market and the climate responsibilities of enterprises are primarily driven by the compulsory financial regulations.

2.1 Equity Market

Almost every industry has seen a noticeable shift to stressing sustainability, leading to Environmental, Social, and Governance (ESG) becoming a consideration (Diagram 3). There is no exception for the real estate industry, as developers face increasing pressure from their investors, regulators, tenants, and employees to act on ESG. However, as the world's second-largest economy, China ranks near the bottom in ESG performance, ranking 47th out of the 50 nations in the MSCI All Country World Index 2021. The alarming low levels of disclosure practices and a lack of uniformity of reporting metrics among domestic enterprises are mostly to account for the poor ESG performance.

ESG investment is a hot topic in China. Multiple policy reforms and government guidelines have been the early driving force in building awareness of ESG in China. The percentage of Chinese companies in the Shanghai-Shenzhen CSI 300 Index that have voluntarily disclosed some level of ESG data rose from 43% to 82% from 2009 to 2018 because of the recognition of the benefits of information disclosure in attracting foreign capital.



Diagram 3: ESG Regulations and Guidance in China

Source: Open market news from major stock exchanges and government authorities; Arisaig Partners

The real estate industry presents a vital position in the China national economy. In general, ESG information disclosure by real estate listed companies in China is in the early stage. Chinese real estate companies have taken actions to improve ESG management. For example, most

of them have set up sustainable development goals, engaged in new technology research and innovation to improve energy efficiency, and developed green finance solutions and social charities. According to the China Index Academy, as of July 31, 2020, 53% of all A-share real estate companies (54) had published ESG reports. In comparison, 94% of all H-share real estate companies (103) had issued ESG reports (Diagram 4).¹⁶ ESG information disclosure by HKEx for listed companies has been upgraded to a semi-mandatory disclosure level. Shanghai and Shenzhen exchanges are gradually implementing and refining the ESG disclosure system of listed companies; the gap between A and H shares will narrow in the future.

However, quantitative information appears insufficient in most real estate companies' ESG reports: only 31% of them released an independent ESG report; 3.36% of the ESG reports have been assured by an independent third-party auditor. Environmental strategies of listed real estate companies are integrated mostly at the vision level and are seen as a brand promotion or are formulated passively based on regulatory requirements.

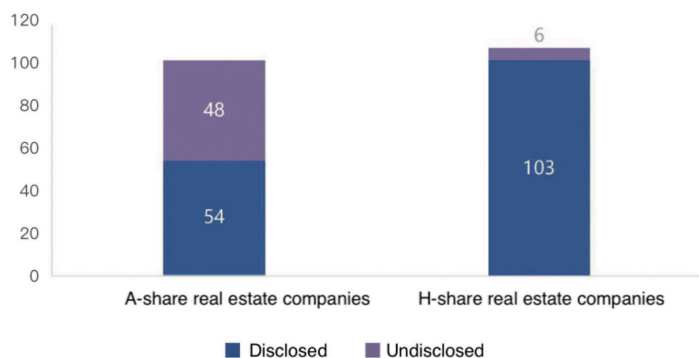


Diagram 4: ESG Disclosure of Listed Real Estate Companies in China, 2020

Source: ESG Report Measurement Study of Chinese Real Estate Listed Companies in 2020, China Index Academy, 2020

2.1 Debt Market

Numerous green financial offerings emerge across banking and corporate sectors in the Chinese market because of the policy support and capital demand for environmentally friendly businesses. They have recently elevated China to become the second-largest green-bond issuer globally. In 2018, China's internationally aligned green-bond issuance reached US\$31.2 billion, accounting for 18% of the global volume. According to the People's Bank of China's report, by the end of 2019, the balance of domestic and foreign currency green loans was RMB10.22 trillion. Funds involved are mainly invested in green transportation and renewable energy. Diversified green financial instruments have also been developed to support the real estate industry.

Green financial instruments in China's real estate industry are mainly focused on green loans and green bonds. For developers and landowners, despite the credit control and tightened lending environment in China, fundraising activities remain active in the real estate sector. Green bonds tend to bear a lower interest rate than regular bonds. Taking conventional corporate bonds as an example, average financing costs for real estate companies fall between 5.5% and 7.5%. The average financing costs for issuing offshore bonds are on the rise and often unstable,

given the currency fluctuations. According to financial data provider Wind Information, as of the first half of 2019, the average coupon rate of offshore bonds issued reached 8.8%. By contrast, the average coupon rate of domestic green bonds issued remained at approximately 4.5%. According to China Central Depository & Clearing Corporation (CCDC), green bonds received higher oversubscription than conventional bonds on the domestic market, reflecting strong interest from investors.

According to the People's Bank of China Green Bond Guidelines and Green Bond Endorsed Project Catalog, allocations to transportation account for 33% of the total proceeds raised in 2018. By contrast, only 9% is allocated to the building and construction sector (Diagram 5). In 2018, only two companies, New World China and Hang Lung Properties, issued green bonds, accounting for only 1% of the total amount issued. By contrast, allocation to buildings dominated at 37% in the Hong Kong market. Following the largest and most frequent green-bond issuer, MTR Corporation, Link REIT, and Swire are among the top issuers to have issued a benchmark-sized deal of US\$500 million. Green projects command greater building specifications, quality control, and maintenance. As a result, only a few leading real estate companies have more resources to pass the requirements and become potential issuers. China's policies in facilitating green finance focus on the approval process but lack practical subsidies for issuing activities. Green bonds could offer lower financing costs; however, extra costs may be incurred during the process, such as certification expenditures owed to third-party reviewers.

Ample opportunity remains for Mainland Chinese real estate companies to issue green bonds to achieve the green development targets through tax reduction and subsidies, among other policy incentives.

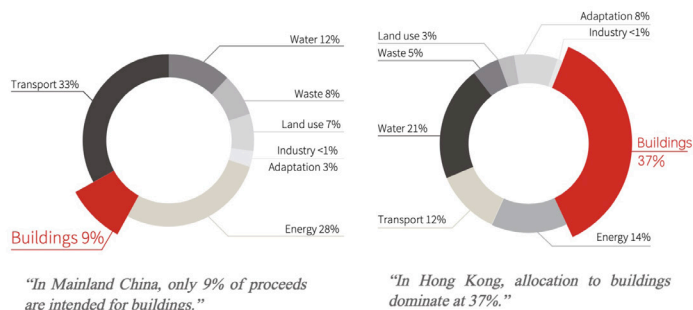


Diagram 5: Use of Proceeds Raised by Green Bonds

Source: Hong Kong Green Bond Market Briefing, Climate Bonds Initiative

2.3 Emission trading schemes

The National emissions trading schemes (ETS) are one of China's most important financial tools for meeting its emissions reduction targets. In late 2017, the Chinese government released the Work Plan for the Construction of the National Emissions Trading System, which outlines the national ETS's essential development phases. The electric power sector (which accounts for about 9% of worldwide GHG emissions and 30% of China's GHG emissions) is planned to be covered in the first phase. On November 2, 2020, the Ministry of Ecology and Environment (MEE) released a draft of ETS guidelines for public consultation, setting out detailed designs related to offsets, participation thresholds, allocation approach, registry, and penalties, among other things. On

November 20, 2020, MEE also released the draft 2019–20 emission allowance (i.e., quota) allocation plan for the power-generation industry. The draft allocation plan specifies benchmarks and covers 2,267 power generators, including standalone and industrial captive power plants. China's national ETS started operation in 2021, regulating more than 2,200 power companies and covering around 40% of China's carbon emissions in its initial phase.

Currently, the scheme primarily applies to polluters in the power industry, which account for 40% of overall emissions in the country. In 2022, the ETS will bring in new participants, including financial institutions and non-ferrous metals and building materials emitters. Because of the high carbon emissions, iron and steel, cement, and aluminum manufacturers have been identified as critical sectors for the EU Carbon Border Adjustment Mechanism implementation. The production of these materials is largely for the building industry. For example, real estate is the source of demand for 42% of Chinese steel production. In China, these sectors contributed to around 15%, 11%, and 4% of China's total carbon emissions, respectively, and are likely to be included in the national ETS during the 14th FYP.

Commercial banks will likely explore a variety of financial products and services related to carbon emission reduction indicators and carbon emission quotas once China's national carbon trading market is constructed. The possibilities for financial innovation in the carbon control sector will expand even further, encompassing anything from financing instruments backed by carbon emission rights to various sorts of derivatives.

3. Business Innovation

Carbon control and sustainable development have been highlighted in every sector in China. However, the real estate industry is still in the preliminary stages of dealing with the climate crisis. Energy efficiency and carbon reduction in the building sector are predominantly government driven. All exemplary net-zero projects are government properties; currently, few net-zero buildings have been constructed solely by private. However, we cannot ignore the progress and effort that the industry leaders have devoted to the finance, technology, supply chain, construction, and other aspects to move further toward net zero.

3.1 Leading real estate companies

With the execution of green building policies and the increasing public attention to green buildings, some pioneering real estate companies have created corporate images of sustainable development, especially the Hong Kong-funded real estate corporations.

For Hang Lung Properties, a Hong Kong- and Mainland China-based real estate developer, the press to decarbonize is central to its commitment to ESG principles. Within its 2030 sustainability goals and targets, Hang Lung committed to a steep GHG reduction target, namely, a 70% reduction in GHG emissions intensity per m² relative to its 2018 baseline. In the financing arrangements, the company aligned its sustainability principles with its funding requirements. The sustainability-linked loan (SLL) signed with BNP Paribas in March 2021 exemplifies its approach. The proceeds from the HK\$1 billion three-year bilateral revolving credit facility are for general corporate use. However,

it features predetermined sustainability performance targets that result in more affordable funding costs for Hang Lung if met. The company adopts the most suitable techniques for new and existing buildings, including optimizing the operating efficiency of its HVAC systems, retrofitting and replacing aging and inefficient facilities, use of building information modeling (BIM), and installation of solar panels.

Another pioneer, Link REIT (Link), has announced its goal to reach net-zero by 2035. It was the first Hong Kong enterprise and the first property company in Asia to issue a green bond, raising US\$500 million at a 2.875% fixed rate due 2026—one of the lowest rates ever achieved by a Hong Kong corporation. In March 2019, Link became the first real estate sector worldwide to issue a green convertible bond due 2024. In addition, in 2019, Link embarked on a Solar PV Proof-of-Concept to demonstrate how blockchain technology could be an immutable, secure, and verifiable method of tracking carbon impact to enhance sustainable infrastructure development. The practice was initiated with a solar pilot project in Lok Fu Place in February 2021 and extended to TKO Spot and Tai Yuen Commercial Center. The project involves the installation of PV arrays on a portfolio of real estate assets in Hong Kong, with the economic, ownership, or associated carbon-reduction interests in those PV Projects represented by tokens on the Ethereum blockchain.

Swire Properties, the only property developer in Hong Kong and China, has been included in the Sustainability World Index of Dow Jones since 2017 and was named the top sustainability leader in the Hang Seng Corporate Sustainability Index in 2018. The Global Real Estate Sustainability Benchmark (GRESB) named it a Global Sector Leader for Mixed-Use developments and awarded Swire Properties the highest 5-star rating since 2017. Additionally, its sustainability performance was recognized as being within the top 15% of companies in the real estate industry worldwide, according to the RobecoSAM Sustainability Yearbook 2021.

An increasing number of real estate companies in Mainland China have also regarded green development as a new competition track. Vanke, Evergrande, Country Garden, and Longfor promote green technology research and innovation and set up near-zero research centers to industrialize construction systems and create industry standards for near-zero energy-consumption building practices. See Table 2 for details.

Table 2: Green Technologies of Some Chinese Real Estate Companies

Source: ESG Report Measurement Study of Chinese Real Estate Listed Companies in 2020, China Index Academy, 2020

| Company | Green Building Design Specification | R&D System | Technology Application |
|----------------|--|--|---|
| Vanke | Vanke Green Building Standard Guidelines The Promotion of Vanke's Industrialization System from 2018-2021 | Vanke Architecture Research Center and Xiong'an Vanke Green R&D Center in building a green building industry chain | Healthy, fast installation system, mechanical and electrical intelligent operation and maintenance, healthy landscape, lean management practice, etc. |
| Evergrand | Evergrande Group Green Housing Design Requirements and Standards (2019 Edition - Star Rating) Guidelines on the Implementation Process of Ultra-Low Energy Buildings | Green Building Research Center and the Residential Industrialization Center actively promote green building design work; strengthen the energy-saving design of residential buildings and large cultural and tourism projects | Assembled construction, intelligent waste recycling, high-performance envelope structure and window and door system, high air tightness, no cold and heat bridge design, high-efficiency heat-recovery fresh-air system |
| Country Garden | Country Garden Healthy and Comfortable Housing (Passive Ultra Low Energy cum Assembly) Building Technology Guidelines Country Garden Green Building Design Guidelines Country Garden Technical Study on the Landing of Sponge City Projects Country Garden Sponge City Design Guidelines Healthy Community Evaluation Criteria | Established institute of sustainable development mainly focuses on the technical, quality, contractual, and cost control of the green building, passive house, LEED, WELL, and sponge city | BIM technology, renewable energy, energy-saving technologies (condensing heat recovery, high-efficiency chillers, frequency conversion technology, etc.) |
| Longfor | Quality Control Standard for Near-Zero Energy Residential Buildings (Longfor formulated the national standard) | Jointly with Tsinghua University School of Architecture, China Architecture Design Institute, Tsinghua University, China Architecture Design Institute, and Orient Sundar Group established a near-zero energy-consumption research center "four-party center" to promote the development of near-zero buildings | Green intelligent sponge city and near-zero building technology system, the integrated use of digital, ecological natural repair, and new energy technology, etc. |

3.2 Leading Projects

The number of projects in China that focus on energy consumption and carbon emissions levels is growing. With the encouragement of a series of policies, China's ultra-low-energy representative demonstration projects have been built. By adapting to the climate characteristics and site conditions, making full use of technical measures such as natural ventilation, natural lighting, and thermal insulation of the envelope structure, and adopting energy-efficient equipment, ultra-low-energy buildings reduce the energy consumption of building heating, air conditioning, and lighting to the greatest extent. Based on ultra-low-energy-consumption buildings, technical measures such as the application of renewable energy are added to achieve zero carbon. At the regional level, from 2015 to 2019, 13 cities in nine provinces and autonomous regions in China issued 28 policy documents to promote the development of near-zero-energy buildings. By the end of 2019, 18 projects nationwide had obtained the ultra-low, near-zero, and zero energy building labels.

Meishan Near-Zero Carbon Zone, Ningbo

Key feature: The building life-cycle carbon emissions standard and management mechanism.

With a total site area of 330 square kilometers, Meishan is a "port-industry-city" integrated urban development zone in the southeastern part of Ningbo in Zhejiang province. Following comprehensive technical and economic analysis and benchmarking against leading international cities, Meishan has released ambitious quantitative near-zero carbon goals with stable economic growth. Reaching these goals would triple the permanent population and develop the economy fourfold while meeting a near-zero carbon target by reducing emissions by 70% relative to what is expected under the business-as-usual scenario by 2030 and will achieve carbon neutrality around 2050.

With these clear targets, Meishan further clarifies the carbon reduction potential of each sector (Diagram 8). The building sector assumes a large portion of the task. All building energy end-use applications will be elec-

trified for the buildings sector, except cooking, and significantly improve overall building energy efficiency by 40%. In addition, to achieve the overall 74% carbon-reduction target in the buildings sector, Meishan implements a life-cycle assessment (LCA) standard. It set up quantitative targets for carbon reduction, requiring the whole process-management system to promote green building materials and products, scale-up energy-efficient building designs, recycle construction waste, and facilitate new building industrialization. Meishan incorporates building LCA standards in the green and low-carbon building plan, which requires a new building's LCA carbon-reduction rate to be equal to that of a reference building. Meanwhile, Meishan is extending a green and low-carbon development concept from only the operation phase to the entire lifespan: planning, design, construction, operation and management, and demolition. The policy promotes low-carbon ideas to the industry value chain of the building sector, pushing suppliers to provide green products. Through the cross-department collaboration of the government, the management covers nine key points in a building's life cycle. Project contractors submit LCA indicators and get approval from corresponding government departments. The management mechanism supports the near-zero carbon target strongly and efficiently.

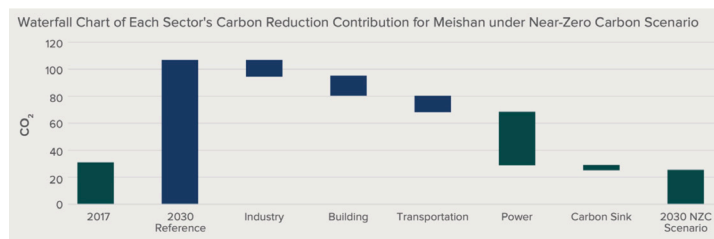


Diagram 6: Each Sector's Carbon Reduction Contribution for Meishan going to Near-Zero

Source: Near-Zero Carbon Zones in China, Policy Roadmap and Case Study. RMI. 2019.

Hanergy Renewable Energy Center, Beijing

Key features: solar energy utilization; first LEED Zero Carbon certification.

A 7,119-square-meter, all-solar green building in Beijing's Olympic Park was the first to achieve a LEED Zero Carbon certification. During the certification process, Hanergy Renewable Energy Center was adjudged to uphold the three-level energy-efficiency concept of self-sufficiency, surplus storage, and grid independence. Furthermore, the center's case was strengthened by the annual estimation of saving 104 tons of standard coal and reducing CO₂ emissions by 314 tons, equivalent to planting 13,745 trees.

The center features flexible thin-film solar modules on the top and sides of the building. It adopted a thin-film copper indium gallium (CIGS) technology for power generation and a micro-grid management system that optimizes renewable energy generation, consumption, storage, and sales. The project team created a unique approach that enabled energy sharing with the company's headquarters to form a regional microgrid. The building had previously achieved LEED Platinum certification and pursued LEED Zero to obtain third-party verification of its sustainability efforts. be elec

Nanjing Green Light House, Nanjing

Key features: PV panels; natural ventilation; natural lighting.

The Nanjing Green Lighthouse is one of China's first zero-carbon buildings. The circular facade is optimized and carefully planned with operable openings and daylight horizontal reflectors. The system minimizes the exposure to the sun's forthright heat while maximizing access to soft natural light. The building inside can achieve 200 LUX natural daylight levels for all the work areas. The interior is mainly covered by white surfaces to reflect light, making the workspaces free, bright, and airy. Colorful furnishings and lush plantings, including full-height green walls and hanging plants, punctuate the interior. The technology allows the building to achieve energy consumption below 25 kWh/m²/year, and Photo Voltaic panels will offset the remaining energy load. Through sophisticated facade design, the building fully utilizes the natural daylight and indoor climate in general and increases the well-being and productivity of the occupiers. With the support of a multidisciplinary team and 3D tools, optimized areas of windows and skylights have been calculated to achieve the highest efficiency with the lowest use of high-performance facade openings.



Diagram 7: Nanjing Green Light House

Source: <https://www.archdaily.com/792110/nanjing-green-light-house-archiland-international>

4. Opportunities

4.1 Regional Collaboration

In the urban development and construction sectors, the Chinese government participates in a wide range of international programs on low-carbon cities, including programs between central government ministries and counterparts in other national governments, "sister city" programs between Chinese and foreign cities, and programs that run by international associations such as the Climate-Smart, Low-Carbon Cities (CSLCC) program, which is funded by USAID under the US-China Joint Agreement on Climate Change. Such programs facilitate shared learning on best practices and tools for promoting low-carbon urban development. Examples include bilateral programs with the US, UK, Germany, Singapore, and others and the C40 program (a network of megacities committed to addressing climate change).

For inter-cities cooperation, the International Low Carbon City (ILCC) in Shenzhen is a model of low-carbon city construction projects. Shenzhen ILCC is a flagship project of China–Europe cooperation on sustainable urbanization, planned and built-in cooperation with the Netherlands, and is committed to building a climate-friendly city pioneer area, a cluster of emerging low-carbon industries, a low-carbon lifestyle leader area, and a demonstration area for low-carbon international cooperation. The ILCC Project, with a total planned area of 53 square kilometers, takes the 5-square-kilometer area of Gaoqiao Park and its surroundings as the extension zone, of which a one-square-kilometer area is the initial zone, with a building area of 1.8 million square meters. The total estimated construction period is seven years.¹⁷

Plenty of such international collaboration has taken place to push forward China's cities carbon commission. In 2013, Langfang in Shandong province, Weifang and Rizhao in Shandong province, Hebi and Jiyuan in Henan province, and Hefei in Anhui province became the first low-carbon ecological pilot cities to take part in a collaboration between China and the US. In 2014, Yixing and Haimen City in Jiangsu province, Yantai in Shandong province, Urumqi in Xinjiang Province, and Zhangjiakou (including Huailai) in Hebei Province became the pilot cities for the Sino-German Low Carbon Ecological City Cooperation Project. The China-Switzerland Low Carbon Cities Chengdu project, launched in 2016, is a strategic partnership of innovation.

4.2 Opportunities

The Chinese government plays a major role in promoting energy efficiency and reducing GHG. By contrast, market-based promotion mechanisms such as contract energy management, carbon trading, and comprehensive energy-efficiency services have yet to be improved. The current purchase- and price-restrictions policy greatly impacts the development of green and energy-efficient buildings, while requiring developers to engage in green building development corresponds to a significant increase in costs. Therefore, the relevant policies should be adjusted, and a market-oriented mechanism that promotes green buildings should be established. Meanwhile, the shift can rely on the housing and construction authorities and the joint efforts of multiple governmental departments. For example, in terms of land management, when granting land-use rights, the minimum green building star rating of the plot could be clarified. If the developer promises the future building's star rating will be higher than the required minimum, priority can be given to land acquisition. After the project is completed, the housing and construction bureau will assess the green building performance.

In addition, information disclosure needs to be enhanced during the project development or renovation process. Developers will be required to disclose the design and implementation of green strategies and be scrutinized by government departments.

The Chinese government is targeting environmentally sustainable growth. Investors can provide financing to developers, specifically concentrating on the control of energy consumption and carbon emission for all sizes of construction projects, including small residential properties and large office spaces. China is the world's largest market for construction investment globally, representing around 20% of the total,¹⁸ and the IFC estimates the cumulative investment potential for the construction of new green buildings in China may be around \$13 trillion by 2030. Moreover, China has a large stock of existing residential

buildings and needs sufficient financial support for energy-saving renovation and other work. Around 85%–90% of construction investment in China is available to the private sector; investors play a critical role in providing financing to enable higher energy efficiency in buildings.¹⁹

Investors will have an opportunity to provide loans to residential and commercial properties to invest in energy-efficiency improvements with passive or active technology, including three main aspects: integrated and passive design concepts, heating and cooling, and information technology that empowers systematic solutions for building management.²⁰ For example, in northern rural areas without access to a centralized heat-supply network and in buildings with growing heating demands, such as in the areas in the Yangtze River Basin with hot summers and cold winters, clean and efficient decentralized heating technologies have considerable value.

About the Author



Zehao You

Zehao You is a current student at the MIT Center for Real Estate and is working on the Sustainable Urbanization Lab research project. Zehao joins MIT with a background in architecture and professional experience in project management for commercial real estate development in the Chinese market. He is passionate about integrating capital, technology, and civic responsibility into urban development and investment and is keenly interested in climate issues and sustainability in the built environment.

Real Estate Industry Overview

The real estate market size in India was around US\$200 billion as of 2021. It is projected to reach a market size of US\$1 trillion by 2030.¹ This growth is depicted in Diagram 1. Seventy percent of the buildings that will exist in India by 2030 will be constructed in the next 10 years.² This number is much lower at around 1/4 in the US and 1/10 in Europe. This observation signifies new developments are likely to be a major focus as India addresses the issue of sustainability in the real estate market.

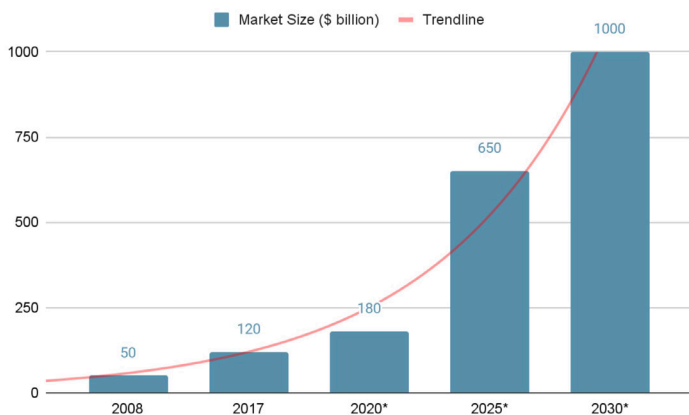


Diagram 1. Indian Real Estate Market Size

Source: Indian Real Estate, Indian Brand Equity Foundation, 2020, <https://www.ibef.org/download/Real-Estate-June-2020.pdf>

India has over 400 cities spread across 28 states and eight union territories. Forty of these cities have a population of over 1 million. Eight cities have a population of more than 3 million with significant real estate development³: Mumbai Metropolitan Region (comprising Mumbai and peripheral cities), National Capital Region (comprising New Delhi, Noida, Gurgaon, Faridabad), Bangalore, Pune, Hyderabad, Chennai, Kolkata, and Ahmedabad (Diagram 2). More than three-fourths of development is by private for-profit developers.



Diagram 2. Location of Top Eight Real Estate Markets

Commercial Real Estate: Office

The office-space market is organized with significant institutional ownership (more than one-third).⁴ The development trend is driven by the office spaces catering to information technology and information technology-enabled services (IT/ITES) in these cities. Office development is then followed with a lag of a few years by residential development in the cities. Historically, Mumbai MMR and Delhi NCR have witnessed a large portion of commercial real estate development. However, during the 2010s, Bangalore and Hyderabad picked up the pace, with several global technology firms establishing their offices and offshore centers started by several other conglomerates across the globe. Bangalore has also witnessed the emergence of several unicorn startups, which play an active role in the commercial real estate market. A substantial portion of commercial real estate development also takes place in the form of captive consumption by industries; that is, it is not leased out to companies but is either sold in the market or is owner occupied real estate.

Residential Real Estate

The residential space market is highly fragmented by individual ownership. Residential development is primarily for customers because demand from institutions is limited.

Global Real Estate Sustainability Index

The major Indian cities lag their global peers, namely, London, Paris, New York, Seoul, and Tokyo, by 10 years in terms of sustainability.⁵ Only Delhi NCR is in the top 100 sustainable cities in the world. The CBD area of New Delhi has no new real estate development, apart from government buildings, which rank high in terms of sustainability and the use of green technologies. The Knight Frank sustainability index has rated cities on four major parameters: brown initiatives, green initiatives, climate-risk initiatives, and urbanization pressures. The current state of Indian cities with respect to their global position on sustainability indicates a lot is yet to be done not only in terms of city planning but also in terms of green buildings.

The net-zero commitment by the Indian government has been delayed relative to other western countries for various reasons, including the base timeline for peak greenhouse gas (GHG) emissions, the focus on per-capita emissions instead of countrywide emissions, the cost of achieving net zero, and the financial and technological supports required in achieving net zero. At the COP26 in November 2021, India finally committed to a net-zero target by 2070.⁶ Various participants have announced other climate-related commitments in the building sector:

India National Government

- The Ministry of Environment, Forest and Climate Change (MoEFCC) has committed to cut emissions intensity by 33%–35% of 2005 levels by 2030.⁷

- The MoEFCC has committed to reducing cooling demand and energy by 20%–25% and by 25%–40% by 2037–38.⁸

- The Indian Green Building Council has committed to 10 billion square feet of green building by 2022.⁹

India Local Government

- Forty-three cities in Maharashtra joined the UN Race for Net-Zero (no time commitment).¹⁰

- Bengaluru (Bruhat Bengaluru Mahanagara Palike—the local administrative authority of Bengaluru) has committed to being net-zero by 2050.¹¹

Despite having made these commitments recently, the fine print of the road map to net zero for the real estate sectors has not emerged. As has been the practice with other government schemes, the drive toward net-zero in real estate requires definitive budgetary allocation.

1. Policy

The central government formulates policies that the respective state governments adapt with certain modifications. The real estate development policies are consistent across states, with certain alterations at the city or municipal level. None of the eight covered major metropolitan regions mention any net-zero or resilient building mandates. However, certain policies either directly influence the operations of buildings by reducing carbon emissions or assessing and managing the adverse environmental impact of the real estate project. A few of the effective and widely popular carbon-related policies are discussed below.

1.1 Energy Conservation Building Code 2017 (ECBC)

The Energy Conservation Building Code (ECBC) intends to provide minimum requirements for energy-efficient design and construction of buildings. The code also provides two additional requirements for buildings to achieve enhanced levels of energy efficiency beyond the minimum requirements. The code was first issued by the Bureau of Energy Efficiency (BEE), a government agency operating under the Ministry of Power, in 2007, and the modified version was issued in 2017. The code is a result of a joint effort of collaboration between the BEE and the United Nations Development Program. The code is applicable to commercial buildings with a connected load of 100 kW or a contract demand of 120 kVA. The code does not cover buildings intended only for private residential purposes. The code issued detailed guidelines for construction and operation of real estate buildings across hospitality building, offices, warehouses, residences (mixed use), and so on. The code prescribes building technologies to reduce building energy consumption and promote low carbon growth.

ECBC has various implementation parameters, including daylight calculations and implementation, roof insulation, heating ventilation, air conditioning, and lighting. The GHG emission reduction of 0.14 MtCO₂ is estimated annually, which will scale up to 3.4 MtCO₂ in the 25-year lifespan of the buildings for the 355 ECBC compliant buildings to date.¹² If ECBC is implemented rigorously throughout India, GHG emission reduction has the potential reach over 250 MtCO₂.

Energy Conservation Building Code Implementation

To date, 18 states and union territories have notified the ECBC of implementation. Hyderabad (Andhra Pradesh), Bangalore (Karnataka), Part of Delhi NCR (Uttar Pradesh & Haryana), and Kolkata (West Bengal) have adopted ECBC. The other cities, Mumbai MMR and Pune (both part of Maharashtra), Ahmedabad (part of Gujarat), and Chennai (part of Tamil Nadu), still do not have the mandate to implement the code. Although these states are working toward the notification, their exact timelines of implementation are not certain.

1.2 Environmental Clearance, 2006

The MoEFCC issued guidelines for Environment Impact Assessment in 2006. The notification mandated every infrastructure project, including large-scale real estate projects and both public and private developments, to obtain environmental clearance from the designated authorities before commencing any construction work on the project site. The entire implementation of the environmental clearance process is jointly implemented by the central and state government bodies. The multi-level authority approvals provide for accountability and transparency at different levels. The application for approval of environmental clearance among other factors includes the following:¹³

- Effect of the project on forests, wildlife, coastal region, and so on.
- Benchmarking of projected energy consumption, water usage, and waste generation of the development.
- Management of emissions and pollutants, noise, vibration, and emissions of light and heat.
- Building materials (embedded carbon) and energy conservation.

The project proponent is required to present a detailed plan of applicability and mitigations of the above-mentioned factors for seeking environmental clearance. After a detailed discussion, the approving authority might approve the project with or without any recommended changes to ensure the environmental impact of the project is minimized. The level of approval authority that can provide environmental clearance is determined by the below rules¹⁹:

- Local zoning authority environmental clearance for real estate projects with a built-up area (BUA) less than 20,000 square meters.
- EIA approval from the Ministry of Environment & Forest to be obtained for buildings with a BUA between 20,000 and 150,000 square meters.
- EIA approval from the State Environment Impact Assessment Authority to be obtained for buildings with a BUA greater than 150,000 square meters.

The process of environmental clearance has been effective in keeping a check on the proliferation of real estate projects across the country and laying out a detailed environmental management plan for the projects. However, in the absence of a specific benchmark and mandate with regards to the energy requirement and GHG emissions, assessing the effect of this policy on emission reductions to date is difficult.

In addition to the above, the Indian real estate market has several other policies that guide energy savings, GHG emissions, and other sustainability parameters. However, these policies are still in the nascent stage, and their impact has been minimal across the country. These policies include the following: India Cooling Action Plan, 2016—a detailed guideline for cooling and conditioning operations across the country; Building Energy Efficiency Program—a program to retrofit commercial buildings into energy-efficient complexes; Eco Niwas Samhita 2018—an Energy Conservation Building Code for Residential Buildings (ECBC-R); and the Bureau of Energy Efficiency Star Rating for existing buildings.

1.3 Green Building Ratings

Three existing green building rating systems are prevalent in India, namely, Leadership in Energy and Environmental Design (LEED),

Green Rating Integrated Habitat Assessment (GRIHA), and Bureau of Energy Efficiency Star (BEE-S). Of these, the BEE-S rating is only for energy efficiency. Accordingly, we cover the first two rating systems in detail. Both LEED and GRIHA have come up with a Net-Zero Energy Building Rating system in 2018; however, it is not yet prevalent across the real estate market.

Leadership in Energy and Environmental Design (LEED) signifies how much a building is lowering carbon emissions, conserving resources, and cutting costs, while prioritizing sustainable practices and creating a healthier environment. As of 2021, around 1,478 LEED-certified green buildings in India having an area of 50,000 square feet. Maharashtra (including Mumbai MMR & Pune), Karnataka (including Bangalore), and Tamil Nadu (including Chennai) are the leading states in terms of the number of projects that have obtained LEED across the country. IT parks, offices, banks, airports, convention centers, educational institutions, hotels, and residential complexes are the major structures that register for an LEED rating. Many government buildings have chosen LEED certification, and several government agencies, including key state governments, have started offering incentives around LEED.

Green Rating Integrated Habitat Assessment (GRIHA) is an independent not-for-profit society established jointly by The Energy and Resources Institute (TERI) and Ministry of New and Renewable Energy (MNRE), and the government of India. It promotes and facilitates the GRIHA national rating system for green buildings in India. The rating system was adopted as the national rating system for green buildings by the government of India in 2007. GRIHA measures a building's environmental performance on a scale of 1–5 stars. As of 2021, 1,733 projects had been registered under GRIHA. Initiatives under GRIHA during FY15-19 resulted in a saving of 69.9 MU and avoidance/ reduction of 57,340 tons of CO₂ emission during FY18-19. These implementations during FY15-19 also added 58.1 MW of renewable energy. In 2019, the total number of GRIHA certified green buildings in India was 1,733.

Incentives for Green Building Ratings

The central and state governments have incentivized the adoption of green ratings by buildings. In certain other cases, the city-level municipal corporations have announced incentives. A few major examples follow:

- **The Ministry of Environment & Forest, Government of India** offers fast-track environmental clearance for buildings certified by Indian Green Building Council.
- **Rajasthan (including Ahmedabad)**: 5%–15% FAR free of cost for various Indian Green Building Council (IGBC) ratings.
- **West Bengal (including Kolkata)**: 10% FAR for gold-rated and above IGBC.
- **Uttar Pradesh (including part Delhi NCR)**: 5% additional FAR for gold-rated and above IGBC.
- **Pune (part of state of Maharashtra)**: PMC/PMRDA/PCMC—3%–7% additional FAR for IGBC. Mandate for all renovation and new government buildings to be IGBC certified. This benefit is not applicable for the city of Mumbai MMR.
- **Andhra Pradesh (Hyderabad)**: 25% subsidy on fixed costs for industries; reduction in permit fees and stamp duty.
- **Haryana (Part Delhi NCR)**: 9%–15% additional FAR for IGBC.

2. Capital Market

The capital market in India is still in an emerging state relative to developed countries. Capital market investors' demand for sustainability in real estate investment is minimal; however, the trend is catching up. The funding for energy efficiency in the real estate market is primarily driven by the financing options provided by the government-owned entities and several global financing institutions. A few leading private institutions also have offerings in this segment, but their impact is limited. Some key financing options for sustainable and green development in India are presented in Table 1.

| Type of Support | Details |
|------------------|---|
| Equity Financing | <ul style="list-style-type: none"> • Bureau of Energy Efficiency offers Venture Capital Finance – Venture Capital Fund for Energy Efficiency - \$ 30 million. • Indian Renewable Energy Development Authority offers capital subsidy for solar rooftop and hot water installation - \$ 55 million. • International Finance Corporation ties up with banks providing equity which can be used for green financing. • Limited examples with mostly traditional investments in real estate. Recent emergence of REITs (3 till date) to provide an impetus. |
| Debt Financing | <ul style="list-style-type: none"> • Bureau of Energy Efficiency offers: <ul style="list-style-type: none"> ○ Loan Loss Reserve – Partial Risk Guarantee Fund - \$ 50 million. ○ Risk Mitigation – Energy Efficiency Financing Program. • State Govt. offer project finance through the State Energy Conservation Fund. • Asian Development Bank offers project finance through The Energy Efficiency Initiative - \$ 3 billion • Infrastructure Development Finance Company Limited offers project finance for energy efficiency and renewable energy projects - \$ 400 million • Small Industries Development Board of India offers energy efficiency renewable energy projects - \$ 325 million • Public Sector Banks: <ul style="list-style-type: none"> ○ State bank of India offers mortgage finance with lower margins, lower interest rates and zero processing fees for green buildings. ○ Bank of Baroda offers Project Finance up to \$ 0.2 million for efficiency audits, retrofits, and upgrades. ○ Canara Bank offers project finance with interest rate concessions for energy efficiency upgrades and retrofits. • Private Banks: <ul style="list-style-type: none"> ○ ICICI Bank offers: <ul style="list-style-type: none"> ▪ Mortgage Finance at reduced processing fees ▪ ESCO Financing Options. ▪ Seed Funding of IGBC. ▪ Project finance in collaboration with Japan Bank for funding energy efficiency and renewable energy projects \$ 300 million. ○ Kotak Bank offers ESCO financing. ○ Yes Bank offers ESCO financing. ○ Axis Bank offers ESCO Financing and project finance with a total amount of \$ 100 million raised from IFC & Others. • Two specialized green financing institutions namely Indian Renewable Energy Development Agency (government) and TATA Cleantech Capital Ltd (private). Both are likely to emerge as Green Banks in near future. • Limited market for green bonds in real estate. |

Table 1: Equity and Debt Schemes for Green Buildings and Energy Efficiency in India¹⁴

2.1 Equity Schemes

Venture Capital Fund for Energy Efficiency

The Venture Capital Fund for Energy Efficiency (VCFEE), established by the Bureau of Energy Efficiency (BEE), is one of the financial instruments under the Framework for Energy Efficient Economic Development. The VCFEE provides risk capital support to energy-efficiency investments in new technologies, goods, and services. The scheme was a pilot scheme and has not received much traction from the industry. The government of India has approved about US\$30 million for the VCFEE, which is nominal given the overall market. The fund helps to create the volume in energy-efficiency deal flow by the fund manager of VCFEE through advertising and soliciting opportunities in the energy-efficiency area. Energy Service Companies (ESCOs) and companies that plan to undertake energy-efficiency projects in the energy-performance contracting mode are the potential key beneficiaries of the VCFEE. The fund was registered with the Securities and Exchange Board of India under its Alternative Investment Funds Regulation in 2012. VCFEE will provide equity capital for energy efficiency projects in Government buildings and Municipalities in the first phase. The fund will invest in the form of equity. A single investment by the fund shall not exceed US\$300,000. The fund will provide last-mile equity support to specific energy-efficiency projects, limited to a maximum of 15% of

total equity required, through special-purpose vehicles or US\$300,000, whichever is less. The total life of the fund will be 10 years from the date of commencement.¹⁵

Capital Subsidy

Indian Renewable Energy Development Authority (IREDA) jointly with the MNRE offers various capital-subsidy schemes for the implementation of solar water heaters in commercial and residential buildings. Under this scheme, IREDA had until June 2020 to disburse approximately US\$55 million in the form of capital subsidy to various developers and owners of the buildings who had implemented the solar water heater systems.¹⁶

International Finance Corporation (IFC)

The IFC and its affiliated funds invest in the form of equity in banks or financial institutions to ensure these institutions' commitment to green financing. In July 2021, the IFC and two investment funds managed by IFC Asset Management Company—IFC Financial Institutions Growth Fund, LP and IFC Emerging Asia Fund, LP—made an equity investment for a 4.99% stake (amounting for \$126 million) in Federal Bank Limited, a private bank in India. The investment will be towards the bank's commitment to environmental, social, and governance (ESG) standards, while strengthening its Tier 1 capital adequacy ratio and expanding its micro-, small-, and medium-sized enterprises and climate finance portfolios—key for growth opportunities as the country recovers from the COVID-19 pandemic. Although no specific earmarking exists for the real estate sector, the sector is likely to benefit from these similar schemes.¹⁷

2.2 Debt Schemes

The Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE)

PRGFEE is a risk-sharing mechanism or loan loss reserve promoted by BEE to provide commercial banks partial coverage of risk involved in extending loans for energy-efficiency projects. The government of India has approved around US\$50 million for PRGFEE. The PRGFEE guarantees a maximum of 50% of the loan (only principal) provided by the Participating Financial Institutions (PFI). In the case of default, the fund will either cover the first loss subject to a maximum of 10% of the total guaranteed amount or cover the remaining default (outstanding principal) amount on a pari-passu basis up to the maximum guaranteed amount. The exact guarantee for each guarantee facility will be finalized by the supervisory committee based on the risk assessment. PFI will take a guarantee from the PRGFEE before disbursement of the loan to the borrower, that is, ESCO subject to payment of guarantee fees. The guarantee will not exceed US\$400,000 (proposed to increase to US\$2 million) or 50% of the loan amount, whichever is less.¹⁸

Banks and Financial Institutions Loans

Several banks and financial institutions offer loans at a reduced cost and an enhanced loan-to-value ratio for energy efficiency in buildings and green buildings. Every state has a State Energy Conservation Fund wherein equal contributions are made by the central government and the respective state governments. The fund offers project finance for energy efficiency or conservation projects across the state. To date, approximately US\$20 million has been contributed to the fund across India. The Asian Development Bank (ADB) offers project financing at a low-interest rate through the Energy Efficiency Initiative. These projects are usually guaranteed by the government of India. To date,

approximately US\$3 billion has been lent under this initiative.

Infrastructure Development Finance Company Limited, a public sector undertaking, offers project financing for energy-efficiency and renewable-energy projects. The total amount lent to date is US\$400 million. Small Industries Development Board of India, a regulatory body, offers energy-efficiency and renewable-energy project financing. To date, US\$325 million has been lent.

The State Bank of India, India's largest public sector bank, offers mortgage financing with lower margins, lower interest rates, and zero processing fees for green buildings. The Bank of Baroda, a public sector bank, offers project financing up to \$ 0.2 million for efficiency audits, retrofits, and upgrades. Canara Bank, a public sector bank, offers project financing with interest-rate concessions for energy-efficiency upgrades and retrofits.

In the private segment, the offerings, although limited, have been increasing. ICICI Bank, the largest private sector bank, offers mortgage financing at reduced processing fees for green buildings, energy-saving companies, financing options, project financing in collaboration with the Bank of Japan for funding energy-efficiency and renewable-energy projects. To date, US\$300 million has been committed for this initiative. Kotak Bank, Yes Bank, and Axis Bank, leading private sector banks, offer ESCO financing. Axis Bank also offers green project financing through US\$100 million raised through IFC. HDFC Ltd, a leading mortgage financier, has recently raised US\$250 million from IFC for affordable green housing finance.

Green Bonds

The ESG and green bonds market in India has witnessed little traction from corporations and market participants. The Securities and Exchange Board of India (SEBI), the regulatory authority for capital markets, formulated a detailed policy for green bonds in 2015. Fundraising has increased substantially recently. During H1 2021, 12 ESG bonds were issued in India, amounting to US\$4.95 billion. Seven of these were green bonds with a total fundraising of US\$3.52 billion as per Refinitive, a London Stock Exchange Group Business.¹⁹ Energy-efficient and green buildings are two of the purposes approved by the SEBI. For example, in a first-of-its-kind green bond, Ghaziabad Municipal Corporation (part of Delhi NCR) raised US\$20 million through the issuance of green bonds in 2021 at a coupon of 8.1% for a 10-year tenure. The purpose of the bond was the construction of a sewer treatment plant in the city. Although several banks and financial institutions have issued green bonds in the Indian market to provide lending for green projects not limited to the real estate market, no bond issuance by a real estate developer or by a public authority has earmarked the proceeds toward green buildings. However, with an increased focus on this segment, India could soon witness the issuance of green bonds in this area.

Green Banks

A green bank is a pioneering institution that finances the deployment of renewable energy, energy efficiency, and other clean infrastructure projects in partnership with private lenders. They are commonly government funded and run and catalyze private financing for low-carbon technologies by using many financial tools, including issuing green bonds. The Reserve Bank of India (RBI), the apex banking regulator, has been working toward formulating policy for green banks in India. Currently, India has only two specialized green financing institutions: the

Indian Renewable Energy Development Authority (IREDA) and TATA Cleantech Capital Ltd. RBI is contemplating providing a green bank license to IREDA, which is poised to become the first green bank of India.

3. Business Innovation

The net-zero and green buildings development by the government and affiliated organizations is still in its nascent stage in India. As of 2021, India had no net-zero commercial real estate buildings. Several global conglomerates have included net zero in their building designs and operations. In the absence of any substantial financial market-based benefit available for these operations, financing has primarily been through government support/financing or internal accruals by corporates.

3.1 Net-Zero Projects

Indira Paryavaran Bhawan

Indira Paryavaran Bhawan, the new 31,489-square-meter office building for the Ministry of Environment and Forest (MoEF) in Delhi NCR, completed in 2014, is one of the first net-zero buildings in India. The building, which the MoEF intended to serve as an example for future net-zero buildings in India, is the country's highest green-rated building. A few of its standout features follow:

- Received GRIHA 5-Star and LEED Platinum ratings
- 100% ECBC compliant
- 75% daylight usage in building lighting
- 930 kW peak power solar rooftop energy system
- 40% energy saving through energy-efficient chilled beam systems (uses water as coolant)
- Use of fly ash bricks, high reflectance terrace tiles, rock wool insulation of walls.
- Use of UPVC windows, calcium silicate ceiling tiles
- Financed by the central government funds

Godrej & Boyce Manufacturing Company

Plant -13 Annexe completed in 2010, developed by Godrej & Boyce Manufacturing Company Limited (part of Godrej Group, a private conglomerate in India), is the first building in India to achieve a Net Zero Energy Rating from Indian Green Building Council (IGBC). Plant-13 Annexe, spread across 24,443 square meters, is a mixed-use office and convention center located in the Godrej campus at Vikhroli, Mumbai MMR. A few of the standout features of the buildings follow:

- Rated GRIHA Net-Zero, IGBC Platinum, BEE 5 Star
- 40% reduction in energy usage as per ECBC baseline
- Improvement in lighting, cooling, and equipment efficiency
- Use of Building Management Systems and Real-Time Energy Management & Systems
- Example of an existing building that achieved net-zero through repeated retrofitting over the last decade
- Financed by internal accruals of the company

Infosys Campus

Infosys Limited, the second-largest Indian multinational information technology company headquartered in Bengaluru, has been actively engaged in making its office buildings sustainable and resource efficient. The company currently has 25,080 square feet of office space that is LEED Platinum and GRIHA – 5-star rated with an additional 4,300 square feet under development as green buildings. The improvement in

efficiency was obtained through

- Large-scale retrofitting across campuses
- Re-engineering of chiller plants and air-handling units
- 44.3% of total electricity procured for India operations from renewable sources

renewable sources

- 33.5 MW reduction in connected load
- Reduction in per-capita electricity consumption has dropped by 55% relative to the 2008 level

by 55% relative to the 2008 level

- Implementation of integrated building management systems

systems

- Smart automation through remote monitoring, control, and optimization

optimization

- Financed by internal accruals of the company

Indian Institute of Technology, Jodhpur (IIT Jodhpur)

The new campus of the Indian Institute of Technology, Jodhpur, spread across 8,07,518 square meters, is the first net-zero energy campus of its size built in the desert area of Rajasthan. Campus operations started in 2017, and certain phases are still under development. At its peak, the campus was designed for net-zero operations with a total of ~15,000 residents. Some of the salient features of the campus follow:

- De-desertification is achieved through landscaping and an earthen berm.
- 33% reduction in energy usage through efficient designs
- 15 MW of consolidated and 7.5 MW of roof-distributed solar generation connected through smart grid systems
- Implementation of a double wall system having XPS insulation
- Designed for better than 5-star GRIHA-rated buildings
- Funded through grants from the central government funds for which allotments were made in the union budget

3.2 Leading Real Estate Companies

Lodha Group, one of the top 10 real estate developers in the country, has committed to being net zero across its building portfolio by 2035 in 2020. The group currently has a portfolio of over 10 msf of area across the residential and commercial real estate market in Mumbai MMR.

Godrej Properties, one of the top 10 real estate developers in the country, has joined the World Green Building Council's commitment to being net zero by 2050 in 2021. The group has a significant presence across multiple cities and has a portfolio of over 20,000 square feet of real estate development.

Several other leading real estate developers such as DLF Ltd and Oberoi Realty, Prestige, have expressed their desire to achieve net zero; however, they have specified no commitment or timeline.

A few developers publish their ESG reports in compliance with extant regulations. These reports in general talk about green development, improvement in energy efficiency, reduction of GHG emissions, and other ESG parameters; however, the scope defined for net-zero buildings or any time commitment by which these institutions are likely to achieve net-zero across the built environment is limited. A detailed analysis was conducted to identify the major achievements as per the ESG report of a few of the top developers. A snapshot of the analysis is attached below:

| Developer | Profile | ESG Achievements in build environment |
|-----------------------|---|--|
| Godrej Properties Ltd | Godrej Properties Limited is part of the Godrej Group, one of the largest conglomerates in India. Headquartered in Mumbai, it has presence in more than 12 domestic locations. Over the past five years, the company has delivered over 22 million square feet of real estate with 10 new projects and ~19 million square ft. of saleable area in FY20. | <ul style="list-style-type: none"> • 6th ESG Report in FY20 • 100% organic waste treated on site. • GHG intensity reduced by 12% in FY20. • Energy savings of 12-15%. • About 390 GJ of energy sourced from renewable sources in FY20. • Global ESG Benchmark for Real Assets (GRESB) Score of 95/100 in 2020. |
| DLF Ltd | DLF is one of the leading real estate companies in India with over seven decades of experience. With its headquarters in Gurugram, DLF has developed 150+ real estate projects in 22 cities across the country with a rental portfolio of over 36 msf, and delivered over 100 msf | <ul style="list-style-type: none"> • 3rd ESG Report in FY21 • Over 33 msf of area is LEED Platinum Certified. • Energy intensity in rental portfolio reduced by 28.5% in FY21. • Commitment: <ul style="list-style-type: none"> ○ By 2030, to reduce energy intensity in our rental Assets (energy consumption per square foot of rental portfolio) by 15% using FY 2019-20 as baseline. ○ By 2025, increase renewable energy intensity in our rental assets by 20% using FY 2019-20 as baseline. |
| Lodha Group | Lodha Group is the largest real estate developer in India, by Revenues for the financial year 2020. Headquartered in Mumbai, the group is involved in development and sales of residential apartments in Mumbai MMR and Pune. | <ul style="list-style-type: none"> • 1st ESG Report in FY21. • 22 lakh kWh units per year of renewable solar power generated. • 1,950 tons per year of CO2 emission reduced due to implementation of various sustainability initiatives like smart street lights, renewable power, awareness drives and others. • 11,700 trees saved per year (CO2 equivalent). • The group is confident of achieving the net-zero target by 2035. |

Table 2. ESG Report Analysis of Several Developers

Other developers do not specifically compile their ESG reports but do report certain initiatives, such as energy efficiency, GHG reduction, and green building certification, as part of their Annual Reports.

Developer Confederations

Several developer confederations have committed to net-zero buildings. This commitment is mostly voluntary in nature and does not stand as a hard commitment. However, these commitments can be considered a general direction in the real estate market toward a more resilient building environment.

- Confederation of Indian Industries - Indian Green Building Council (250 developers) committed to net zero by 2050.

- National Real Estate Development Council & The Confederation of Real Estate Developers' Associations of India (1,000+ Private Developers + Government Organizations) expressed intention to adhere to government commitments.

3.3 Real Estate Technology /Proptech

The proptech market has witnessed increased traction from global investors as well as adoption in the real estate market. The Indian proptech market saw investments totaling US\$551 million in 2020. Globally, India is among the leading countries in terms of the number of proptechs in operation, as can be seen in Diagram 3.

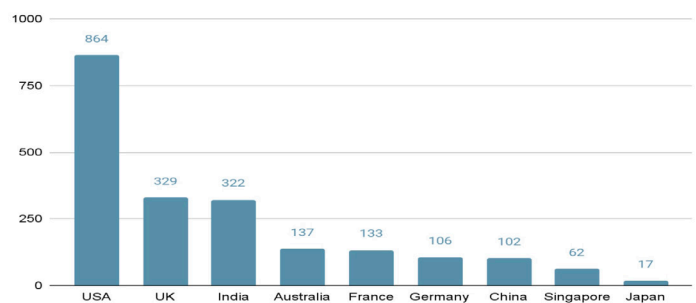


Diagram 3. India's Position on Proptech Globally

Source: Tracxn, Startup India, Housing Research https://cdn.spark.app/media/housingcom/pdf/2021_proptech_the_future_of_real_estate_in_india.pdf

The total investment in proptechs in India during 2015–20 stood at US\$2.1 billion considering various forms of investments such as private equity, venture capital, debt, private investment in public entity, project-level investments, and pre-IPO private equity deals at the early, growth, and late stages. Of the segments in which proptechs operate, sales & marketing and shared economy (mostly co-working) have seen the most traction, comprising almost 66% of the deals during 2015–20 (Diagram 4). Note that property management and construction technology are the market segments that address the issue of carbon emissions in the built environment. Property-management proptechs transactions are low at 4%, and construction-technology proptechs transactions are even lower at 2% of overall transactions. These segments are likely to gain traction in the coming years with the government’s increased focus on green and energy-efficient buildings, along with the recent commitment to net zero by 2070, for which the real estate sector is likely to be a major contributor.

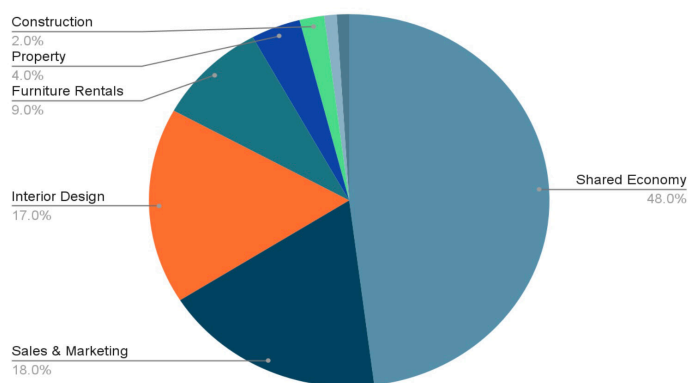


Diagram 4. Segment Share of Capital Flow into Proptech in India (2015–20)

Source: Venture Intelligence, Housing Research, https://cdn.spark.app/media/housingcom/pdf/2021_proptech_the_future_of_real_estate_in_india.pdf

A few prominent proptechs that are addressing the issue of green, energy-efficient or sustainable buildings are as follows:

Snaptrude, a construction technology proptech, is a web-based design tool for architecture that can directly convert a hand-drawn sketch of a floorplan to a 3D building information model with just a few clicks. With Snaptrude, architects and design team can save weeks’ worth of manual efforts in the fragmented design process that at the minimum involves four tools that are non-intuitive and non-collaborative. The company was established in 2017 with seed funding received from Brigade Group, one of the leading private real estate developers, based out of Bengaluru.

Turiyatree Technologies, an energy technology proptech established in 2015, is an internet of things (IoT) startup in building energy management space. The IoT-enabled SaaS application employs IoT, machine learning, AI, and process automation to manage and optimize energy consumption, improve asset performance and lifetime, and achieve sustainable energy efficiency. The company offers a GYATIX, which is a smart energy management and predictive maintenance platform.

Avishakti Solar, a rooftop solar solution provider, was established in 2015 in Mumbai MMR, Maharashtra. The company is an end-to-end provider of solar rooftop solutions that include the installation and maintenance of rooftop photovoltaic plants for residential as well as

commercial establishments. The company specializes in the designing and engineering, installation and commissioning, and operation and maintenance of rooftop solar plants.

HomeOne Technologies, a home automation product and service provider, is based out of Pune and was established in 2010. The company is a manufacturer of various products for home automation including Illume motion sensor LED lights, motion sensors, blasters, sensors, and controllers. The company also provides a platform for the management of the entire home automation process. The company has major real estate developers as its clients, such as Godrej Properties Ltd and Gera Developers (leading developer based in Pune).

4. Opportunities

4.1 Regional Collaboration

Several global and regional collaborations have been created over the years to advance the green, energy-efficient, and net-zero buildings in India. These collaborations are majorly centered around the flow of technology from developed economies and the financing of specific projects by global institutions. Several joint research collaborations with global counterparties have arisen.

United Nations Development Program - Bureau of Energy Efficiency Collaboration²⁰

The BEE estimates that new large commercial buildings can reduce 30%–40% of their energy consumption by incorporating appropriate design interventions in lighting, heating, ventilation, and air-conditioning systems. In 2007, the BEE proposed the ECBC, which sets minimum energy performance standards for new commercial buildings. However, the code was not made mandatory, due to several challenges, such as lack of appropriate knowledge and capacities at various government levels, limited availability of trained designers and architects, and the absence of suitable energy-efficient materials and equipment in the local market. The MoEFCC and the government of India, in partnership with UNDP, initiated a project to outline specific activities and outputs required to achieve energy efficiency in commercial buildings. The project began with an initial funding of US\$21 million contributed by various agencies. The initial duration of the project was 2010–17. As a result of the collaborations, revised ECBC guidelines were formulated in 2017 by substantially improving the previous version of the ECBC. The collaboration has been extremely useful, as is evident from the significant contribution it has made to its agenda in the country. The partnership is likely to continue its agenda of improving energy efficiency in commercial buildings in India.

Center for Building Energy Research & Development²¹

In 2009, India and the US (through its Department of Energy) signed a Memorandum of Understanding (MoU): the U.S.–India Partnership to Advance Clean Energy (PACE). Through the PACE- Research program, a new five-year joint U.S. India Center for Building Energy Research and Development (CBERD) was created to advance energy-efficiency building in both nations. The program, which began with an initial funding of US\$5 million, was extended and continues to operate. The initial goal of CBERD was to foster research in promotion and innovation of energy efficiency, and the partnership has since resulted in groundbreaking research in the field of energy-efficiency building.

Newton Bhabha Fund²²

The Newton Bhabha Fund was created in 2014 between the UK Department for Business, Energy and Industrial Strategy, and the Ministry of Science & Technology in the government of India to foster research in the field of sustainability. The fund was announced for the period of 2017–21 initially. The fund's primary goal is a reduction in the demand for energy in the built environment, via four approaches:

- **Residential Building Energy-Demand Reduction in India** - To enable the development of a data-driven residential energy code and implementation framework by assessing all aspects of residential energy use in India.

- **Integrated Urban Model for Built Environment Energy Research (iNUMBER)** - To undertake research to develop a new model of building and municipal energy services that is grounded in appropriate empirical data.

- **Zero Peak Energy Building Design for India** - To decouple building energy use from economic growth in India through a new science of zero peak energy building design for warm climates.

- **Community-Scale Energy Demand Reduction in India** - To provide exemplary strategies for energy-demand reduction in Indian communities. This approach is conscious of building activities and operations, but also the performance of the energy networks that are serving those buildings.

US Green Building Council (USGBC) and The Energy Research Institute of India (TERI)²³

In 2014, USGBC and TERI formed a strategic partnership to accelerate the development of green, high-performing buildings across India and Southeast Asia. Both entities have their own green building and net-zero rating systems, known as USGBC's LEED and TERI's GRIHA, respectively. The main foci of the partnership are as follows: building a green community; performance measurement of green buildings; and capacity building and stakeholder management.

Finance Collaborations

The IFC and ADB have provided financing to several market participants, such as banks and financial institutions, to carry out their agenda of green and sustainable financing, which is not limited to the building sector. In certain other cases, the government of Singapore and the Bank of Japan have entered into project-specific partnerships to advance the agenda of green financing in India. However, these instances are limited and are done on a case-to-case bilateral basis. No platforms or large-scale collaborations have been announced specifically for the built environment.

4.2 Investment and Business Opportunities

Sustainability-Focused Proptechs

As discussed in section 3.3, India has seen an emergence of proptechs over the last few years that have been primarily focused on sales and marketing as well as the shared economy. However, a dearth remains in the construction-technology and property-management proptechs that are pertinent for handling the issues of sustainability in the real estate market. Although a few proptechs have started to address the issue in the market, the operation of an integrated player in this space is still

necessary. As an investor or a global player in this space, entering the market with the right strategy and product offering is likely to yield a significant benefit not only in terms of gaining market share, but also in terms of addressing the sustainability issue in the real estate market in India.

Green Bonds and Green Banks

As discussed in section 2.2.2, India has experienced a growing trend of ESG bond issuance, and even municipalities have started to issue green bonds for specific infrastructure purposes. Currently, there has not been any instance of bond issuance in the real estate-built environment. However, with the expected push from the government in the right direction, the bond issuance in real estate-built environment is likely to catch up in the near future. Any agency with global expertise in this segment can benefit by making the first move. Further, as seen in section 2.2.3, IREDA and TATA Cleantech are the only two green financing institutions in India, although they are not specifically focused on the real estate sector. These two entities are likely to receive a green bank license soon. Given the dearth of expertise in operating a green bank, a global collaboration in this regard would be warranted. Even a global entrant in this space is likely to reap benefits with the growing market and the existence of more than sufficient demand for green capital and financing in the real estate market.

Sustainability-Focused Real Estate Investment Trusts (REITs)

EBI, the governing body for securities in India, issued the guidelines for REITs in 2014. However, response in the market for REITs has been lukewarm, with the first REIT operation starting in 2019. To date, India has only three REITs: Embassy Office Parks REIT (Bengaluru), Mindspace Business Park REIT (Mumbai), and Brookfield India Real Estate Trust (Mumbai). These REITs do not have a specific focus on sustainability in the real estate market. Several REITs were in advanced stages but have been delayed because of the COVID-19 pandemic. Going forward, REIT issuance is likely to increase. With the right direction from the policymakers, a drive toward sustainability-focused REITs could prove to be a sound business strategy for enterprises eyeing the Indian market, considering the huge capital requirement in the next decade or so.

4.3 Future Research Questions

Exploring various issues in the net-zero and resilient building sector in India is imperative so that the grass-root level issues can be addressed in a time-sensitive manner.

With the recent net-zero commitment by 2070, what policy initiatives and implementation measures will be announced by the central as well as respective state governments, especially in the cities contributing most to real estate development, remains to be seen. As has been the case in other developing countries, the market participants must have sufficient incentives to include net-zero building concepts across the life cycle. These incentives can either be provided either directly by the government or by the creation of an efficient market. To address the issue of net-zero buildings, the federal and state governments acting in sync becomes imperative, and different policy measures must work together in a cohesive and coherent manner. To address the issue of net-zero and resilient buildings, ensuring that adequate data are captured and performances are benchmarked across the country is important, so that any new or existing development can leverage the data and benchmark

to ensure an improvement in their performances. The BEE through its ECBC and other initiatives has taken a leap in the right direction; however, a lot remains to be done in terms of the collection and dissemination of the data so that the desired target of net-zero buildings is achieved within the desired timeframe.

The role of financial and capital markets as an enabler for achieving the net-zero targets remains extremely important. Although the emergence of green bonds, green banks, and sustainability-focused REITs is likely to address the financing needs of the real estate sector, the government agencies and market participants alike must help take the agenda to its logical conclusion. Further, given the anticipated scale of real estate development in the next decade, the contribution of sustainability-focused proptechs—especially those addressing construction technologies and property management—cannot be ignored. The financial and capital markets will need to provide a continuous flow of capital to these startups not only to ensure the proptechs come out with innovative technologies to address the sustainability issue at hand but also to provide for the next level of growth capital to the emerging proptechs. Only with a flux of proptechs and their rise to unicorns can the sustainability and net-zero issue in the built environment be addressed adequately and timely.

Apart from providing capital, the flow of technology from developed countries to India also needs further exploration. In some instances, the technologies have been imported by the developers globally and have proved to be effective in addressing sustainability issues. A few notable examples are aluminum formwork (MIONE) technology from South Korea, tunnel formwork technology from Turkey, and drywall technology from Germany. However, making these technologies accessible and affordable to the Indian real estate market, and ensuring local manufacturing benefits from the flow of technology—particularly given the recent Made in India drive by the central government—remain key in addressing the issue at hand.

About the Author



Himanshu Tiwari

Himanshu Tiwari is a current student at Massachusetts Institute of Technology graduating in Real Estate Development at the Center of Real Estate. Prior to MIT, he has worked extensively across leading financial institutions involved in real estate debt underwriting across asset classes in both standalone and leadership roles. He has a passion for addressing the issue of sustainability in the real estate environment.

Real Estate Industry Overview

According to the World Bank “Thailand Country Overview,” Thailand is one of the great development success stories.¹ Over the last four decades, Thailand has made remarkable progress in social and economic development, moving from a low-income to an upper middle-income country in less than a generation. Thailand is now the second largest economy in the Association of Southeast Asian Nations (ASEAN) after Indonesia.²

Thailand, which translates to “land of the free,” is a constitutional monarchy with a total population of 69.48 million (2021) and is growing at a rate of 0.26% per annum. By 2030, Thailand’s population is projected to reach about 71 million to 77 million. Nevertheless, Thailand faces demographic challenges and is considered one of the world’s rapidly aged societies. According to a UN report, Thailand will become a super-aged society within the next 10 years, jumping from 10th in 2015 to 6th in 2035 among all Asian countries.³

Thailand has a high urban population, accounting for 52.2% of the total population and growing at 1.43% per annum. The highest population density is found in and around the capital city Bangkok.² Bangkok’s sheer size makes it the center of Thailand’s cultural, economic, and governmental activity. It also is a popular tourist destination and has ranked as one of the top three of the world’s most popular tourist destinations.⁴

Economy-wise, the combination of industry (35.0%) and service (56.3%) sectors produced above 90% of Thai GDP. As of 2020, the total labor force was 37.5 million, including an estimated 3.0 million to 4.5 million migrant workers, mostly from neighboring countries.⁵

Thailand’s real estate sector accounted for 8% of total GDP⁶ (2020), within which 60%–66% is the residential sector. Major real estate developers, that is, listed real estate developers and their subsidiaries, control 60%–70% of both housing units and total market value.⁷ Pre-pandemic, the market was in a slow but consistent upward trend for over a decade, partially due to the increasing number of foreigners who visit, live, or work in Thailand. Investors from Mainland China and Hong Kong make up almost half of total foreign demand, followed by investors from the US, Singapore, Taiwan, Japan, and the UK. Due to the heavy reliance on foreign investors, the Thai real estate market was hit hard by the pandemic, particularly in coastal cities and islands.

Thailand is highly vulnerable to climate-change impacts. According to the 2020 Nationally Determined Contribution (NDC) report, the country is ranked 13th in the “extreme risk” category that is most vulnerable to future climate change.⁸ Thailand is also ranked as one of the top 10 countries at high risk of long-term climate change, as illustrated in Diagram 1.⁹

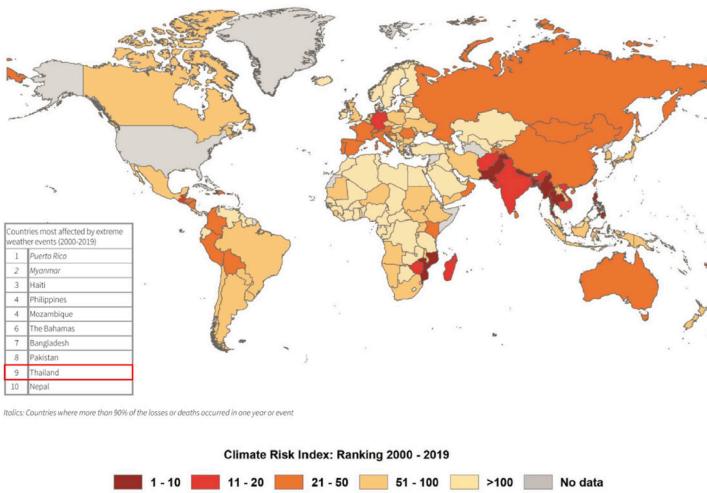


Diagram 1: World Map of the Global Climate Risk Index 2000 - 2019¹⁰

Source: germanwatch.org

Thailand faces increasing environmental degradation in many regions. As illustrated in Diagram 2, floods are by far the greatest natural hazard in terms of economic and human impacts. Thailand is cited as one of the 10 most flood-affected countries in the world, and it may intensify in future climate scenarios. The number of people affected by extreme river floods could grow by over 2 million by 2035–2044, and coastal flooding could affect a further 2.4 million people by 2070–2100.¹¹ The agricultural sector is more vulnerable to the floods caused by rising sea levels, because the intrusive saltwater damages fields.¹² Compared with the global average of 3.3mm per year, sea levels are rising approximately 4mm a year in Thailand, causing greater danger to the country.

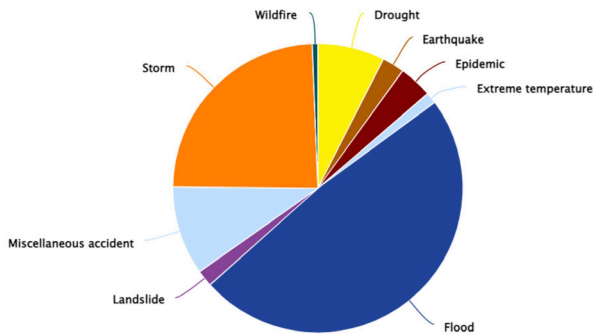


Diagram 2: Thailand's Average Annual Natural Hazard Occurrence 1980-2020

Source: World Bank Climate Change Knowledge Portal

Bangkok Metropolitan Region (BMR) is a major coastal city with low elevation, only 1.5m above current sea levels, making the population very susceptible to the risk of rising sea levels. The average sea-level rise in BMR is about 1.3 cm per year, of which 3 mm is related to the actual sea-level rise and 1 cm to land subsidence. Bangkok is sinking. The weight of the urban landscape is a particularly strong force against Thailand's layers consisting of soft clay and sand. Drained aquifers are also accelerating the rate of sinking.¹³

As a developing country, Thailand still relies heavily on fossil fuel energy and is continuously expanding its urban areas. As illustrated in Diagram 5, Thailand's CO₂ emissions have significantly increased

over the past decade. In 2020, Thai CO₂ emissions were 255 megatons (which translates to 0.21 tons per 1000-dollar GDP), making Thailand rank as the 159th country in terms of CO₂ emissions.¹⁴

The Thai building sector represented 20.9% of final energy consumption in 2018, of which 13.1% is residential and 7.8% is commercial.¹⁵ As illustrated in Diagram 3, among the commercial buildings, shopping malls represent the largest electricity consumer, followed by hotels and office buildings. Shopping malls also have the highest energy intensity, estimated to consume roughly 295 KWh per square meter per year.¹⁶ Electricity consumption has been the most rapidly increasing energy use within the building sector, showing an average annual increase of 5.91% and a total of 49,128 GWh in 2019, almost doubling in the past decade. Air conditioners are one of the key drivers of this jump in electricity demand.

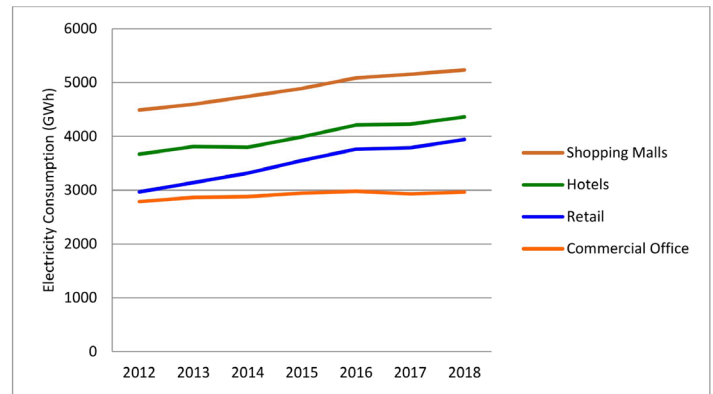


Diagram 3: Electricity Consumption by Building Types

Source: "Energy Efficiency Retrofits in Commercial Buildings", Seeley & Dhakal 2021

1. Policy

In Thailand, climate change is being addressed at the highest policy level under the National Strategy (2018–2037) to ensure long-term continuity. The Climate Change Master Plan 2015–2050 reflects on climate-change mitigation, adaptation, capacity building, and cross-cutting issues. More specific energy targets are put forward in the Energy Efficiency Plan (EEP), the Alternative Energy Development Plan (AEDP), and the Power Development Plan (PDP). In addition, the Thailand National Adaptation Plan and the Nationally Determined Contribution Roadmap on Mitigation (2021–2030) have also been formulated to enhance the concrete and effective implementation of national climate-change policy across sectors.

In 2015, the Thai government submitted the country's NDC to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) and updated it in 2020. The NDC aimed to reduce greenhouse gas (GHG) emissions by 20%–25% from projected Business As Usual (BAU) levels by 2030, a target that was reaffirmed in the updated NDC. Thailand exceeded its target to reduce GHG emissions by 7%–20% in 2020 according to its Nationally Appropriate Mitigation Action (NAMA). As illustrated in Diagram 7, Thailand has also formulated its Long-term Low Greenhouse Gas Emission Development Strategy (LT-LEDS) toward a climate-resilient and low-GHG-emissions developing mode, which will serve as a basis for further upgrading its NDC.¹⁷

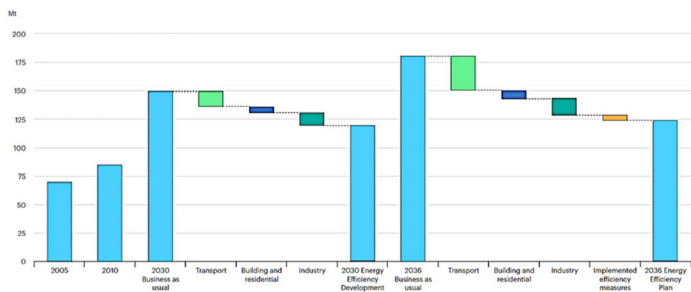


Diagram 4: Thailand's Energy-Efficiency Plan 2005–2036

Source: "Putting a price on carbon – an efficient way for Thailand to meet its bold emission target", International Energy Agency 2020¹⁸

The top Thai governing body for climate change is the Office of the Prime Minister (OPM), which is responsible for overall regulation of climate-change management in Thailand. The OPM appoints the National Committee on Climate Change Policy (NCCCP), also chaired by the prime minister. The secretariat has been set up at the Office of Natural Resources and Environmental Policy (ONEP) under the Ministry of Natural Resources and Environment (MONRE). ONEP is the national focal point for the UNFCCC and is the secretariat to the NCCCP. ONEP is also responsible for the overall coordination of the national climate-change policy and planning, with an allocated budget from the central government. Besides ONEP, The Thailand Greenhouse Gas Management Organization (TGO) was also established under MONRE in 2007, as a public organization to be the designated as the national authority for the clean development mechanism. The structure of Thai government bodies relating to climate change is illustrated in Diagram 5.



Diagram 5: The Structure of Government Bodies Relating to Climate Change

Source: "Putting a price on carbon – an efficient way for Thailand to meet its bold emission target," International Energy Agency 2020

1.1 National Policy Highlights

2003 Thailand's Energy Efficiency Revolving Fund was established by the Department of Alternative Energy Development and Efficiency to provide a line of credit to local banks, and low-interest loans to developers for developing energy-efficient products. The loan period is up to 7 years with a maximum allowable interest rate of 4%.

2005 Thailand initiated a number of tax incentives to encourage investment in energy efficiency (EE). They include a Pilot Program of Tax Privilege for Energy Conservation made available to building and factory owners. This measure provides a tax deduction for 100% of the savings generated by an EE investment, up to a cap of THB 2 million (US\$50,000); (b) a Cost-Based Tax Incentives Program, which is a tax measure that provides companies a 25% tax break on investments in projects that result in EE improvements. The tax incentives apply to the first THB 50 million (US\$1.25 million) invested and can be spread over five years; and (c) the Import Duty Exemption, administered by the Board of Investment, which is an incentive that offers an exemption on import duties for new investments in energy conservation businesses, such as high-efficiency machines or equipment and renewable energy equipment and manufacturing, ESCOs, and so forth.

2009 The 2009 updated Building Energy Codes (BEC) aimed at improving energy efficiency for new or retrofitted buildings larger than 2,000 square meters, through better design of a building's envelope, and its lighting, cooling, and heating systems. It will be extended to a wider array of buildings while promoting the construction of energy-efficient buildings respecting certain certificates (such as LEED and TREES); it will also promote Zero-Energy Building (ZEBs) for new private and government constructions. For public buildings, it proposes that Energy Service Companies (ESCOs) will provide energy-performance contracts and ensure energy savings.

2015 Thailand adopted the 20-Year Energy Efficiency Development Plan (EEDP) with a target of 30% energy-intensity reduction by 2036. Under the plan, the government identifies the need for buildings and appliances to be more energy efficient. It set an energy-consumption reduction target of 4,819 ktoe by 2036 in the commercial and public buildings sector, with an additional reduction of 2,153 ktoe in the residential sector. The target to reduce the energy demand in new buildings by 36% was included under the compulsory program designed under the EEP.

Thailand's Ministry of Energy adopted the AEDP with the goal of increasing the share of renewables in the electricity sector to between 15% and 20% by 2036. It also contains a target for heat generated by renewables: 30%–35% by 2036. Three solar technologies (solar water heater, solar dryer, and solar cooling) have also been promoted heavily in the plan.

2015 Thailand's Climate Change Master Plan (2015–2050) was designed to help Thailand achieve sustainable development, low carbon growth, and climate-change resilience by 2050. In terms of the building sector, the CCMP stipulated multiple strategies to (1) increase energy efficiency in buildings and (2) reduce energy consumption in buildings.

2020 The Long-term Low Greenhouse Gas Emission Development Strategy was enacted: the energy efficiency improvement of energy devices in the residential sector will have to increase to 29% of total final energy consumption by 2050. The share of renewable energy use in households will have to increase to 49% of total final energy consumption by 2050. The energy-efficiency improvement of energy devices in commercial buildings will have to increase to 33% of total final energy consumption by 2050. Solar water heating devices have to be promoted to produce hot water in hotels, condominiums, and hospitals. The share of solar water heating will have to increase to 5% of total final energy consumption by 2050.

Thailand also announced the latest update of the Building Energy Code (BEC) – Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E. 2563 (2020) – which repealed previous regulations, mandated an energy-efficient design for new building with a total area in all stories of 2,000 square meters or more.

1.2 Bangkok Metropolitan Region Policies Highlights

Bangkok Climate Change Master Plan (2013–2023) aimed at reducing GHG toward a low-carbon city. The Master Plan includes both mitigation and adaptation measures. It consists of five sections: (a) sustainable and environmentally friendly public transport, including bicycle lanes; (b) energy and water efficiency in buildings, including promoting renewable energy; (c) improvements in waste-water treatment systems, especially waste from communities; (d) green urban planning; and (e) adaptation plans from disasters such as inundation, drought, coastal erosion, and intrusion of saltwater.

The 2013 Bangkok's Comprehensive Plan stipulated that the development FAR can be increased by up to 20% for projects that are green certified (LEED, TREES). The buildable area can also be increased by 5% if the building can address rainwater retention issues by providing at least one cubic meter of rain capacity per 50 square meters of built area. Moreover, tax incentives are available for green developers attracting international companies to set up their headquarters in Bangkok (i.e., a 10-year 10% fixed income tax rate, a steep discount from the conventional 30%¹⁹). Moreover, the Thai government has approved 350 energy-efficiency projects with a five-year 25% corporate tax credit, which back investment up to US\$1.25 million. Similarly, 100% of energy saving can be used for tax exemption up to US\$56,000 for demonstrating proven energy conservation no less than US\$3,000 per year.²⁰

1.3 Green Building Standards and Data

Green Building in Thailand was certified in LEED (US), TREES (Thailand), and Green Mark (Singapore). By the end of 2016, 113 projects from 201 assessed projects were certified by LEED, followed by TREES with 12 certified projects from 74 registered projects. Green Mark has only three projects certified. Overall, as illustrated in Diagram 6, the number of green certified commercial buildings was increasing, partially due to the tax incentives promulgated in Bangkok Metropolitan Area (BMA). LEED was introduced to Thailand in 2007. Most buildings certified are under the Retail Commercial Interior category, mostly Starbucks. In 2009, TREES was established under The Thai Green Building Council using LEED as a model but tailored to fit Thai law instead of US standards. Ninety-eight percent of green buildings in Thailand are commercial buildings. Residential developers are comparatively lagging in building green certified projects. The brand-image improvement associated with green certifications, the attractiveness to international clientele, and associated financial returns are less significant for residential buildings than for commercial buildings. Because of the 2013 Bangkok's Comprehensive Plan, high-end condominium developers started to certify projects to gain a FAR bonus.²¹

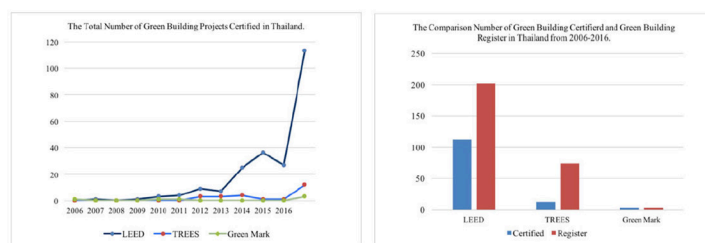


Diagram 6: Thailand's Green Building Certification Profile

Source: "State of The Art of Green Building Standards and Certification System Development in Thailand," Lohmeng, Sudasna & Tondee 2017

2. Capital Market

2.1 Equity Market

Thailand has taken several steps to promote responsible business conduct and sustainability through two regulatory bodies — Thai Securities Exchange Commission (Thai SEC) and the Stock Exchange of Thailand (SET). Thai SEC has been working to shift the focus of capital markets development beyond corporate governance to broader sustainability. From December 31, 2021, listed and to-be-listed companies need to submit a new "One Report" combining an Annual Registration Statement and an annual report, including information on carbon emissions and provident funds, and so on. On the other hand, efforts are being made on the asset-management side; in particular, asset managers must issue self-assessment forms and guidelines to promote the implementation of the Investment Governance Code (I code), and listed companies must use ESG criteria to select fund managers. In addition, guidelines spanning more broadly across real estate and infrastructure sectors will be issued by Thai SEC to encourage investment in green Real Estate Investment Trusts (REITs) and green infrastructures.

2.2 Carbon Market

Carbon pricing is going to be Thailand's primary channel to encourage private investment in the reduction of GHG emissions. Thailand Greenhouse Gas Management Organization (GGMO) has established the Thailand Carbon Neutral Network (TCNN) to promote cooperation among government organizations, private sectors, and local communities by creating demands for carbon credit in line with the Thailand Voluntary Emission Reduction Program (T-VER) standards.²²

Thailand has also initiated efforts to establish domestic carbon market mechanisms. The Thailand Carbon Offsetting Program was established to enable organizations and individuals to offset their carbon emissions by purchasing carbon credits from the voluntary market. On the other hand, Thailand has engaged in international carbon market mechanisms, through the Clean Development Mechanism (CDM) as well as international voluntary carbon markets. As of January 2020, 154 CDMs had been developed by private actors in the country.

3. Business Innovation

3.1 Leading Real Estate Companies

Real estate sustainability is still at a nascent stage in the Thai real estate sector. As of 2021, only two companies directly involved in the real estate business had publicly pledged to the UNFCCC Race to Zero global campaign, namely, Charoen Pokphand Group Co., Ltd. and Siam Cement Public Company Limited.²³

- The Charoen Pokphand Group (CP) is Thailand's largest privately held conglomerate. It is the only company in Thailand that signed up to reach net-zero carbon emissions from the organization's operations by 2030 and set a target in line with "Business Ambition for 1.5°C."

- Setting GHG mitigation targets in compliance with the Paris Agreement's goal of limiting global warming to 1.5 degrees Celsius and net zero in 2050,²⁴ The Siam Cement Group Public Company Limited is the largest and oldest cement and building material company in both Thailand and Southeast Asia. In 2016, SCG was also ranked the second largest company in Thailand.

- The Central Group is a family-owned conglomerate in Thailand involved in merchandising, real estate, retailing, hospitality, and restaurants. The subsidiary Central Pattana operates 35 malls with a total net leasable area of 1.8 million square meters (15 projects in the Bangkok metropolitan area, 19 projects in other provinces, and 1 in Malaysia), 30 food courts, 10 office buildings, 2 hotels, and 19 residential projects. Central Group won two prestigious "Climate Action Awards" from the UN in recognition of its GHG reduction efforts. Central Pattana is the only Thai real estate developer that has been listed on the Dow Jones Sustainability Indices (DJSI) for four consecutive years. The company's "Journey to Zero" scheme aims at reducing GHG emissions through renewable energy adoption such as solar panels, water recycling, and efficient waste management. The Central Tham project, which involves installing rooftop solar panels at 41 locations, produced 24,621 MWh of power — enough to supply 3,169 households for a year—and reduced GHG emissions by 145.3 tons a month.

- Asset World Corporation (AWC) is a member of the TCC Group. AWC is the first real estate company in Thailand to receive a green loan from the International Finance Corporation of the World Bank Group. Also, the company develops projects in line with The Excellence in Design for Greater Efficiencies (EDGE), a green building certification system for emerging markets, through reducing consumption of water, energy, and materials by 20% compared with conventional buildings.

- LPN Development Plc is a renowned real estate developer in Thailand developing residential projects, commercial office buildings, and retail strips. The company has a total asset base of US\$732 million as of September 2020. It is the winner of the Best Sustainable Developer (Asia) 2020 award, recognized for consistent application of environmentally sensitive design features, low-impact materials, and energy- and waste-efficient systems.²⁶

- Pruksa Real Estate Plc is one of the largest listed real estate developers in Thailand, focusing on residential properties in Thailand, the Maldives, and India. The company received The Thailand Sustainability Investment Award and The Sustainable Stock Award conferred by the SET, in appreciation of excellence in sustainability-driven corporate governance. The company generates economic growth in parallel to a well-balanced development of the society and the environment, as well as transparent disclosure of its environmental and social impact.²⁷

3.2 Exemplary Real Estate Projects

Thailand is still at the early stage in terms of green building development. Though net-zero building is yet to be accomplished, the green certified buildings, particularly LEED and TREES, have gained steam in the past decade. Climate resilient buildings are also emerging.

Climate Mitigation Projects — Newly Constructed

Energy Complex (Enco)

| | |
|-------------------|--|
| Developer | Petroleum Authority of Thailand (PTT Group) – state-owned SET-listed oil and gas company |
| Location | Vibhavadi Rangsit Road, Bangkok |
| Completion Time | 2009 |
| Project Use | Office (owner occupied) |
| Size | Land: 11.46 acres GFA: 304,000 square meters |
| Construction Cost | US\$233 million |
| Key Achievements | - EnCo is the first commercial building to attain LEED certification outside of the US, and the first commercial office complex in both Thailand and Southeast Asia to be awarded the highest Platinum level from LEED for Core+Shell v.2. - An open space and a green area that are cumulatively 287% higher than the requirement of the Bangkok Administration. |

Energy Complex (Enco)

| | |
|------------------|---|
| Key Achievements | - Tower A is a 36-story office building in clear green glass that is curved based on aerodynamics to reduce outside heat. Tower B is a 25-story office building with a curved-glass facade that resembles rising flames to reflect Tower A. |
|------------------|---|

Park Ventures Ecoplex

| | |
|-------------------|---|
| Developer | Univentures Public Company Limited |
| Location | Wireless Road and Ploenchit Road, Bangkok CBD |
| Completion Time | 2011 |
| Project Use | Mixed-use: Office, Hotel |
| Size | Land: 2.6 acres GFA: 81,400 square meters |
| Construction Cost | US\$212 million |
| Key Achievements | Thailand's first LEED platinum mixed-use building |

Ritta HQ

| | |
|-------------------|--|
| Developer | Ritta Company Limited – a design-build construction company, with subsidiary company Thai Global Energy, which provides a turnkey solution for solar power plants and green construction |
| Location | 300 Romklao Rd, Bangkok (near Suvarnabhumi Airport) |
| Completion Time | 2011 |
| Project Use | Office (owner occupied) |
| Size | Land: 5.37 acres GFA: 21,181 sq.m. |
| Construction Cost | US\$11 million |
| Key Achievements | The first building to receive LEED Gold for New Construction in Thailand |

One Bangkok (under construction)

| | |
|-------------------|--|
| Developer | TCC Assets Frasers Property |
| Location | Wireless Road and Rama IV Road, Bangkok |
| Completion Time | Phase One: 2023 (expected); Phase Two: 2026 (expected) |
| Project Use | Mixed-use complex comprising <ul style="list-style-type: none">- 5 Grade-A office towers- 5 Luxury and lifestyle hotels- 3 Ultra luxury condominiums- 4 Distinctive retail precincts- Art & Culture spaces- Public plaza, parks, & open space |
| Size | Land: 41.12 acre GFA: 1.83 million square meters |
| Construction Cost | US\$3.8 billion (estimated) |
| Key Achievements | - Aims to be the first LEED-Neighborhood Development Platinum project in Thailand with towers built to both LEED and WELL Platinum standards, setting a new standard for green and sustainable development. - A generous 19.77 acres of the total 41.12-acre land plot is allocated to green and open space, including a 40-meter-wide linear park. - Implement the onsite waste management system where construction waste, hazardous waste, and food waste are separated using a real-time display system, allowing staff to track the volume of waste and meet the zero-waste plan. |

PARQ Bangkok

| | |
|-------------------|---|
| Developer | TCC Assets Frasers Property |
| Location | Bangkok |
| Completion Time | 2020 |
| Project Use | Mixed-use: Office, Retail |
| Size | Land: 9.5 acres GFA: 320,000 square meters |
| Construction Cost | US\$255 million |

| | |
|-------------------------|---|
| Key Achievements | <ul style="list-style-type: none"> - Awarded LEED Gold certification, making the building the first mixed-use development in Thailand to receive LEED Version 4 in Building Design and Construction (LEED v4 BD+C) Core and Shell certification. - Thailand's first commercial building to be equipped with intelligent sensors and IoT integration with office lighting, ultraviolet germicidal irradiation (UVGI) lamps in air-conditioning systems, and holistic waste management. - The project also has the country's highest efficiency of in-building commercial chiller plants and the highest number of electric vehicle chargers among commercial buildings. - Naturally reduced solar heat by as much as 75% by employing a high-performing curtain wall – waves of laminated low-E glass, lined with vertical and horizontal fins, clad the L-shaped, interlocking towers. - The recipient of The Best Office Development Award, and Thailand's Best Commercial Green Development award. In addition, it received the "Special Recognition Award, Green Innovation" awarded from Dot Property Thailand for being the best green development project in 2020. |
|-------------------------|---|

Climate Mitigation Projects — Newly Constructed

1. Chaweng Garden Beach Resort

The hotel had paid US\$150k for electricity bills each year to run a hospitality business with up to 165 guest rooms. Replacement of its electric water heater with a solar water heater reduced electricity costs by 10%.

2. Hotel Grand Mercure Bangkok Fortune

The 400-room hotel previously paid nearly US\$800k per year for electricity bills. After the cooling system was replaced, electricity consumption reduced by about US\$120k per year.

3. Saint Gabriel's College

Having 11 buildings and up to 5,600 students, the school's electricity bill used to be US\$450k per year. High-quality cooling systems and chillers were replaced to reduce electricity use and meet the PEECB's energy-efficiency target. In a 2016 PEECB project evaluation, St Gabriel's managed to save 387,502 KWh per year or US\$45k per year, substantially reducing its carbon footprint by 225 tons.

4. Double A Business Park

Each year, the electricity cost of this business park used to be as high as US\$300k. To reduce the cost and energy consumption, the old air-conditioning system was replaced with a high-efficiency one, reducing the company's energy use by 30%.

5. Kasikorn Bank Office

The bank paid US\$3 million in electricity bills each year for the three main buildings: head office, IT center, and parking facility. The chillers' replacement cut energy consumption by 30%. Set up monitoring systems for floods. Strengthened training and emergency drills to employees so they are better equipped to deal with the onset of natural disasters.

4. Opportunities

4.1 Regional Collaboration

As of 2020, 17 Multilateral Environmental Agreements (MEAs) had been ratified by the Thai government, including UNFCCC (1994), The Kyoto Protocol (2002), The Paris Agreement (2016), and others. However, on the national level, the Climate Action Tracker rated Thailand "critically insufficient" in terms of climate change performance.²⁸ Thailand is lagging its peers. Its 2065 net-zero target is 15 years behind the 2050 deadline set by the UN to prevent global temperatures from rising more than 1.5 degrees Celsius. Thailand's next-door neighbors, Malaysia and Laos, both ambitiously adopted the 2050 target. Apart from the subpar pledges, Thailand has neither signed any agreements nor committed to ending coal use. The country is also absent in the Under2 Coalition, a global community representing over 260 state and regional governments, 1.75 billion people, and 50% of the global economy committed to ambitious climate actions in line with the Paris Agreement.²⁹

On a municipality level, Thailand has a meaningful presence in the UNFCCC Race To Zero campaign.³⁰ The campaign comprises various initiatives targeting local governments and business, including Cities Race to Zero (C40), Global Covenant of Mayors for Climate & Energy (GCoM), Local Governments for Sustainability (ICLEI), United Cities and Local Governments, World Wide Fund for Nature, and World Resources Institute. As of 2021, over 10 Thai cities had joined one or more of the global climate change initiatives, including Bangkok, Phuket, Klaeng Town, Khonkaen, Hatyai etc.

4.2 Investment and Business Opportunities

While Thailand is still at the nascent stage in terms of sustainable finance and proptech, the development of green buildings and the applications of renewable energy in buildings are gaining steam. On the supply side, higher upfront investments and a longer timeframe without positive cash flow hinder many Thai developers, especially small-to-medium-sized ones, from going green. On the demand side, however, the picture is relatively rosy. The popularity of green certified buildings is increasing among prime tenants, especially multinational clients who are leading the way in terms of occupier preferences for green certification. Major corporations in North America and Europe, such as Amazon, Google, and BP, have all announced aggressive carbon reduction/neutral goals for their office spaces over the coming decades. Superior building performance, greater tenant satisfaction, better brand image, and higher investment returns are the main drivers of green development of commercial buildings. Prior to the pandemic, the number of green certified buildings had more than doubled annually since 2007. Looking ahead, the cost premium of green construction is expected to continually decrease thanks to technological advancement, supply-chain optimization, and a more skilled workforce. On the other hand, unmet demand from high-end tenants for green buildings is increasing.

Due to the discrepancies between commercial and residential real estate, the emerging trend of green development is still limited to commercial and public buildings by and large. For residential buildings in Thailand, the investment opportunity would be in the applications of renewable energy. The energy demand in the Thai residential sector ge-

nerally comprises a mix of electricity needs for appliances and cooling, limited thermal needs for heating, and fuel needs for cooking. To reach the goals of renewable energy deployment seen in Renewable Energy Roadmaps (REmap) formulated by The International Renewable Energy Agency (IRENA), Thailand needs to invest significantly in renewable capacity for power and thermal uses over the coming decades — an average of US\$2.6 billion per year between 2015 and 2036. As illustrated in Diagram 7, the technologies required to be introduced in the residential sector include but are not limited to efficient air conditioners with a high coefficient of performance, efficient solar heating systems and boilers, efficient cooking devices and energy sources, and efficient lighting systems.

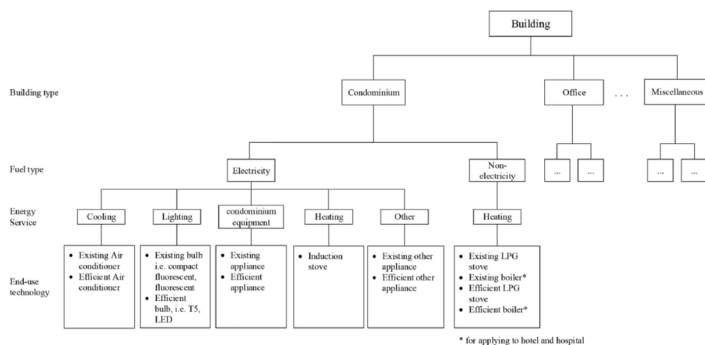


Diagram 7: Structure of Thailand's Residential Building Sector Energy Consumption and Technology

Source: "Thailand's long-term GHG emission reduction in 2050," Misila, Winyuchakrit, & Limmechokchai 2020

One of the largest sources of electricity demand in the residential sector is cooling. Although almost the entirety of this cooling demand is going to be met by traditional air conditioners, whose efficiency is increasing, novel technologies and approaches of electricity and solutions are still required to meet the rising demand. For instance, district cooling is an option for new residential developments, large commercial users, and hotels, where a centralized, highly efficient cooling unit provides either chilled water or cooled air to numerous blocks or buildings.

Solar thermal is another technological low-hanging fruit that has been underused for water heating in Thailand but has significant uptake potential. According to the REmap of IRENA, solar thermal systems are one of simplest and most affordable technologies in the buildings sector. Solar thermal can be significantly scaled up in buildings that have larger heating demand, such as residential complexes and commercial buildings.

For cooking, modern electric cooking technologies, in particular, the highly efficient induction stoves, are a cost-effective means of reducing liquefied petroleum gases (LPG) and other fossil-based energy use in the building sector. The efficiency of induction is closer to 90%, while electric coils, natural gas and LPG have about 50% efficiency. In the last few years, induction cooking technologies have dropped significantly in price, and their efficiency is higher with even lower electricity demand. This trend is clear in developed countries. Remap assumes the uptake of electric cookstoves in Thailand's urban and suburban areas can be increased significantly to around 2 million units by 2036.³¹

About the Author



Zhiyuan (Shawn) Hu

Zhiyuan (Shawn) Hu, CFA, is a candidate for the Master of Science in Real Estate Development at Massachusetts Institute of Technology. Before joining MIT, Shawn served as a vice president at GoHigh Capital, a top-tier independent real estate private equity and urban renovator in China. As the team leader that successfully launched China's first-ever housing rental Quasi-REIT at record speed and shored up the for-rent apartment development boom, Shawn has extensive experience in real estate finance. Additionally, he was also deeply involved in developing the mixed-use complex "Genesis Beijing Bulgari Hotel".

Real Estate Industry Overview

South Korea, officially the Republic of Korea, is one of the few developed Asian countries located in the southern part of the Korean Peninsula in East Asia. South Korea is Asia's fourth-biggest economy.

Since the end of the Korean War in 1953, South Korea has gone through dramatic economic growth that brought about rapid urbanization from the 1960s to the 1990s. Since the 1990s, the urbanization rate has slowed down, and the urban population has remained steady at around 80% of the total population in 2020 (Diagram 1). In 2017, urban areas accounted for 16.6% of the territory. Excluding green spaces in urban areas, only 3.9% of the land is used for residential, commercial, and industrial purposes.¹ Of the total population, 43.6% live in Seoul Special City (18.67%) and six other metropolitan cities,² including Busan (6.52%), Incheon (5.74%), Daegu (4.70%), Daejeon (2.90%), Gwangju (2.88%) and Ulsan (2.21%). The Seoul Capital Area (see Diagram 2), a combination of the metropolitan area of Seoul, Incheon, and Gyeonggi Province, is the most populous and largest real estate market in South Korea,³ with a population density of over 2,000 people per square kilometer. Seoul Special City alone has a growing population of more than 16,000 people per square kilometer, denser than Hong Kong (6300/km²) and Tokyo (6158/km²). South Korea has the lowest birth rate in the world at 0.92. The low birth rate results in a rapidly increasing aging population, threatening the future workforce and national economic growth.

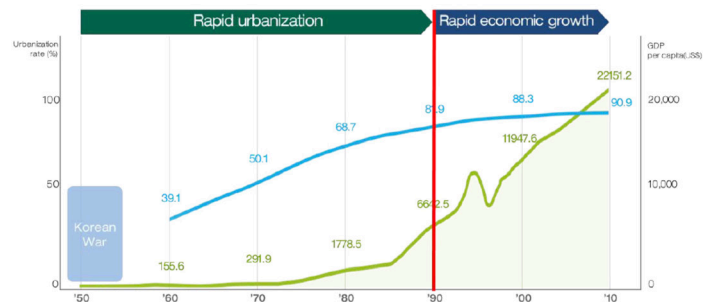


Diagram 1 Urbanization Rate and GDP per Capita (US\$) of Korea (1960–2010)

Source: World Bank, 2014. United Nations, 2014. MLIT, 2013

The real estate sector consists of 7.1% of the total GDP, US\$116 billion as of 2020. Commercial and Residential buildings consist of 69% of the total floor area. After a short oscillation period during the 2009 financial crisis, the Seoul real estate market has experienced a rapid growth in commercial and residential real estate markets. In 2020, the Seoul commercial real estate transactions volume was US\$152.55 billion.⁴

According to Preqin, South Korea-based investors make up the largest proportion (30%) of real estate debt investors in Asia-Pacific, followed by Australia (23%) and China (16%).⁵ In 2001, South Korea introduced “The Real Estate Investment Trust Act” to set up the policy framework of Real Estate Investment Trusts (REITs). The REITs market in South Korea grew steadily, especially after 2006, when the National Pension Service started investing in REITs. Despite COVID-induced market

contraction, operating revenues of real estate trust companies jumped 4.9% (US\$53 million) to reach US\$1,135 million year-on-year. Net profits increased 12.7% (US\$50 million) year-on-year to reach US\$443.8 million (Diagram 2). Although the REIT market in Korea has grown rapidly since 2002, its growth is still relatively slow compared with countries with a more robust legal framework.⁶ For example, Singapore introduced REITs in 2002 and has grown to be one of the largest REIT markets in the world. South Korea has only equity REITs, and no mortgage REITs.

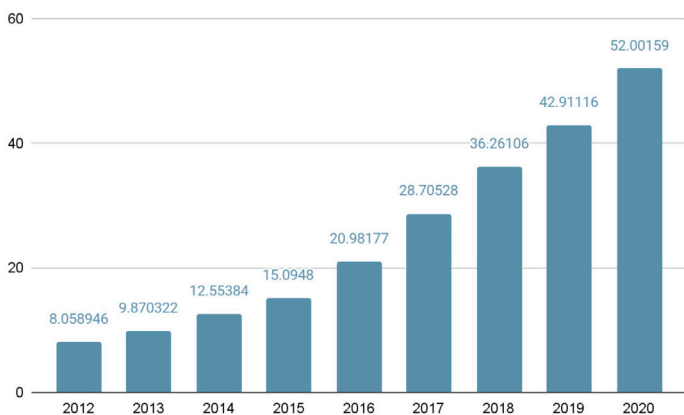


Diagram 2 Total assets of REITs South Korea 2012–2020 (in billion US\$)
Source: Ministry of Land, Infrastructure, and Transport (South Korea), January 2022

Real Estate Funds (REFs) were introduced in 2004 under “The Capital Market and Financial Investment Services Act.” These funds can be in the legal form of a business trust, an investment corporation, a limited liability company, a limited partnership, an investment association, or an undisclosed association. REFs have also grown rapidly since their introduction, from 0.7% in 2005 to 15.1% in 2019.

South Korea relies heavily on traditional energy sources, with 82.5% on fossil fuels. Almost 80% of the energy demand in the country is met through imports.⁷ The country has set a series of policies and measures to increase the supply of new and renewable energy. The Mayor of Seoul committed to reach 100% renewable electricity by 2030 and 100% clean energy by 2050 and promote large-scale clean energy generation. The overall GHG emission is expected to reduce by 24.4% compared to the 2017 level by 2030. New energy such as thermal energy and the energy grid is also put forward to help reach the goal. In the building sector, it committed to deploying clean energy systems on municipal assets and incentivizing decentralized clean energy production on private assets through support mechanisms.

1. Policy

1.1 Key National Policies

Rational Energy Utilization Act, 1979, latest amendments in 2015, is South Korea’s earliest energy act and has been amended several times to match the changing energy demand and introduce new energy-saving measures. It sets the legal ground for all energy-efficiency policies and legal obligations in Korea, including the minimum energy performance standards and labeling, and providing financial support for energy services companies.⁸ The Korean Energy Management Corporation

(KEMCO), created in 1980, was established under this act.⁹

The Low Carbon, Green Growth (LCGG) Economic Development Plan was established by the Korean Ministry of Environment in 2008. It proposes a reduction of 37% greenhouse gas (GHG) emissions from 2009 levels until 2025. This plan is the earliest green development bill in South Korea.

| Stage | Name |
|---------------------------------|---|
| Stage 1 Pre Paris Agreement | • 1979 - Rational Energy Utilization Act, latest amendment 2015 |
| | • 2001 - Building Design Criteria for Energy Saving (BDCES) |
| | • 2002 - Green Standard for Energy and Environmental Design (G-SEED) |
| | • 2008 - The U-cities Act |
| | • 2010 - The Framework Act on Low Carbon, Green Growth |
| | • 2012 - The Act on Allocation and Trading of Greenhouse Gas Emissions Allowances |
| | • 2012 - Green Buildings Construction Support Act |
| | • 2012 - “Enforcement Decree of the Green Building Promotion” Act |
| | • 2014 - Building Renewable Energy Project Support Guideline |
| | • 2016 - Paris Agreement |
| Stage 2 Post Paris Agreement | • 2017 - Zero Energy Building (ZEB) |
| | • 2019 - The 2050 Carbon Neutral Strategy of The Republic of Korea |
| | • 2019 - The Smart City Act |
| | • 2019 - The 3rd Energy Master Plan (EMP) |
| | • 2019 - The Energy Efficiency Innovation Strategy (EIS) |
| | • 2020 - The Korean New Deal and the Green New Deal |
| Stage 3 Korean New Deal | • 2021 - 26th UN Climate Change Conference (COP 26) |
| | • 2021 - C40 Renewable Energy Declaration |
| | • 2021 - Climate Crisis Response Act |

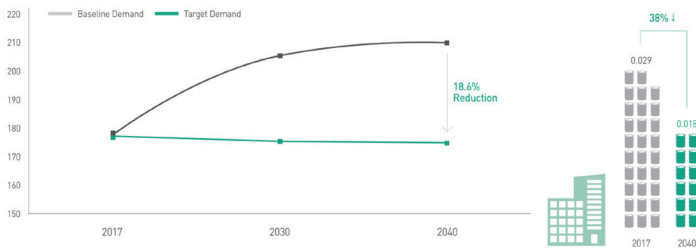
Diagram 3 Legal Framework of South Korea Energy and Green Building

Source: Drawn by author

Established in 2010, the **Framework Act on Low Carbon, Green Growth**¹⁰ created the legal framework for Korea’s mid- and long-term emissions-reduction targets, including the introduction of an Emissions Trading Scheme (ETS) and a GHG and energy target management system (TMS) and the expansion of new and renewable energy. It also requires the government to establish and implement a national strategy, roadmaps, and action plans, as well as a detailed plan covering a 20-year period that is to be rolled over every five years, to address the various aspects of climate-change mitigation and adaptation.¹¹

The Act on Allocation and Trading of Greenhouse Gas Emissions Allowances from 2012 provides the legal framework for the Korea Emissions Trading System, including the scope, target type, allowance allocation method, registry and management, and operation of the carbon-trading houses.

The 3rd Energy Master Plan (EMP)¹² was released in June 2019 by the Ministry of Trade, Industry, and Energy. The plan establishes a national energy blueprint up to the year 2040, with the goal of achieving sustainable growth and enhancing the quality of life through energy transition by gradually phasing out nuclear power generation and coal-fired generation. According to the plan, an Energy Efficiency Resource Standard (EERS), a policy that mandates energy savings to achieve energy-efficiency targets, will be legislated. The target is an 18.6% reduction for final energy consumption and a 38% reduction for building energy intensity, both compared to the 2017 baseline (Diagram 4). The plan also promotes global collaboration on energy, such as leading the Northeast Asia Super Grid.



Unit: (Tonnes of Oil equivalent (TOE)/million won)

Diagram 4 Reduction Target for Final Energy Consumption / Energy Intensity Reduction Plan of the Building Sector

Source: Ministry of Trade, Industry and Energy, Third Energy Master Plan, 2019

The Energy Efficiency Innovation Strategy (EEIS) was released in August 2019 to supplement the 3rd Energy Master Plan and to provide interim targets and measures up to 2030.¹³ This strategy proposes using the latest technology in Korea to achieve the goal of energy-saving and emission reduction¹⁴ and to meet further development goals put forward by the Fourth Industrial Revolution and energy-efficiency innovation.

The Korean New Deal is a five-year strategy established on July 14, 2020, with the goal of accomplishing South Korea's post-pandemic recovery based on three pillars: the Digital New Deal, the Green New Deal, and the Stronger Safety Net. The Green New Deal is worth US\$188 billion in investments, giving priority to green infrastructure, low-carbon and decentralized energy, and innovation in green industries. The plan will promote the development of commercial technology for large-scale carbon-capture utilization and storage (CCUS) by 2023. The plan further envisages converting 227,000 public buildings into zero-carbon ones, creating urban forests as a barrier against fine dust, launching 1.13 million electric vehicles and 200,000 hydrogen vehicles, installing 15,000 rapid chargers and 30,000 standard chargers, scrapping 1,160,000 diesel-powered cars and construction machines and 32,000 farming machines, and converting 135,000 freight vehicles and 88,000 school buses to LPG ones. Small businesses are to receive support for the green transition: 9,000 will receive support for facilities preventing fine dust, whereas 123 specialized in the environmental and energy sectors will receive support over the entire process of developing a business line. Additionally, 100 smart ecological plants and 1,750 clean factories will be established.¹⁵

Approved by the National Assembly on September 2, 2021, the "Climate Crisis Response" Act¹⁶ mandates over a 35% cut in GHG emissions by 2030 compared with the 2018 level, 9% higher than what the country had previously pledged, to help reach the final goal in 2050. A US\$10.3 billion budget to reduce GHG emissions in the 2022 state budget plan is under approval by the National Assembly.

The Green Buildings Construction Support Act was established by the Ministry of Land, Infrastructure, and Transport in 2012. It has become the legal framework of green building development in South Korea. It provides national legislation of sustainable construction standards and the key definitions of incentives, GHG emissions, and energy-demand monitoring. It also institutionalized the Green Standard for Energy and Environmental Design (G-SEED)¹⁷ and Building Energy Efficiency Certificate (BEEC) systems in the first version. The G-SEED serves as a domestic counterpart of international standards such as LEED and BREEAM. Over 8,000 buildings were certificated from 2002 to 2016.

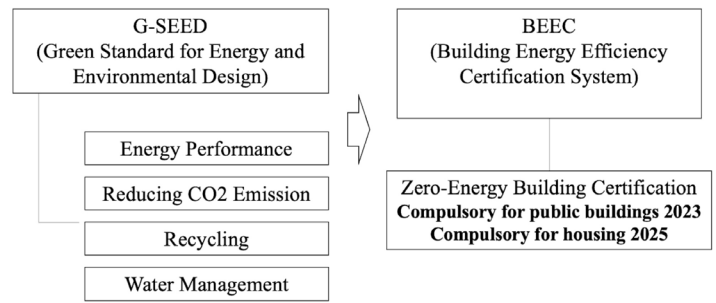


Diagram 5 Progressing Domestic Systems of Green Certification

Source: Drawn by Author

As G-SEED's successor, the Ministry of Land, Infrastructure, and Transport and the Korea Energy Agency implemented the ZEB (Zero Energy Building) Standard in 2017 (Diagram 5), promoting ZEB to achieve goals of "reducing GHG emissions by "improving building energy performance, driving a new growth in the nation's construction industry, and creating a pleasant living environment with low-cost energy." "Zero Energy Building" does not mean 100% energy independence. According to evaluation criteria, the lowest energy independence rate¹⁸ is $\geq 20\%$ (ZEB5). Additionally, both G-SEED and ZEB are standards mainly designed for new buildings. The assessment standards are primarily for existing buildings, and only a few are targeted toward renovations projects. Now the ZEB implementation is mainly market-based with governmental incentives. The Korean Government subsidizes the increasing construction cost in long-term, low-interest loans, up to a 15% reduction in land donation, and a 15% deduction in the real property acquisition tax. Other incentives include prioritizing building permits and 11% to 15% relaxations on construction standards.¹⁹ Reconstruction public building projects are also eligible for ZEB certification.

According to the Mandatory ZEB Implementation Roadmap (Diagram 6), ZEB will become a compulsory certification for new public buildings with a total floor area above 1,000 square meters. By 2030, all new buildings with a total floor area of more than 500 square meters will comply with the ZEB code. The mandatory ZEB certification will substantially affect the development progress of the Korean real estate market.

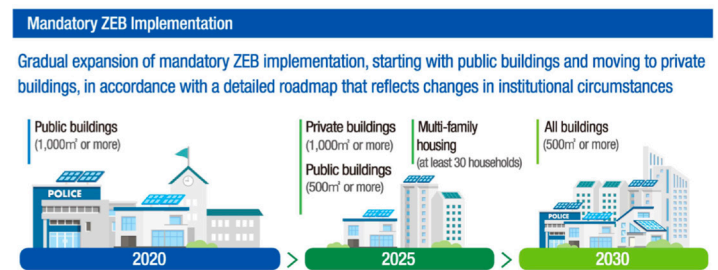


Diagram 6 Mandatory ZEB Implementation Roadmap

Source: Ministry of Land, Infrastructure and Transport; Ministry of Trade, Industry and Energy, Korea Energy Agency, Zero Energy Architecture Promotion Booklet, 2020

1.2 City Policies

Established in 2019, The Smart City Act has a direct relationship with green development in South Korea. The act regulates city development and provides a sandbox for developers to try out new technologies on green city development. This act defines a smart city as "a sustainable city wherein various city services are provided based on city

infrastructure constructed by converging and integrating construction technologies, information, and communications technologies, etc. to enhance its competitiveness and livability.”²⁰ It is a combination of two national planned pilot cities, Sejong and Busan (see Diagram 7), and 42 municipal development projects by 2020. The Smart City Act and Industrial Promotion Act were passed by the National Assembly on April 5, 2019. As national pilot cities that actively promote the smart city implementation, Sejong released its master plan in 2018 and Busan in 2021.



Sejong 5-1 Living Area



Busan Eco-Delta Smart City

Diagram 7 Pilot Smart Cities

Source: <https://smartcity.go.kr/en/>

Seoul

The 2030 Seoul Plan²¹ was launched by the Seoul Metropolitan Government in 2014.²² Seoul city is planning to develop eco-friendly mass transportation to reduce environmental pollution and traffic congestion. Energy conservation is also stressed to ensure all development activities, including construction projects, are carried out in consideration of the natural environment and pursue sustainable development through new and renewable energy and reductions in energy consumption. Public buildings and facilities in particular should be the leading projects with energy-conservation efforts.²³

Busan

The Busan Metropolitan City Climate Change Response Comprehensive Plan introduced five strategies established to achieve a 30% CO2 reduction target based on the 2020 GHG emission forecast. Following the comprehensive plan, the Busan Metropolitan City Climate Change Adaptation Detailed Plan is a five-year statutory plan with 30 action tasks and 62 detailed projects in 10 areas, including water management, clean air, and risk prevention.

In March 2021, Busan drafted the Busan Green Energy Targets for 2030 & 2050. It consists of two phases. The first phase is set up until 2030, with a goal of a 20% power-independence rate through renewable energy. The second phase aims to achieve a 100% power-independence rate through renewable energy by 2050.

The Busan Smart Green City Plan,²⁴ drafted by the Busan Metropolitan City Government, aims at establishing Busan's green infrastructure to become the leading carbon-neutral city by 2050. The government is making an effort toward the green remodeling of public facilities with the aim of realizing carbon neutrality by expanding the supply of renewable energy and reducing travel time with information technologies. The Busan Metropolitan City Government promotes hydrogen cars and hydrogen production and charging infrastructure to establish a hydrogen economy in the surrounding region.

Daegu

In September 2020, Daegu conducted a 2020 GHG Reduction Implementation Inspection Project, including both an executive plan and a resulting report, to diagnose GHG reduction activities. According to the report, the resulting GHG reduction is 1,269,231 tons of CO2, and 13.2% is from the building sector. The objective was a 9% reduction (1,049,000 tons), and the result has been an 11% reduction, exceeding the 2020 target. Daegu is also the first South Korean city to publish the actual amount of GHG reductions.

The 2030 Daegu Climate Change Response Comprehensive Plan²⁵ is a comprehensive climate-change response plan started in September 2021. They established and published annual reduction goals to reduce emissions by 30% over the previous year.

The Daegu 2050 Carbon Neutrality Vision and Strategy, established in 2021, sets the goal of reaching a 45% reduction of GHG emissions by 2030 and a 70% reduction by 2040, and achieving carbon neutrality by 2050, relative to the 2018 level. It puts forward “8G strategies” in eight major sectors: Green Growth, Green Lifestyle, Green Cycle, Green Forest & Farm, Green Innovation, Green Energy, Green Mobility, and Green City.

The 2022 Government Department's Carbon Neutrality Project is a plan to promote carbon neutrality by government departments, published on January 7, 2022. Each government department has set its goal on carbon-neutral promotion. The Ministry of Environment sets the financial promotion for carbon-neutral facilities (KRW 87.9 million) and the target number of electric/hydrogen vehicles and chargers. It also promotes green infrastructure and a circular economy by regulations on limited package usage and recycling. The Ministry of Strategy and Finance plans to establish a financial infrastructure to provide a budget and green classification system, facilitating the green bonds review process. R&D and technology development are promoted by the Ministry of Science and Technology Information and Communication. The Ministry of Land, Infrastructure, and Transportation established the plan to convert the existing transportation system into a carbon-neutral one.

2. Capital Market

2.1 Equity investment

South Korea is a major creditor in the equity market in East Asia. South Korean real estate companies are beginning to attach importance to environmental, social, and corporate governance (ESG) and add it to their corporate strategic planning as an upgrade from their previous social and ecology commitments. The ESG market size is growing rapidly since 2017 (Diagram 8). Global pension funds and large management

companies are using ESG as a significant investment principle and strategy. According to a CBRE survey²⁶ in 2021, 34% of South Korean respondents stated they already incorporated ESG criteria into their investments, while 49% of Asia-Pacific respondents stated they had already adopted ESG criteria in their investment strategies. For the construction company sector, GS E&C is pushing the companies' environmental management and issued their ESG paper in 2021.

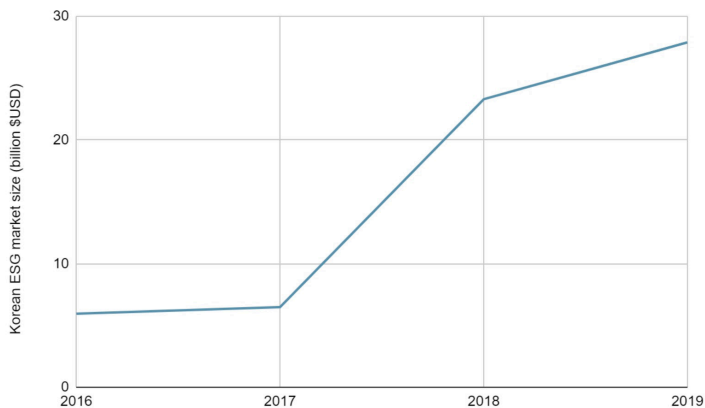


Diagram 8 Korean ESG Market Size 2016–2019

Source: Assessing South Korea's Role in Promoting ESG Investing in the Asia-Pacific—Korea SRI Market Landscape," Korea Sustainability Investing Forum, 2021; "Market Data," Korea Exchange, 2021

On January 1, 2015, South Korea became the first country in Northeast Asia to implement a nationwide emissions trading scheme, the **Korea Emissions Trading System (K-ETS)**,²⁷ which was the second-largest energy trading market at that time after EU ETS. The ETS is designed to gradually deliver emissions reductions in the large industry and power generation sectors that account for around 80% of Korea's GHG emissions. Participation in the ETS is mandatory for individual facilities with annual emissions above 25,000 metric tonnes of CO₂ and companies with annual emissions above 125,000 metric tonnes of CO₂. The ETS is implemented in three phases from 2015 to 2025. After initial setup and auctions in the first two phases, the current phase in 2022 is Phase III (2021–2025), which is intended to actively and effectively reduce GHG emissions. Thanks to the nation's Energy Target Management System (TMS), launched in 2012, 685 of the country's largest emitters' emissions data could be collected, accounting for ~73.5% of national GHG emissions.²⁸

2.2 Debt Market

In 2020, South Korea overtook Japan as the largest social and sustainability bond issuer in the Asia-Pacific region.²⁹ In 2021, government agencies contributed 97% of ESG investment, derived from the pandemic response. Retail funds account for only a small portion of the entire market.³⁰ As Diagram 9 shows, the number of green bond issuers is the highest, but their volume is the lowest, meaning, on average, fewer green bonds are issued than bonds in the sustainability and social sector. The diagram shows the rapid expansion of South Korea's ESG market, especially from 2017 to 2018.

The first "green bonds" in Korea were issued by the Export-Import Bank of Korea in 2013. In 2018, South Korea's green bond market ranked the fifth largest cumulative issuer in the Asia-Pacific area.³¹ In the global context, the market size is still relatively small. However, the market

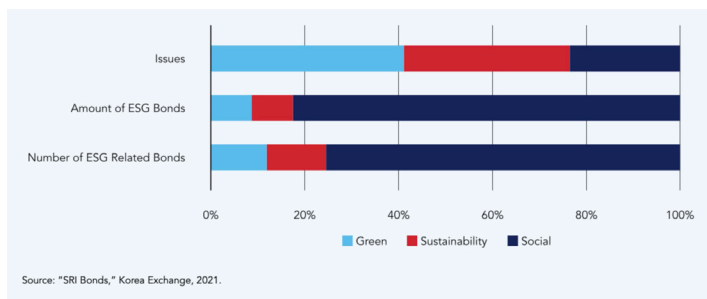


Diagram 9 Korea's ESG Bond Market Landscape 2021 (% of Total)

Source: "SRI Bonds," Korea Exchange, 2021

has grown at a fast pace (Diagram 10). Since January 2021, 116 Korean entities have issued green bonds, social bonds, and sustainable development bonds worth a combined 60.6 trillion won (US\$52.3 billion), according to data compiled by the Korea Exchange.³² The issuer type has also become more diverse, with both publicly and privately owned issuers. The Korea Land & Housing Corporation remains the top green bond issuer in South Korea in 2021, followed by the Korea SMEs and Startups Agency and the Industrial Bank of Korea.

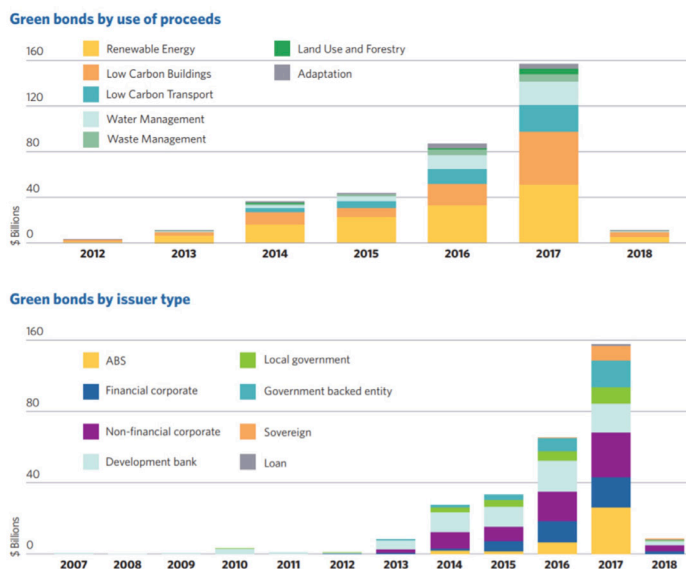


Diagram 10 Korea Green Bond Analysis

Source: Bridget Boule, Kwangyul Peck, Korea Climate Bond Market Overview and Opportunities, 2018, Climate Bonds Initiative and SK Securities, United Kingdom

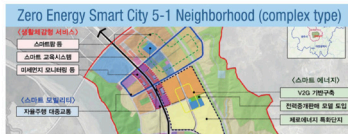
3. Business Innovation

3.1 Government Lead Sustainable Projects

Pilot ZEB certificated projects (Diagram 11) with different scales from townhouse development to urban planning as applicable templates for nationwide implementation. The Korea Land & Housing Corporation is the key player in the field of governmental-led ZEB. It is a government-owned corporation responsible for the development of land in cities and the maintenance and management of land and housing.



- Type and size: Single-family dwellings / townhouse-type single-family dwellings (floors: two above ground)
- Total floor area: 5,260.8m²
- Location: Coun-dong, Sejong City
- Certification: Class 2 ZEB certification (energy independence rate: 83.18%)



- Type and size: Residential, commercial, and public facility
- Total floor area: 2,741,213m²
- Location: Multifunctional Administrative City 5-1 Neighborhood



Kolon e+ Green Home

Diagram 11 Pilot Zero-Energy Projects Led by The Korea Land & Housing Corporation

Sources: Korea Energy Agency, Zero Energy Building,2020; https://zeb.energy.or.kr/BC/BC05/BC05_01_001.do

Smart City Development

South Korea's Smart City development is also a vital promoter of zero energy developments. Founded in 2007, the Sejong Smart City is a national planning project aimed at developing a zero-energy smart city that serves as the new planned capital for government institutions and home for 500,000 residents by 2030.³³ Sejong is located in the southern part of the nation, the least-populous first-level administrative division in South Korea, making it an excellent incubator for future development. The city aims to become the pilot city with intensive use of sustainable city technologies, such as solar-powered buildings, zero-waste food disposal, and electric car infrastructures.³⁴ It also put forward a Smart Grid-based Energy Management System to further reduce excessive emissions by active energy monitoring and managing. Twenty-two other cities have been named national pilot cities as well.

3.2 Private Lead Projects

Since 2008, several corporations have begun to build small-scale experimental net-zero buildings (Diagram 12) as experimental fields for new technologies:

- Green Tomorrow project is the first building in South Korea to obtain LEED Platinum certification. The project is designed by Moo Architects and developed by Samsung C&T Corporation, with Ove Arup & Partners as the project manager. These kinds of projects, backed by large companies, are non-profit and don't involve financial issues.

- Kolon e+ Green Home: Developed by Kolon Institute of Technology with Unsangdong Architects Corporation, Korean Institute for Construction Technology (KICT), and Fraunhofer Institute for Solar Energy (ISE) as strategic partners among six build partners and 29 supply partners.

- Daelim Greenhome Plus: Developed by Daelim, Yonsei University, and 30 other organizations.



Samsung Green Tomorrow



Greenhome Plus

Diagram 12 Experimental Zero Energy Building Led By Large Developers

Source: Schuetze, Thorsten. 2015. "Zero Emission Buildings in Korea—History, Status Quo, and Future Prospects" Sustainability 7, no. 3: 2745-2767. <https://doi.org/10.3390/su7032745>

More and more zero-energy projects led by private development companies (Diagram 13) are being implemented. Many of them are large-scale high-rise residential projects by big developers:

- The Songdo 6-8 Zone A11 Block Multi-Family Housing project consists of multiple 34-floor shared apartments for 886 households located in Songdo-dong, Incheon, and developed by Hyundai.

- The Jangwi 4 Zone Housing Redevelopment Project is an urban renewal project that is going to be developed by the Jangwi 4 Zone Housing Redevelopment Union and GS E&C, located in Seoul and surrounded by low-rise traditional blocks.



- Type and size: Multi-family housing / 886 households (floors: two underground, 34 above ground)
- Total floor area: 155,833.02m²
- Address: 397-11 Songdo-dong, Yeonsu-gu, Incheon
- Certification: Class 5 ZEB certification (energy independence rate: 23.37%)



- Type and size: Multi-family housing / 2,840 households (floors: three underground, 31 above ground)
- Total floor area: 433,686m²
- Address: 51 Hwarang-ro 37-gil, Seongbuk-gu, Seoul

Diagram 13 Pilot Zero-Energy Projects Led by The Korea Land & Housing Corporation

Sources: Korea Energy Agency, Zero Energy Building,2020; https://zeb.energy.or.kr/BC/BC05/BC05_01_001.do

- The Oceanix City (Diagram 14), also known as “the floating city,” is expected to be built in Busan Metropolitan city in 2025 with a budget of \$200 million. The project aims at becoming a zero-waste city confronting climate change. Locally sourced materials that could provide negative carbon footprints are featured for building construction. Waste would be converted to energy to sustain the city’s operation. Various clean, renewable-energy sources, including solar and waves would help the city reach the goal of net-zero energy.



Diagram 14 Rendering of the Oceanix City

Source: https://nypost.com/wp-content/uploads/sites/2/2021/11/south-korea-floating-city_40.jpg?quality=90&strip=all

3.3 Real Estate Technology / PropTech

South Korea has advanced mobile communication and electronic information technology, resulting in many emerging proptech products, such as rental housing, smart furniture, and so on.

- In the clean & green tech sector, the Seoul-based company, Brite Energy Partners, is a solar-energy-oriented company that is making an effort to establish a renewable independent power producer (IPP) platform that develops and finances small utility-scale solar farms in Korea with a strong focus on the asset ownership model.

- Re-imagining Cities Foundation is a non-profit research firm based in Seoul focusing on smart, resilient cities, innovation districts, digital twins, and sustainability. They aim to help investors and large portfolio owners decarbonize their existing portfolios or new constructions by providing energy-optimization solutions.

- Herit are promoting their IoT product to provide an integrated management solution for zero-energy building with cloud-based building energy management and optimization.

- Hanmi Global is beginning to provide zero-energy-specialized consulting services and has developed a building energy management system in the construction and operation phase.

4. Opportunities

4.1 Regional Collaboration

The Green Climate Fund (GCF)³⁶ was established under the Cancún Agreements in 2010 and is serving as the Financial Mechanism of the

UNFCCC and the Paris Agreement. Hosted by the city of Incheon in South Korea, it is currently the world’s largest global fund dedicated to helping fight climate change. GCF was created as an international financing vehicle to foster investment in smart climate action in developing countries. It also encourages the private sector to pursue investment opportunities in clean energy. Since the approval of the first project funding in 2015, GCF has made rapid strides in building a portfolio of more than 100 projects.

The Global Green Growth Institute (GGGI)³⁷ was established at the 2012 Rio+20 UN Conference on Sustainable Development as an intergovernmental organization with over 30 members in 2020 for the purpose of offering technical advice and economic development strategies to climate-stressed developing countries. The current GGGI Strategy 2030, approved in October 2019, lays out GGGI’s vision and strategy to build on this foundation to help its members achieve their green growth aspirations, particularly to set and achieve ambitious NDCs for the Paris Agreement and meet their SDG targets. It also established the Corporate Results Framework in 2015 as a management tool for GGGI to monitor, report, and improve its results and performance to achieve the goals and corporate targets set out in Strategy 2030.

In 2018, Korea organized the **Partnering for Green Growth and the Global Goals 2030 (P4G) summit**.³⁸ The P4G is a global platform pioneering green partnerships to deliver inclusive and sustainable growth. South Korea is the leading country of the P4G’s 12 partner countries. Each country establishes a National Platform to coordinate national engagement and accelerate partnerships. It brings together governments, businesses, and civil society organizations to form public-private partnerships, particularly in developing countries, to support GHG-related goals. The P4G provides catalytic funding to selected start-ups and scale-up partnerships to prepare them for institutional investment. As of December 2021, the P4G had impacted the lives of over 2 million people regarding economic opportunities, water, food, and energy access, and driven US\$287 million in investment in developing countries.³⁹

The EU and South Korea’s agreement on energy and climate change were established by the **Framework Agreement**,⁴⁰ which entered into force in June 2014. The EU and South Korea affirmed their commitment to “cooperating to address global environmental challenges, in particular, climate change. They also agreed ‘to develop new, sustainable, innovative and renewable forms of energy, including, inter alia, biofuels and biomass, wind and solar energy as well as hydropower generation,’”⁴¹ as well as to cooperate on the reduction of GHG emissions in the transport sector. The EU has provided financial support to South Korea on energy cooperation. In 2016, The Korea Emissions Trading System was supported by the EU by a three-year, €3.5 million cooperation project funded under the EU’s Foreign Partnership Instrument.⁴² In January 2018, the EU funded the EU-Korea Climate Action Project with €2.400⁴³ aimed at accelerating climate actions in Korea with the actions from non-state stakeholders such as NGOs, businesses, and research institutions. The project was successfully completed in October 2021.⁴⁴

The UK-South Korea Smart Energy Innovation Collaboration Competition was a bilateral competition on smart energy innovation⁴⁵ held by the UK and South Korean governments from 2018 to 2021. The competition aimed to develop and demonstrate innovative technologies

and business models in the field of smart energy.⁴⁶ Three projects were selected and secured total funding of £1,664,839 from the BEIS energy innovation program.

In December 2021, the **UK-Republic of Korea Innovation Twins Programme**⁴⁷ finished its first phase of research and evidence gathering and moved to the second phase to find convening and lighthouse projects looking to improve the development and application of innovations in their cities and how they can open new R&I and business collaborations. Four pairs of cities (Liverpool-Busan, Birmingham – Ulsan, Glasgow – Daegu, Belfast – Sejong) were established to learn from each other and further develop smart city and clean-energy management strategies and technologists.

The **Tripartite Environmental Cooperation** between the People's Republic of China, Japan, and the Republic of Korea was inaugurated in 1999⁴⁸ and has been held annually since then⁴⁹. The three countries aim to promote environmental management, take a leading role in regional environmental management, and contribute to global environmental improvement. Each government shares one third of the total operational budget.⁵⁰ In the 22nd Tripartite Environment Ministers Meeting on December 7, 2021, the three countries vowed to cooperate over the next five years in eight areas, including air quality, water management, and climate change.

4.2 Investment or Business Opportunities

Proptech

As a global information and communication technology leader, the venture companies and developers in South Korea are actively making use of the countries' information infrastructure by creating new applications on real estate. For example, under fast, low-latency wireless internet, investors can perform real-time exploration of properties through mixed reality technologies.

Supply-Chain Decarbonization

South Korea is proposing new city development across its nation, which takes large-scale infrastructure and real estate development outside the existing city center. Innovative supply-chain management, optimized logistics, and sustainable warehouses could have a huge potential to reduce the energy cost and emissions during the development phases.

Sustainable Materials

In South Korea, the low-embodied-carbon materials market and the related legislation are underdeveloped. Sustainable construction with low-embodied carbon, such as using decarbonated cement, recycled materials, and components with low-emission construction machinery, would considerably reduce emissions in the process of building construction.⁵¹

Renewable Energy

South Korea used to rely on imported energy for more than 95% of its energy needs, because the country lacks sufficient natural resources. However, with the nation's target to reduce emissions and reach carbon neutrality by 2050, domestic new and renewable-energy industries are expected to grow substantially. Coal-fired power plants are rapidly being shut down. Both existing state-owned power-generation companies and independent power producers are required to add renewable energy to their product portfolio, and new power plants are under construction.

Among all the types of renewable energy currently implemented in South Korea, bioenergy is undergoing the fastest growth.

Existing Building Stock

In South Korea, we see huge efforts from the government in the form of policy incentives and pilot projects. But the efforts from the private side are still limited to a few projects developed by large developers such as Hyundai and GS & EC. Although we numerous laws and plans are focusing on new buildings, policies regarding existing buildings and renovation projects are lacking. The greatest potential to reduce emissions lies in the country's highly urbanized existing building stock.

About the Author



Jin Gao

Jin Gao grew up in Beijing, China. He is currently a graduate student in the SMArchS Urbanism program in the MIT Department of Architecture, pursuing combined interests in urban design, real estate, and computer science. He intends to acquire a more robust, cross-disciplinary skillset and toolset through current studies, to find a structured understanding of contemporary urban issues and innovative ways to contribute to the technology-driven world.

Real Estate Industry Overview

Real estate in Singapore accounted for roughly 3% of nominal GDP in 2020.¹ For international investors, Singapore's real estate market is a secure haven, and property values appear to be gradually increasing. Despite the predicted drop in transaction volume and prices of prime non-landed properties as a result of the COVID-19 recessionary climate, the Singapore real estate market is expected to grow in 2022. According to Knight Frank Singapore, Private residential prices could rise between 1% to 3% in 2022.²

In 2020, Singapore had 1.37 million resident households, and the average household size was 3.22 people. The total number of Housing & Development Board (HDB, Singapore's public housing authority) dwellings had decreased from 82.4% in 2010 to 78.7%. Four-room flats remained the major layout of residential design in both 2010 and 2020, with five-room flats and executive rooms being the second most popular options.³ As of June 2021, Singapore's total population was 5.45 million, which was a 4.1% decline from the previous year. The resident population in 2021 was 3.99 million, representing a 1.4% decline from the past year.

The majority of Singapore's residential buildings are built by the HDB. The Government of Singapore subsidizes, constructs, and manages public housing in Singapore. The Singapore Improvement Trust (SIT) developed the country's first public housing in the 1930s, in the style of contemporaneous British public housing developments, and housing for squatter relocation began in the late 1950s. In the 1960s, the HDB,

the successor to the SIT, built public housing consisting of small units with minimum utilities as rapidly and as cheaply as possible at high densities, and used it for resettlement programs.⁴ Over 80% of Singapore's resident population live in public housing built by HDB. Public Housing is heavily subsidized to ensure it is affordable. HDB towns have a full range of facilities to meet the various needs of residents, such as commercial spaces, schools, transport nodes, and parks.⁵

Despite a faltering economy caused by the COVID-19 outbreak, Singapore's property market remains solid. According to the Urban Redevelopment Authority (URA), the private residential property index increased by 2.21% in 2020, following increases of 2.67% in 2019, and 7.85% in 2018.⁶ The ongoing rise in housing prices was mostly due to high demand and slow residential development activity. According to URA estimates, 10,833 uncompleted private residential units were launched in Singapore in 2020, down from 11,345 units in 2019.⁷

The office market is divided into two tiers, with occupiers favoring prime office buildings with tech-enabled features over older office stock with outdated specifications. The Grade B market accounted for the majority of the negative net absorption in 2020, with -0.79 million square feet. Some tenants downsized, while others decided to take advantage of the present economic slowdown to "fly to quality." By contrast, the Grade A (Core CBD) market saw positive net absorption of 0.51 million square feet in 2020. The Grade A office market's resiliency was evident in its vacancy rate, which remained unchanged year-over-year at 3.9%. Due to the constrained vacancies, prime space for occupiers with approaching lease expirations was limited. Total new supply is expected to reach 3.40 million square feet by 2023.

The retail market ended 2020 with more optimism, with customer traffic returning to pre-pandemic levels. As customers readjusted to the pandemic and increased their spending levels, retail sales declined to -2.5% year-over-year in November 2020, down from roughly -9.0% to -12.0% in the previous three months.⁸

1. Policy

Climate change makes coastal communities such as Singapore more vulnerable to increasing sea levels. Even though Singapore is a pioneer in sustainable urban planning, it hasn't provided a specific year of when it will reach net-zero emission. Instead, it has set the goal of achieving it "as soon as feasible" in the "second half of the century." Minister for Sustainability and Environment Grace Fu also mentioned at COP26 that Singapore would go back and look at what it needed to do, look at its responsibilities, and review its position. Because each country will be required to provide a national roadmap explaining how to reach net zero at COP27, Grace mentioned Singapore would review the nationally determined contributions (NDCs) seriously. At COP26, Singapore agreed to keep alive the ambition of limiting global warming to 1.5 degrees above pre-industrial levels.⁹

Singapore's climate policies and actions are rated as "Highly Inadequate" according to the Climate Action Tracker. This rating implies Singapore's policies and actions are incompatible with the 1.5°C temperature target set by the Paris Agreement.¹⁰ However, the National Climate Change Secretariat said the Climate Action Tracker report has not fully accounted for such factors as the unique challenges and limitations Singapore faces as a small island economy.

Singapore published a Long-Term Low Emissions Development Strategy in April 2020, with the goal of halving emissions from their peak in 2030 to 30 Mt CO₂e by 2050. The government also changed its emissions-intensity target to a 65 Mt CO₂e absolute target for 2030, which is 28% higher than 2014 emission levels.¹¹

Because the government of Singapore does not provide a specific year for reaching net-zero emissions, no public policy is in place to guide private sectors to reach carbon neutral. However, a few carbon-related or general sustainable-related public policies are effective.

1.1 Singapore Green Plan 2030

Singapore's initial environmental blueprint is the Singapore Green Plan (SGP). The goal of the document, which was published in 1992 by the Ministry of the Environment (now known as the Ministry of the Environment and Water Resources or MEWR), is to ensure Singapore can build an economic growth model that is not harmful to the environment. A second SGP, known as the Singapore Green Plan 2012 (SGP 2012), was introduced in 2002. The goal of SGP 2012 is to assist Singapore in achieving environmental sustainability by defining a series of environmental targets. The Sustainable Singapore Blueprint, however, was published in April 2009 to ensure the country's sustainable development initiatives could be maintained until 2030.¹²

Five key pillars under the Green Plan¹³ engage almost every aspect of a Singaporean's life. Specifically, under the Greener Infrastructure and Buildings, Singapore agrees to the following:

2025 targets:

- Energy consumption of the desalination process will be reduced from the current 3.5kWh/m³ to 2kWh/m³.
- Singapore's first integrated waste and used water treatment facility will be 100% energy self-sufficient (Tuas Nexus).

2030 targets:

- 80% of Singapore's buildings (by gross floor area) will be green.
- 80% of new buildings (by gross floor area) will be super low energy buildings.
- Best-in-class green buildings will see an 80% improvement in energy efficiency (over 2005 levels).
- Long-term target: Reduce desalination energy further to 1kWh/m³.

1.2 Carbon Pricing Act

Singapore is the first Southeast Asian country to implement carbon pricing. The Carbon Pricing Act of 2019 imposed a S\$5 per ton of greenhouse gas (GHG) emissions (tCO₂e) carbon tax in 2019.¹⁴ The carbon price is intended to encourage emissions reductions in all sectors and help the country transition to a low-carbon economy. To ensure a transparent, fair, and uniform price signal across the economy, no exemptions are in place for covered facilities. Any industrial plant emitting direct GHG emissions equal to or greater than 25,000 tCO₂e per year must register as a taxable facility and submit an annual Monitoring Plan and Emissions Report.¹⁵

Since January 1, 2019, taxable facilities are required to pay a carbon tax for their measurable GHG emissions. Until 2023, the carbon tax will be \$5 per ton of GHG emissions (tCO₂e). To achieve our climate ambition, the carbon tax will be raised to \$25/tCO₂e in 2024 and 2025, and \$45/tCO₂e in 2026 and 2027, with a view to reaching \$50-80/tCO₂e by 2030. By 2022, the carbon-tax level and trajectory beyond 2023 will be evaluated, giving businesses time to respond to any changes in the carbon-tax trajectory.¹⁶

1.3 Green Mark Scheme

The BCA Green Mark Scheme is a program to promote sustainable design and best practices in building construction and operations in Singapore, with the goal of creating a more sustainable built environment. It provides the standards in energy performance. This certification scheme is also tailored for tropical climates. The Green Mark Scheme 2021 Whole Life Carbon section (Cn) was developed using major international initiatives such as the World Green Building Council's commitment to net-zero carbon buildings and professional standards, such as the RICS Whole Life Carbon Assessments for the Built Environment.¹⁷

As of January 2018, around 3,200 buildings in Singapore had passed the Building and Construction Authority's (BCA) Green Mark standards. These buildings total more than 94 million square meters, or around one third of Singapore's entire gross floor space.¹⁸

2. Capital Market

2.1 Equity Markets

The Financial Stability Board, an international organization that oversees the global financial system, established the Task Force on Climate-related Financial Disclosure (TCFD) in 2015 to improve climate-related disclosures, allowing investors to better understand carbon-related assets and climate-related risk exposure. In 2017, SGX began voluntarily recommending the TCFD framework for sustainability reporting.¹⁹ SGX is the first Asian exchange to propose enforcing climate disclosures in accordance with the recommendations of the TCFD. The Singapore Exchange (SGX) has released a roadmap for issuers to disclose climate-related financial disclosures, based on the TCFD recommendations. From the fiscal year (FY) beginning in 2022, all issuers must publish climate reporting in their sustainability reports on a “comply or explain” basis. From FY 2023, issuers in the (i) financial, (ii) agriculture, food and forest products, and (iii) energy industries will be required to report on climate change. From FY 2024, the (iv) materials and buildings and (v) transportation industries must follow suit.

2.2 Debt Markets: Green Finance Action Plan

The Monetary Authority of Singapore (MAS) wants to make Singapore a leading center for green finance in Asia and globally. It has four strategies: (1) Strengthen financial-sector resilience to environmental risks, (2) develop markets and solutions for a sustainable economy, (3) harness technology to enable trusted and efficient sustainable finance flows, and (4) build knowledge and capabilities in sustainable finance.

To accomplish the second strategy, Singapore launched a US\$2 billion MAS Green Investments Program. This green investment mandates asset managers to commit to drive regional green efforts out of Singapore.

MAS also announced it will spend US\$1.8 billion in climate-related investment opportunities. MAS Managing Director Ravi Menon announced at the launch of the central bank's first sustainability report that these funds will be placed with five asset managers under its Green Investments Programme to “manage new equity and fixed income mandates focused on climate change and the environment.”²⁰

MAS is taking active steps to promote sustainable financing and encourage financial institutions to consider ESG criteria in the decision-making process. It initiated a Green Finance Action Plan, which will be implemented based on three main pillars: strengthening resilience, developing markets, and harnessing technology. MAS has issued two schemes:

- **The Sustainable Bond Grant Scheme** supports the issuing and listing of green bonds in Singapore by subsidizing the costs of external project evaluation, lowering the borrower's borrowing costs and contributing to the growth of the green bond market.²¹

- **The Green and Sustainability-Linked Loan Grant Scheme** requires the proceeds of the loan or bond to be used for “green purposes” and for the loans and bonds, in which the borrower's performance against certain pre-determined sustainability-linked key performance indicators is tied

to certain terms (typically pricing) applicable to the loan or bond.

The government stated in the Singapore Budget 2021 that it would issue green bonds for S\$19 billion worth of infrastructure projects, bolstering the nation's ambitions to transition to a low-carbon economy and become a leading green finance hub in Asia and beyond. Given that ASEAN's total green bond issuances from 2016 to 2019 were only about US\$8.1 billion (S\$10.8 billion), with Singapore contributing 55%, these green bonds are substantial.²²

Below is a list of government-initiated funding and incentive schemes in the areas of green buildings, sustainable finance, and urban solution:²³

- Pilot Building Retrofit Energy Efficiency Financing (BREEF) Scheme
- Green Mark Incentive Scheme for Existing Buildings (GMIS-EB)
- Green Mark Incentive Scheme – Design Prototype (GMIS-DP)
- Green Mark Gross Floor Area Incentive Scheme (GM-GFA)
- MND Research Fund for the Built Environment
- A*STAR-MND Joint Grant Call
- Skyrise Greenery Incentive Scheme
- Sustainable Construction Capability Development Fund

Below is a list of private real estate companies targeting sustainable issues:

- **Temasek:** Temasek Holdings, one of the world's most powerful state investors, announced plans in 2019 to reduce GHG emissions due to its portfolio assets by half by 2030. It stated that it aimed to reach zero net emissions in its portfolio by 2050.²⁴

- **The National Environment Agency** has raised S\$1.65 billion worth of green bonds in a dual-tranche issuance after pricing the first and second series of its S\$3 billion multi-currency medium-term note program the night before.²⁵

- **CapitalLand:** CapitaLand has obtained a S\$500 million sustainability-linked loan from the United Overseas Bank (UOB). The loan is the largest sustainability-linked bilateral loan in Singapore's real estate sector. In total, CapitaLand and its real estate investment trusts (REITs) have raised over S\$2.42 billion in less than two years, through sustainable financing instruments, reinforcing the group's commitment to responsible growth.²⁶

- **The four-year S\$500 million sustainability-linked loan from UOB** is CapitaLand's fifth sustainability-linked loan, the highest number of sustainability-linked loans obtained by a real estate company in Singapore. To date, CapitaLand has partnered with seven financial institutions to secure a total of 12 sustainable financing instruments comprising sustainability-linked loans, green loans, and green bonds.²⁷

- **Ascendas REIT** raised S\$100 million through its first green bond, issued under a newly established Green Finance Framework in August 2020. Ascendas REIT's first green bond, to be issued pursuant to its S\$7 billion Euro Medium Term Securities Program, has a tenure of 10 years and a fixed coupon rate of 2.65%. The orderbook was in excess of S\$650 million (good at final price guidance), with orders from across 47 accounts. The green bonds were allocated to asset managers, insurance companies and hedge funds (80%), banks and corporates (11%), and private banking accounts (9%).²⁸

3. Business Innovation

3.1 Leading Net-Zero Projects

According to a recent study by the National University of Singapore, a sample of office buildings designed to satisfy Green Mark criteria cut total operating expenses by 11.6 % on average while increasing capital value by 2.3%. According to the BCA, although new Green Mark buildings might cost up to 5% extra, most developers return their original investment through energy savings within seven years. The fact that the agency promised landlords in 2009 that they would pay for efficiency audits and install energy-efficient cooling units, motion sensors, and shading devices over a five-year period, for a total of S\$100 million, or approximately US\$80 million, was helpful.²⁹

So far, the two examples of net energy buildings have funds supported by the government or non-profit institutes. More business cases of net-zero buildings without public funds are needed to motivate private developers. SDE4 and the Keppel Bay Tower are the only two examples that are close to the concept of net-zero emissions. As the building sector strives to meet its goals, the lessons learned and experience gained throughout the development and management of SDE4 and the Keppel Bay Tower will be useful and important.

NUS SDE4

Zero energy here refers to achieving energy self-sufficiency without relying on grid electricity. The achievement of this goal by SDE4 is thrilling for an energy-scarce Singapore that is also empty of natural resources. It has huge ramifications for how energy is used in Singapore for specific types of buildings.

SDE4 was converted from a former three-story workplace. It's now owned by the School of Design and Environment at the National University of Singapore with the uses of offices, classrooms, and a resource center.

SDE4 is a zero-energy building because it generates enough energy to operate on its own. The 4,500-square-meter structure seeks to create enough energy to power the building as a critical testbed facility. On sunny days, it is designed to create and feed electricity into the grid, whereas on cloudy/rainy days, it is designed to draw power from the grid. It spans six stories and contains 1,200 solar panels on the roof, totaling 91,644 square feet.³⁰

The façade is amply shaded and provides access to daylight, which reduces the demand for electrical lighting and creates a more naturalistic experience. A series of "floating boxes" create a porous space that allows for cross ventilation, natural lighting, and views to the outside space.

When compared with a typical workplace in Singapore, the building will save S\$84,000 per year in energy costs. This estimate is based on a 21.69 cents per kWh electricity rate.³¹

The innovation comes from the structure that seeks to achieve this energy saving by using a combination of green building technology, creative building design that takes advantage of natural ventilation and illumination (i.e., "passive design"), and solar-energy harvesting.

It's a tripartite collaborative between the Building and Construction Authority (BCA), NUS, and the Ministry of Energy, with funding from the MND Research Fund and EDB's Clean Energy Research Program.



Diagram 1: Zero-Energy Building – NUS SDE4

Source: <https://www.newswise.com/articles/nus-sde4-is-first-in-southeast-asia-to-achieve-ifli-zero-energy-certification>

Keppel Bay Tower

Keppel Land is committed to developing and managing low-carbon buildings, with a goal of lowering its carbon-emissions intensity by 40% by 2030 relative to 2010. Keppel Bay Tower, located in the Keppel Bay waterfront district, was certified as a Green Mark Platinum (Zero Energy) skyscraper by the BCA in 2020, as a testament to the company's efforts. It is Singapore's first commercial building to receive this honor.

In 2018, as part of Keppel Land's efforts to make Keppel Bay Tower Singapore's first Green Mark Platinum (Zero Energy) commercial building, the company took advantage of a BCA grant to test five new and emerging energy-efficient technologies at Keppel Bay Tower that would significantly reduce the building's energy consumption and improve its energy efficiency by 20% relative to other BCA Green Mark Platinum buildings. It was the first time any of these technologies had been used in a Singapore development. Keppel Land had reduced the building's annualized energy use by 22.3% by February 2020, above its initial target of 20%.³² The following are new and innovative technologies highlights:

1. A smart building control system that manages energy usage. To improve data analytics and control, the system uses a high-precision physics-based simulation engine based on accessible data for energy optimization. The building's total energy consumption has been decreased by almost 5% thanks to increased data analytics and tighter control.

2. Intelligent lighting system. Occupancy sensors are used in the smart lighting system, allowing for a smooth transition in lighting settings based on the occupancy of the building. When daylight near the window area is sufficient, photosensors decrease the perimeter illumination. This completely autonomous system, which has been installed across seven floors of Keppel Bay Tower, saves over 10% more energy than best-in-class LED lighting.

3. Air distribution system with high efficiency. The air-handling-unit fans of the Keppel Bay Tower are approximately 45% more energy efficient than other best-in-class technology. The fans also make less noise than standard systems, making the environment more comfortable for building occupants.

4. A sensor system with integrated controls to optimize fresh-air intake. This system makes use of integrated sensors to optimize the intake of fresh air in the building based on indoor activities. The machine-learning technology is being trialed on one floor of Keppel Bay Tower and has resulted in a 10% reduction in air-conditioning energy consumption, improved thermal comfort, and a more pleasant indoor environment for building residents.

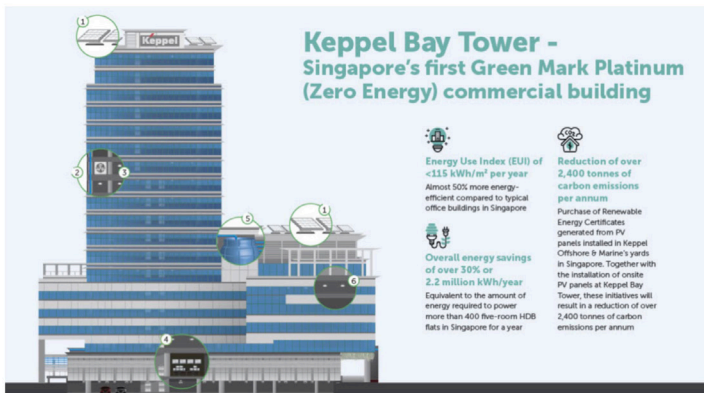


Diagram 2: Design of Keppel Bay Tower³³



Diagram 3: Image of Keppel Bay Tower

Source: <https://www.eqmagpro.com/keppel-bay-tower-to-be-singapore-first-commercial-building-fully-powered-by-renewable-energy/>

3.2 Leading Real Estate Firms and Their Net-Zero Emission Target

City Developments Limited is the first real estate developer in Singapore to sign the WorldGBC's Net Zero Carbon Buildings Commitment, with the goal of achieving net-zero carbon by 2030 for all new and existing wholly owned assets and developments under its direct operational and management control.³⁴

Frasers Property plans to reach net-zero carbon by 2050. Frasers Property is focusing on expanding its portfolio of green buildings to fulfill its goal, which includes investing responsibly and improving the sustainability of existing structures. Since 2018, Frasers Property has received 12 green and sustainability-related loans totaling over S\$4 billion, as well as increasing the number of green-certified buildings and projects. In FY2020, 35 developments in Singapore received the Building and Construction Authority's Green Mark certification, up from 31 in FY2019. Six Green Mark Platinum buildings and 11 Green Mark GoldPLUS buildings are among them.³⁵

Lendlease committed to accomplish its Mission Zero goals of net-zero carbon by 2025 and absolute-zero carbon by 2040. It will take a multi-pronged strategy in Asia, examining the fuels burned, power consumed, materials and services purchased, and tenant emissions across all its projects, assets, and activities.³⁶

Capital Land has stated that it will reduce its carbon-emission intensity by 23% by 2020 and 30% by 2030 using 2008 as base year.³⁷

3.3 Real Estate Technology/PropTech

Singapore is building a Smart Nation from the ground up. The Strategic National Projects (Diagram 4) are examples of the building blocks for bringing sustainability to life.

Punggol Smart Town*
Bringing together residents, businesses and students, Punggol is slated to become a thriving, tech-enabled, sustainable town showcasing our Smart Nation ambitions.

Smart Nation Sensor Platform*
SNSP is an integrated, nationwide platform that uses sensors to collect essential data that can be analysed to create smart solutions.

Automated Meter Reading
From tap to app, we're making water usage data readily accessible for our residents so they can better manage their water consumption and bills.

OneService App
A convenient, one-stop platform for the public to report issues they come across in their neighbourhoods.

OneService Chatbot
The Chatbot guides residents to provide the relevant information, in real-time conversational manner, to ensure that feedback is comprehensively logged.

Smart Urban Planning
Tech helps urban planners better make use of our limited land to create sustainable, quality spaces for working and living in Singapore.

Smart Towns
We're using technology to plan, develop and manage HDB towns to create more efficient, sustainable and safe living environments for our people.

Diagram 4 List of Strategic National Projects
Source: <https://www.smartnation.gov.sg/initiatives/urban-living>

Under the Smart Towns Initiatives, residents are expected to reduce electricity bills by the following:

1. Smart lighting

HDB can collect data on human-movement patterns by adding sensors and anticipatory software to lighting in common spaces. Urban planners will subsequently be able to reduce lighting in regions with little or no human traffic at various periods of the day to save electricity.

2. SolarNova

SolarNova is a program that promotes solar energy. HDB had gradually installed 220 MWp of solar panels throughout 5,500 HDB blocks under this initiative in 2019, providing 350 MWp of solar power from solar photovoltaic (PV) systems alone.

This amount is the equivalent of solar energy powering 82,500 four-room flats, lowering carbon emissions by 198,000 tonnes each year.³⁸ Since then, a new solar target of 540 MWp by 2030 has been declared, which could generate 648 GWh of green energy annually. It also aligns us with HDB's Green Towns Program, which aims to introduce

renewable energy to all HDB towns.

3. Waste-conveyance system using pneumatics

This automated garbage-collection system collects and transports home waste to a sealed container through underground pipes using a vacuum-type underground pipe network. Waste is collected by trucks on a regular basis for disposal. The smart towns or homes are mostly located at Punggol Town and North Shore Residence I&II.

Below are a couple of other examples of proptech startups that are trying to make the built environment more sustainable and are listed in the “Top 20 Hottest Startups” by Singapore Business Review:³⁹

1. Smarten Spaces

Founders: Dinesh Malkani, Anushka Verghese, and Prithvi (Harkirat Singh) Shergill

Funding: Smarten Spaces raised a total of S\$17.13 million (US\$12 million) in a series A funding in November 2019, with Symphony International Holdings as its leading investor.

Start of operations: 2017

Smarten Spaces began in 2017 with the goal of digitizing spaces for businesses, commercial real estate, coworking, coliving, and warehousing. It leverages AI and IoT technology to help businesses engage their renters and employees, as well as successfully manage spaces. The system includes a fully integrated mobile app that allows end users to complete daily chores with ease. Booking meeting spaces, ordering food, navigating, booking flexible seats, securely inviting visitors, and community participation are just a few examples. The complete technology platform for space management from Smarten Spaces includes full AI capabilities and over 100 reports. It has had considerable success in the US, Singapore, and India.

2. Gush

Founders: Lester Leong, Ryan Lim

Funding: Gush raised S\$3 million (US\$2.1 million) in July 2019 from property group City Developments Limited (CDL).

Start of operations: 2017

Gush, a Singapore-based firm, is developing environmentally friendly paints and sophisticated construction materials to help avoid health problems caused by indoor air pollution. The company’s main product is believed to clean the air by removing 99.9% of bacteria, manage humidity, and prevent mold. It also emits negative ions, which have health benefits such as neutralizing free radicals and increasing blood circulation. Gush paints have been utilized in over 600 residential and 60 commercial projects in Singapore and the area to date, with the majority of delivery rooms in Thomson Medical sporting its logo.

4. Opportunities

Singapore has not provided a target year for reaching net-zero emission, because it faces the challenges of space limitations on land to pursue solutions such as hydro, nuclear, and solar power. One way to solve the solar capacity issues is to use a floating solar photovoltaic system. While solar installations in Singapore continue to grow, its share of the overall electricity mix remains as low as 3%, despite strong policy support. A new Singapore–Australia Green Economy Agreement is expected to reduce

carbon emissions and improve existing areas of cooperation, including renewable energy and the adoption of low-carbon and green technologies.⁴⁰ Temasek and BlackRock, the world’s largest asset manager, will co-found a series of venture capital and private equity investment funds to help achieve net-zero goals around the world. Temasek is willing to serve as a bridge to encourage the progressive establishment of carbon markets in China and the rest of the world, as well as to stabilize the carbon-pricing mechanism.⁴¹

Singapore, as a city-state and an island, faces unique obstacles such as limited space for renewable-energy generation and a large manufacturing sector, as well as serving as a maritime, aviation, and tourism hub. Around three quarters of all industrial emissions come from oil and gas refining and petrochemical processing.⁴² Even though Singapore faces such challenges, it can turn its natural limitations such as lack of land, water, and natural resources into possibilities by focusing on establishing capabilities, utilizing technology and innovation, and being relevant to global value chains. Research on how to build an island economy as a sustainable nation is worth discussing because the experience of Singapore will be helpful to economies such as Denmark. For instance, Singapore may look at moving more transportation and utility infrastructure, as well as storage facilities, underground. An underground goods-mover system to reduce freight transit on roadways,⁴³ underground electrical substations, and rock caves for storm-water drainage and storage to strengthen water resilience are just a few examples that should be considered.

Pricing emitting carbon is a powerful tool for mitigating emissions. However, because carbon credits aren’t a standardized commodity, like gold or oil, the market values credits from different projects differently. Buyers tend to pay a premium for credits that come from more verifiable and credible projects, as well as those that provide co-benefits, such as community economic development and biodiversity conservation, within the sector of nature-based carbon credits — generated from projects that conserve and restore carbon-sequestering ecosystems.⁴⁴ The basis of the problem is a lack of reliable carbon-measurement technology and procedures. Scope 3 carbon emissions are indirect emissions, which are difficult to detect and manage. Relying on voluntary carbon markets alone won’t suffice without appropriate technology to measure.⁴⁵

About the Author



Shao Lan Wang

Shaolan is currently an MSRED student at MIT. She received a Bachelor of Commerce degree in Finance from McGill University in 2015 and an MSc in Real Estate Economics and Finance from the London School of Economics and Political Science in 2016. Upon graduation, Shaolan joined Vanke, a leading developer in China, as a management trainee. At MIT, Shaolan aspires to fill her knowledge gaps in engineering, design, and technology. She is also passionate about expanding her professional footprint to infrastructure investing, prop-tech, and smart city solutions to achieve sustainable urbanization.

Notes

Chapter 1.

1. <http://www.statista.com/statistics/1096511/share-of-real-estate-investment-europe-by-sector>
2. <https://dividend.asia/european-reits/>
3. <https://dividend.asia/european-reits/>
4. Among the EU member countries, the percentage keeps fluctuating from 0.4% to 1.2%. Source: https://ec.europa.eu/info/news/focus-energy-efficiency-buildings-2020-feb-17_en
5. https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en
6. <https://www.consilium.europa.eu/en/policies/green-deal/>
7. https://ec.europa.eu/clima/eu-action/european-green-deal/european-climate-law_en
8. "A directive is a legal act of the European Union[1] that requires member states to achieve a particular result without dictating the means of achieving that result. Directives first have to be enacted into national law by member states before their laws are ruling on individuals residing in their countries.[2] Directives normally leave member states with a certain amount of leeway as to the exact rules to be adopted. Directives can be adopted by means of a variety of legislative procedures depending on their subject matter."
Source: [https://en.wikipedia.org/wiki/Directive_\(European_Union\)](https://en.wikipedia.org/wiki/Directive_(European_Union))
9. <https://find-energy-certificate.digital.communities.gov.uk/>
10. <https://gov.wales/written-statement-energy-efficiency-measures-all-new-homes>
11. https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/european-green-bond-standard_en
12. https://prodapp.epra.com/media/EPRA_Report_Green_Bonds_Monitor_2021_1632309134056.pdf
13. https://prodapp.epra.com/media/EPRA_Report_Green_Bonds_Monitor_2021_1632309134056.pdf
14. https://prodapp.epra.com/media/EPRA_Report_Green_Bonds_Monitor_2021_1632309134056.pdf
15. https://www3.weforum.org/docs/WEF_Case_study_Extensa_Brussels_2022.pdf
16. https://www3.weforum.org/docs/WEF_Case_study_Enel_Turin_2022.pdf
17. <https://www.fastcompany.com/1752595/greenest-skyscrapers-world>
18. <https://www.smartcitiesdive.com/ex/sustainablecitiescollective/germany-micro-algae-facade-will-power-net-zero-house/82046/>
19. https://www.researchgate.net/figure/Net-Zero-Energy-Buildings-Cluster-Plus-energy-settlement-in-Freiburg-DE-design-Rolf_fig2_271522787

Chapter 2.

1. The total value of Global Real Estate. Savills, from <https://www.savills.com/impacts/market-trends/the-total-value-of-global-real-estate.html>, Paul Tostevin, September 2021
2. 2021 U.S. GDP by industry, Forbes, from <https://www.forbes.com/sites/andrewdepietro/2021/08/23/2021-us-gdp-by-industry/?sh=7838b5e86970>, Andrew DePietro, August 23, 2021
3. Canadian real estate provided over 10% of GDP growth, Better Dwelling, from <https://betterdwelling.com/canadian-real-estate-provided-over-10-of-gdp-growth/>, December 29, 2021
4. Canada real GDP by industry: Real estate and rental and leasing, from https://ycharts.com/indicators/canada_real_gdp_by_industry_real_estate_and_rental_and_leasing
5. Canada Is Now 50% More Dependent On Housing Than The US At Peak Bubble, Better Dwelling, from <https://betterdwelling.com/canada-is-now-50-more-dependent-on-housing-than-the-us-at-peak-bubble/>, June 1, 2021
6. Real Estate Investment Market 2020/21, MSCI, from <https://real-estate-find.com/combining-as-part-of-real-estate-enterprise/>
7. 2020 getting to Zero buildings list, New Buildings Institute, from https://newbuildings.org/wp-content/uploads/2020/09/NBI_GTZ-_List_2020.pdf
8. 2020 getting to Zero buildings list, New Buildings Institute, from https://newbuildings.org/wp-content/uploads/2020/09/NBI_GTZ-_List_2020.pdf
9. Source: National Energy Code of Canada for buildings building, from <https://www.calgary.ca/pda/pd/green-building/national-energy-code-of-canada.html>
10. Source: International code council launches "code on a mission" challenge urging adoption of modern energy efficiency codes, ICC, from <https://www.iccsafe.org/about/periodicals-and-newsroom/international-code-council-launches-code-on-a-mission-challenge-urging-adoption-of-modern-energy-efficiency-codes/>, July 27, 2021
11. Source: America 2021: Renewing the nation's commitment to climate action, McKinsey & Company, from <https://www.mckinsey.com/business-functions/sustainability/our-insights/america-2021-renewing-the-nations-commitment-to-climate-action>, Dickon Pinner and Matt Rogers, March 3, 2021
12. Elements of RGGI. RGGI, Inc., from <https://www.rggi.org/program-overview-and-design/elements>
13. Existing building electrification, City of Sacramento, from http://www.cityofsacramento.org/Community-Development/Planning/Major-Projects/General-Plan/About-The-Project/Climate_Change/Existing-Building-Electrification
14. Electrification of new construction, City of Sacramento, from <http://www.cityofsacramento.org/SacElectrificationOrdinance>
15. Climate Action in Davis. City of Davis, from <https://www.cityofdavis.org/city-hall/community-development-and-sustainability/sustainability-program/climate-change>

16. Portland Zero Cities Project Report, from <https://static1.squarespace.com/static/57bf2cf2beba692dd3505c/t/5ff258410493bd282756a674/1609717835001/Zero+Cities+Report.pdf>
17. Climate Emergency Declaration One-Year Progress Report (Resolution No.37494), The Bureau of Planning & Sustainability, from https://www.portland.gov/sites/default/files/council-documents/2021/exhibita_ced_final_report_0.pdf, July 29, 2021
18. History and key documents of Climate Planning and action in Portland, Portland.gov, from <https://www.portland.gov/bps/climate-action/history-and-key-documents>
19. New York City is banning natural gas hookups for new buildings to fight climate change, CNBC, from <https://www.cnbc.com/2021/12/15/new-york-city-is-banning-natural-gas-hookups-for-new-buildings.html>, Emma Newburger, December 15 2021
20. Cities on the path to Zero. Zero Energy Project, from <https://zeroenergyproject.org/advocate/cities-on-a-path-to-zero/>, September 29 2019
21. Boston Enacts Building Decarbonization Ordinance, Smart Cities Dive, from <https://www.smartcitiesdive.com/news/boston-building-decarbonization-climate-change-ordinance/607471/>, Scott Pruden, October 6, 2021
22. Source: How will austin's climate plan reach zero greenhouse gas emissions by 2040, KXAN Austin, from <https://www.kxan.com/news/local/austin/how-will-austins-climate-plan-reach-zero-greenhouse-gas-emissions-by-2040/>, Kelsey Thompson, October 1 2021
23. Source: Zero emissions building plan - vancouver, from <https://vancouver.ca/files/cov/zero-emissions-building-plan.pdf>, July 12 2016
24. Source: ZERO EMISSIONS BUILDINGS FRAMEWORK, from <https://www.toronto.ca/wp-content/uploads/2017/11/9875-Zero-Emissions-Buildings-Framework-Report.pdf>, March 2017
25. Source: Americas Investor Intention Survey 2021, CBRE, from http://cbre.vo.llnwd.net/grgservices/secure/AMS%20IIS%202021_Report.pdf?e=1641576428&h=76e1512169fdf95fdc63d047c6fe0e90
26. Source: 2021 Institutional Real Estate Allocations Monitor, Hodes Weill & Associates and the Cornell Baker Program in Real Estate, from https://5f4e89a9-4c6c-44a4-b3f3-9fb2b125ff9e.filesusr.com/ugd/abfec0_0576c6d1cc264004aef377252ff4f068.pdf
27. Source: 2021 Institutional Real Estate Allocations Monitor, Hodes Weill & Associates and the Cornell Baker Program in Real Estate, from https://www.origoinvestments.com/files/pensionfund-cre-article_bisnow_05.21.pdf
28. Source: Why real estate investors can make a real difference to climate change, from <https://www.schroders.com/en/middle-east/professional-investor/insights/markets/why-real-estate-investors-can-make-a-real-difference-to-climate-change/>, Kristina Foster, August 16 2021
29. Source: ESG and Real Estate: The top 10 things investors need to know, CBRE, from <https://www.cbre.com/insights/reports/esg-and-real-estate-the-top-10-things-investors-need-to-know#environmental>, October 18, 2021
30. Source: 3 reits ESG investors should consider, Millionacres, from <https://www.millionacres.com/real-estate-investing/articles/3-reits-esg-investors-should-consider/>, Matthew DiLallo, October 28, 2021
31. Source: 3 reits ESG investors should consider, Millionacres, from <https://www.millionacres.com/real-estate-investing/articles/3-reits-esg-investors-should-consider/>, Matthew DiLallo, October 28, 2021
32. Source: 3 reits ESG investors should consider, Millionacres, from <https://www.millionacres.com/real-estate-investing/articles/3-reits-esg-investors-should-consider/>, Matthew DiLallo, October 28, 2021
33. Source: The Greening of CRE Bonds, Multifamily Real Estate News, from <https://www.multihousingnews.com/the-greening-of-cre-bonds/>, Anca Gagiuc, November 5, 2021
34. Source: Record \$269.5bn green issuance for 2020: Late surge sees pandemic year pip 2019 total by \$3BN, Climate Bonds Initiative, from <https://www.climatebonds.net/2021/01/record-2695bn-green-issuance-2020-late-surge-sees-pandemic-year-pip-2019-total-3bn>, Liam Jones, January 24, 2021
35. Source: Guess who's the world's largest issuer of green bonds? Investable Universe, from <https://investableuniverse.com/2021/06/16/fannie-mae-multifamily-green-bond-issuance/>, June 16, 2021
36. The Greening of CRE Bonds, Multifamily Real Estate News, from <https://www.multihousingnews.com/the-greening-of-cre-bonds/>, Anca Gagiuc, November 5, 2021
37. 2021 U.S. Green Bank Annual Industry Report, American Green Bank Consortium, from <https://static1.squarespace.com/static/59bc05f0c534a543a9f96b0d/t/609a872db219bc4ce685a281/1620739886886/2021+Annual+Industry+Report+Final.pdf>, May 2021
38. Source: Net-zero transition gains momentum in real estate as commitments grow, from <https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/net-zero-transition-gains-momentum-in-real-estate-as-commitments-grow-67186012>, Pam Rosacia, October 25, 2021
39. Source: Boston Properties announces new ESG achievements and initiatives; commits to carbon neutral operations by 2025 and Establishes Board of Directors Sustainability Committee, Business Wire, from <https://www.businesswire.com/news/home/20210422005343/en/>, April 22, 2021
40. Source: Equinix sets 2030 global climate-neutral target, from <https://www.equinix.com/newsroom/press-releases/2021/06/equinix-sets-2030-global-climate-neutral-target>, June 16, 2021
41. Source: Marriott International announces ambition to go net-zero, Marriott International Newscenter (US), from <https://news.marriott.com/news/2021/09/22/marriott-international-announces-ambition-to-go-net-zero>, September 22, 2021
42. Source: 2020 ENVIRONMENTAL, SOCIAL AND GOVERNANCE REPORT, from http://platform.mi.spglobal.com/Interactive/newlookandfeel/103054/Equity_Residential_ESG_Report_2020_Final.pdf
43. Source: Executive summary: Prologis 2020 Sustainability Report, from <https://www.prologis.com/sites/corporate/files/documents/2021/09/2020-sustainability-report-executive-summary.pdf>
44. Source: Kimco Realty strives for net-zero emissions by 2050. Smart Energy Decisions, from <https://www.smartenergydecisions.com/news/2021/02/19/kimco-realty-strives-for-net-zero-emissions-by-2050>, February 19, 2021
45. Source: 2019 CORPORATE RESPONSIBILITY REPORTFUTURESUSTAINABLE, from <https://p.widencdn.net/dt2xtc/Kimco-2019-CR-Report-FINAL>
46. Source: ESG goals. Ventas, from <https://www.ventasreit.com/corporate-responsibility/esg-goals>
47. Source: Dream to deploy CIB funds for deep retrofits, REMI Network, from <https://www.reminetwork.com/articles/dream-to-deploy-cib-funds-for-deep-retrofits/>, December 1, 2021
48. Source: Net zero by 2030? companies are taking the pledge, The Globe and Mail, from <https://www.theglobeandmail.com.cdn.ampproject.org/c/s/www.theglobeandmail.com/amp/business/industry-news/property-report/article-net-zero-by-2030-companies-are-taking-the-pledge/>, Wallace Immen, November 2, 2021

49. Source: Iron Mountain announces 20 new sustainability focused goals as part of their commitment to secure a sustainable future, Iron Mountain, from <https://www.ironmountain.com/about-us/newsroom/press-releases/2021/may/iron-mountain-announces-20-new-sustainability-focused-goals-as-part-of-their-commitment-to-secure-a-sustainable-future>, May 6, 2021

50. Source: Weyerhaeuser receives highest designation for its greenhouse gas reduction targets, from <https://www.prnewswire.com/news-releases/weyerhaeuser-receives-highest-designation-for-its-greenhouse-gas-reduction-targets-301448478.html>, December 20, 2021

51. Source: Climate tech for real estate, from <https://kleinmanenergy.upenn.edu/wp-content/uploads/2021/03/KCEP-Climate-Tech-for-Real-Estate.pdf>, Stephen Rothstein, March 2021

52. Source: Climate tech for real estate, from <https://kleinmanenergy.upenn.edu/wp-content/uploads/2021/03/KCEP-Climate-Tech-for-Real-Estate.pdf>, Stephen Rothstein, March 2021

53. Source: 2020 GLOBAL STATUS REPORT FOR BUILDINGS AND CONSTRUCTION. Global Alliance for Buildings and Construction, from https://globalabc.org/sites/default/files/inline-files/2020%20Buildings%20GSR_FULL%20REPORT.pdf

54. Source: Zero homes are comparable in cost to standard homes, Zero Energy Project, from <https://zeroenergyproject.org/sell/zero-homes-comparable-cost-standard-homes/>

55. Source: Zero Energy Modular Affordable Housing initiative, Mass.gov, from <https://www.mass.gov/service-details/zero-energy-modular-affordable-housing-initiative>

56. Source: Zero energy buildings in Massachusetts: Saving money from the start, Built Environment Plus, from <https://builtenvironmentplus.org/zero-energy-buildings/>

57. Source: Canada and FCM announce support for energy efficient affordable housing, Government of Canada, from <https://www.canada.ca/en/natural-resources-canada/news/2021/11/canada-and-fcm-announce-support-for-energy-efficient-affordable-housing.html>, November 30, 2021

Chapter 3.

1. <https://www.propertycouncil.com.au/>
2. https://cdn2.hubspot.net/hubfs/2095495/_Industry%20Campaign/REPORTS/ECONOMIC%20SIGNIFICANCE%20OF%20THE%20PROPERTY%20INDUSTRY%20TO%20THE%20AUSTRALIAN%20ECONOMY%20-%20FULL%20REPORT.pdf
3. <https://www.statista.com/statistics/737744/australia-new-residential-buildings-work-value/>
4. <https://www.statista.com/statistics/1051916/australia-commercial-building-activity-value/>
5. <https://www.statista.com/study/75188/commercial-property-in-australia/>
6. https://cdn2.hubspot.net/hubfs/2095495/_Industry%20Campaign/REPORTS/ECONOMIC%20SIGNIFICANCE%20OF%20THE%20PROPERTY%20INDUSTRY%20TO%20THE%20AUSTRALIAN%20ECONOMY%20-%20FULL%20REPORT.pdf
7. <https://www.businesswire.com/news/home/20211103005289/en/New-Research-From-Procure-and-Property-Council-of-Australia-Examines-COVID-19-Impact-Reveals-Digital-Investment-Needed-to-Drive-Growth>
8. <https://www.commercialrealestate.com.au/news/afr-property-summit-looks-to-the-future-of-commercial-real-estate-1107743/>
9. <https://www.abs.gov.au/media-centre/media-releases/value-residential-dwellings-passes-9-trillion>
10. <https://www.bbc.com/news/world-australia-57925798>
11. <https://www.industry.gov.au/sites/default/files/October%202021/document/australias-long-term-emissions-reduction-plan.pdf>
12. <https://www.reuters.com/business/cop/australia-unveil-2050-net-zero-target-ahead-un-climate-summit-2021-10-26/>
13. <https://ncc.abcb.gov.au/>
14. <https://www.cnn.com/2021/10/25/australia/australia-climate-net-zero-intl/index.html>
15. <https://www.nathers.gov.au/governance/national-construction-code-and-state-and-territory-regulations>
16. <https://www.nsw.gov.au/media-releases/nsw-set-to-halve-emissions-by-2030>
17. <https://www.news.com.au/technology/environment/nsw-reveals-new-target-to-reduce-emissions-by-50-per-cent-by-2030/news-story/433a917f75b37a4f3d54f2a3ed91daa9change.vic.gov.au/victorias-greenhouse-gas-emissions-reduction-targets>
18. <https://citiespowerpartnership.org.au/2021/12/20/net-zero-how-are-australian-councils-playing-their-part/>
19. <https://www.cityofsydney.nsw.gov.au/surveys-case-studies-reports/planning-for-net-zero-energy-buildings>
20. <https://www.melbourne.vic.gov.au/sitecollectiondocuments/climate-change-mitigation-strategy-2050.pdf>
21. <https://www.melbourne.vic.gov.au/about-council/vision-goals/ecocity/climate-change/Pages/taking-action-climate-change.aspx>
22. <https://participate.melbourne.vic.gov.au/amendment-c376>
23. <https://iopscience.iop.org/article/10.1088/1755-1315/140/1/012106>
24. https://www.propertycouncil.com.au/downloads/prop-significance/AUS_Full.pdf
25. https://www.energymining.sa.gov.au/__data/assets/pdf_file/0019/315415/NEEBP-final-report-November-2014.pdf
26. <https://thefifthestate.com.au/innovation/rating-tools/building-passports-could-help-repair-australias-energy-efficiency-bane/>

27. <https://www.cityofsydney.nsw.gov.au/surveys-case-studies-reports/planning-for-net-zero-energy-buildings>

28. https://responsibleinvestment.org/wp-content/uploads/2018/08/RIAA_RI_Renchmark_Report_AUS_2018v6.pdf

29. <https://www.pinsentmasons.com/out-law/guides/net-zero-carbon-real-estate-finance>

30. http://cbre.vo.llnwd.net/grgservices/secure/CBRE-Market-Outlook-2021_CAPITAL-MARKETS.pdf?e=1641521719&h=b-fa0fe2d1d783522e8168e2becb4bc5b

31. <https://www.cbre.com.au/about/content-feeds/expert-opinions/articles/socially-conscious-investors-embrace-green-loans>

32. https://www.vicinity.com.au/media-centre/media-and-news/190807_net-zero-carbon-emissions-by-2030

33. <https://www.ampcapital.com/content/dam/capital/02-global-files-only/02-esg-resources/AMP-Capital-2030-Real-Estate-Sustainability-Strategy-Brochure.pdf>

34. <https://www.lendlease.com/us/media-center/media-releases/lendlease-property-funds-ranked-most-sustainable-in-australia/>

35. See <https://www.gpt.com.au/sustainability/environment> for more performance data. for 2020 GPT Sustainability report: <https://www.gpt.com.au/sites/default/files/2021-04/GPT%20Sustainability%20Report%202020.pdf>

36. <https://www.apra.gov.au/news-and-publications/apra-releases-guidance-on-managing-financial-risks-of-climate-change>

37. <https://www.pinsentmasons.com/out-law/guides/net-zero-carbon-real-estate-finance>

38. <https://www.climatebonds.net/resources/press-releases/2020/10/launch-australia-new-zealand-green-loans-report>

39. <https://www.afr.com/property/commercial/lendlease-raises-500m-in-green-bond-debut-20201021-p5671t>

40. <https://www.frasersproperty.com.au/media-centre/news/2019/04/04/fpa-first-syndicated-green-loan-australia>

41. <https://www.investa.com.au/news-and-media/news/2019/investa-commercial-property-fund-closes-first-aust>

42. <https://westpaciq.westpac.com.au/Article/42278>

43. <https://www.cbre.com.au/about/content-feeds/expert-opinions/articles/socially-conscious-investors-embrace-green-loans>

44. <https://worldgbc.org/news-media/australia-and-new-zealand-lead-world-green-building>

45. <https://thefifthestate.com.au/innovation/commercial/australia-leads-gresbs-real-asset-esg-rankings-for-11th-straight-year/>

46. <https://www.afr.com/property/commercial/sustainability-wins-for-listed-property-trusts-20211014-p5900a>

47. <https://thefifthestate.com.au/columns/news-from-the-front-desk/on-city-councils-and-the-race-to-net-zero/>

48. <https://www.realcommercial.com.au/news/the-solar-skin-on-a-melbourne-tower-could-lead-the-way-in-sustainability>

49. <https://www.dfat.gov.au/news/news/Pages/asean-australia-collaboration-on-smart-and-sustainable-city-development>

50. <https://www.worldgbc.org/news-media/australia-steps-challenge-decarbonise>

51. <https://www.worldgbc.org/news-media/australia-steps-challenge-decarbonise>

52. <https://www.dezeen.com/2020/07/08/shop-architects-and-bvn-design-worlds-tallest-hybrid-timber-tower-for-atlassian-in-sydney/>

53. <https://www.afr.com/property/commercial/sydney-super-site-to-house-1-8b-eco-tower-to-rival-atlassian-s-20211124-p59blx#:~:text= TrueGreen%20Positive%20Impact%20Group%20has,marquee%20green%20tower%E2%80%9D%20by%202026.>

Chapter 4.

1. "Demographics of China". Wikipedia
2. "China's urban explosion: A 21st century challenge". CNN. Jaime A. FlorCruz. Jan 20, 2012.
3. Our world in data
4. Global Carbon Atlas
5. "The \$52 Trillion Bubble: China Grapples With Epic Property Boom". The Wall Street Journal. Stella YiFan Xie, Mike Bird. Jul 16, 2020.
6. "Evergrande and the end of China's 'build, build, build' model". Financial Times . James Kyngge, Sun Yu. Sep 21, 2021.
7. "Introduction to SI: Homeownership and housing divide in China." Cities (London, England). Youqin Huang. Jan 2021.
8. "Quarterly Residential Vacancies and Homeownership, Third Quarter 2021". The U.S. Census Bureau. Nov 2 2021.
9. "China's Huge Number of Vacant Apartments Is Causing a Problem". Bloomberg. Linda Poon. Feb 27 2019.
10. "China Commercial Real Estate Market, By Property Type (Offices, Logistics, Industrial, Retail, Hotels, and Multifamily) - Trends, Analysis and Forecast till 2029". PMI. Nov 2019.
11. "Commercial Real Estate in China". IBISWorld. Jan 2022
12. China Building Energy Consumption Research Report. The China Building Energy Conservation Association, 2020
13. "The country builds a 'new London' every year". BBC. Cici Zhang. Jun 11, 2020.
14. "Greater China 2030". CBRE. 2020
15. Action Plan for Carbon Dioxide Peaking Before 2030. The State Council, China's cabinet. 2021
16. 2020 China Real Estate Listed Companies ESG Report Measurement Study. China Index Academy. 2020
17. International Forum: Low Carbon City Shenzhen China.
18. China Is Investing \$13 Trillion in Construction. Will It Pursue Zero Carbon Buildings? World Resources Institute. 2019.
19. Climate Investment Opportunities in Emerging Markets. An IFC Analysis. IFC. 2019.
20. Investing in Zero-Carbon China Opportunities from China's Carbon-Neutrality Goal. RMI. 2021

Chapter 5.

1. Indian Real Estate, Indian Brand Equity Foundation, 2020, <https://www.ibef.org/download/Real-Estate-June-2020.pdf>
2. Role of Green Buildings in Sustainable Constructions, Tathagat & Dod, 2015
3. Census 2011, <https://censusindia.gov.in/2011-Common/Archive.html>
4. Cushman & Wakefield, 2021, Growing confidence of institutional investors in office real estate in India
5. <https://www.knightfrank.com/research/article/2021-09-29-the-search-for-sustainably-led-cities>
6. <https://www.bbc.com/news/world-asia-india-59125143>
7. <https://www.reuters.com/business/cop/india-says-net-zero-target-date-carbon-emissions-not-solution-2021-10-27/>
8. <http://www.indiaenvironmentportal.org.in/files/file/DRAFT-India%20Cooling%20Action%20Plan.pdf>
9. <https://www.worldgbc.org/news-media/india-stacks-3-billion-square-feet-green-building-space>
10. <https://www.theclimategroup.org/our-work/press/43-cities-and-urban-clusters-maharashtra-join-race-zero-ultratech-cement-joins-re100>
11. <https://www.deccanherald.com/opinion/main-article/decentralise-for-net-zero-bengaluru-957847.html>
12. https://beeindia.gov.in/sites/default/files/BEE_Final%20Report_Web-site%20version.pdf
13. <http://www.environmentwb.gov.in/pdf/EIA%20Notification,%202006.pdf>
14. <https://www.nrdc.org/sites/default/files/india-construc-tion-change-report.pdf>
15. <https://beeindia.gov.in/sites/default/files/VCFEE.PDF>
16. <https://www.ireda.in/swhs-capital-subsidy-scheme>
17. <https://pressroom.ifc.org/all/pages/PressDetail.aspx?ID=26537>
18. https://beeindia.gov.in/sites/default/files/PRGFEE_0.pdf
19. <https://www.forbesindia.com/article/sustainability-special/green-bonds-sustainable-bonds-demand-picks-up-in-india-in-the-pandemic-era/68141/1>
20. https://www.undp.org/content/dam/india/docs/energy_efficiency_improvements_in_commercial_buildings_factsheet_project.pdf
21. <http://cberd.org/>
22. <https://dst.gov.in/sites/default/files/Communique.pdf>
23. <https://www.usgbc.org/articles/teri-and-usgbc-join-forces-promote-high-performance-buildings-india>

Chapter 6.

1. <https://www.worldbank.org/en/country/thailand/overview#1>
2. <https://climateknowledgeportal.worldbank.org/country/thailand>
3. https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/unpd_egm_201902_s3_vipanprachuabmoh.pdf
4. https://iclei.org/en/members-search.html?search_query=thailand
5. <https://migrants-refugees.va/country-profile/thailand/#:~:text=Thailand%20has%20attracted%20an%20estimated,and%20irregular%20cross%2Dborder%20activities>
6. <https://www.krungsri.com/en/research/industry/industry-outlook/Real-Estate/Housing-in-BMR/IO/io-housing-in-BMR-21>
7. <https://startupinthailand.com/thailand-industries/real-estate-industry/>
8. <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Thailand%20First/Thailand%20Updated%20NDC.pdf>
9. <https://enviliance.com/regions/southeast-asia/th/th-ghg>
10. https://germanwatch.org/sites/default/files/Global%20Climate%20Risk%20Index%202021_2.pdf
11. https://climateknowledgeportal.worldbank.org/sites/default/files/2021-08/15853-WB_Thailand%20Country%20Profile-WEB_0.pdf
12. <https://storymaps.arcgis.com/stories/6a890abfd3d0470aa78c4cc-006cd1502>
13. <https://storymaps.arcgis.com/stories/6a890abfd3d0470aa78c4cc-006cd1502>
14. <https://countryeconomy.com/energy-and-environment/co2-emissions/thailand>
15. <https://climateactiontracker.org/countries/thailand/policies-action/>
16. <https://www.mdpi.com/1996-1073/14/9/2571/htm>
17. <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Thailand%20First/Thailand%20Updated%20NDC.pdf>
18. <https://www.iea.org/articles/putting-a-price-on-carbon-an-efficient-way-for-thailand-to-meet-its-bold-emission-target>
19. "Thai's Rating of Energy and Environmental Sustainability for New Construction and Major Renovation for Core and Shell Building." Thai Green Building Institute (TGBI). 2014
20. <http://www.oxfordbusinessgroup.com/news/thailand-setting-standard-green-building-incentives>
21. "Economic Analysis of Energy Conservation Building with Floor Area Ratio Bonus." Chulalongkorn University. 2013
22. <https://enviliance.com/regions/southeast-asia/th/th-ghg>
23. <https://sciencebasedtargets.org/companies-taking-action?ambition-Toggle=1#table>
24. <https://www.scg.com/pdf/en/SD2020HL.pdf>
25. <https://www.bangkokpost.com/property/2267863/resilient-cpn-records-profit-of-b7-1bn>
26. <https://www.thailand-business-news.com/press-release/86336-real-estate-in-thailand-on-the-way-to-a-sustainable-architecture.html>
27. <http://unxp.asia/work/pruksa-house/>
28. <https://climateactiontracker.org/countries/thailand/>
29. <https://www.theclimategroup.org/under2-coalition>
30. <https://unfccc.int/climate-action/race-to-zero-campaign>
31. https://www.irena.org/-/media/files/irena/agency/publication/2017/nov/irena_outlook_thailand_2017.pdf

Chapter 7.

1. <https://www.oecd-ilibrary.org/sites/ded0e64c-en/index.html?itemId=/content/component/ded0e64c-en>
2. https://en.wikipedia.org/wiki/Administrative_divisions_of_South_Korea
3. https://en.wikipedia.org/wiki/List_of_cities_in_South_Korea_by_population
4. CBRE Research, Korea Real Estate Market Outlook, 2021
5. <https://www.joneslanglasalle.com.cn/en/trends-and-insights/investor/south-korea-ramps-investment-real-estate-debt>
6. Park, Cho Hae. "An Analysis of Indirect Real Estate Investments in South Korea." Massachusetts Institute of Technology, 2020.
7. https://www.theglobaleconomy.com/South-Korea/Energy_imports/
8. https://iea.blob.core.windows.net/assets/90602336-71d1-4ea9-8d4f-efeeb24471f6/Korea_2020_Energy_Policy_Review.pdf
9. <https://library.e.abb.com/public/4b7048c-c6853105ac12579e600395e15/South%20Korea%20Energy%20efficiency%20Report.pdf#:~:text=The%20Korean%20Energy%20Management%20Corporation%20%28KEMCO%29%2C%20created%20in,Certification%20Program%20%281996%29%20and%20the%20E-Standby%20Program%20%281999%29>
10. <http://extwprlegs1.fao.org/docs/pdf/kor100522.pdf>
11. NLCI, Korea 2020 Energy Policy Review, 2010
12. <https://www.etrans.or.kr/ebook/05/files/assets/common/downloads/Third%20Energy%20Master%20Plan.pdf>
13. NLCI, Korea 2020 Energy Policy Review, 2010
14. Reducing Korea's total final energy consumption by 14.4% in 2030 compared to a business-as-usual level, equivalent to 29.6 Mtoe of energy saved, and improve energy intensity by 27.4% compared with the 2017 level of 0.113 toe/KRW million.
15. [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690693/EPRS_BRI\(2021\)690693_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690693/EPRS_BRI(2021)690693_EN.pdf)
16. <https://www.spglobal.com/platts/en/market-insights/latest-news/energy-transition/090221-south-korea-approves-bill-mandating-carbon-neutrality-by-2050>
17. Formerly named the Ministries of Environment and Construction and Transportation when G-SEED was initially put forward.
18. The energy independence rate equals to primary energy production per unit floor area (kWh/m²-year) divided by primary energy consumption per unit floor area (kWh/m²-year) .
19. Ministry of Land, Infrastructure and Transport, Ministry of Trade, Industry and Energy, Korea Energy Agency, Zero Energy Building, 2020
20. <https://smartcity.go.kr/en/>
21. <https://www.seoulsolution.kr/en/content/2030-seoul-plan>
22. This plan has been revised in 2019 by the Seoul Metropolitan Government. Among all the sectors covered in this plan, "environment, safety and energy" is one of the five main goals.
23. <https://english.seoul.go.kr/policy/urban-planning/urban-planning/1-2030-seoul-basic-urban-plan/>
24. <http://book.busan.go.kr/Viewer/X8MX002YEARM>
25. <https://www.daegu.go.kr/index.do>
26. https://www.cbrekorea.com/en/about/media-centre/korea_investor_intentions_survey_2021
27. ets.krs.co.kr
28. https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=47
29. <https://www.bloomberg.com/news/articles/2020-08-13/korea-over-takes-china-as-biggest-sustainable-debt-seller-in-asia>
30. William Grimes, Yaechan Lee, Assessing South Korea's Role in Promoting ESG Investing in the Asia-Pacific, 2021, Korea Economic Institute of America, United States
31. Climate Bonds Initiative, Korea Climate Bond Market Overview and Opportunities, 2018, <https://www.climatebonds.net/resources/reports/korea-climate-bond-market-overview-and-opportunities>
32. <http://www.koreaherald.com/view.php?ud=20210812000717>
33. <https://smartcity.go.kr>
34. Leem Y., Han H., Lee S.H. (2019) Sejong Smart City: On the Road to Be a City of the Future. In: Geertman S., Zhan Q., Allan A., Pettit C. (eds) Computational Urban Planning and Management for Smart Cities. CUPUM 2019. Lecture Notes in Geoinformation and Cartography. Springer, Cham. https://doi.org/10.1007/978-3-030-19424-6_2
35. <https://www.smithsonianmag.com/innovation/in-face-rising-seas-are-floating-cities-real-possibility-180978409/>
36. <https://www.greenclimate.fund/about/timeline>
37. <https://gggi.org/about/results/>
38. <https://p4gpartnerships.org/>
39. <https://connect.wri.org/webmail/120942/1065476875/4b9833c3394e37150b9eb874a9d17bcfe8daa372c0eebc79f90d3d37a584cee2>
40. [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690693/EPRS_BRI\(2021\)690693_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690693/EPRS_BRI(2021)690693_EN.pdf)
41. Full name: The Framework Agreement Between the European Union and Its Member States, on the One Part, and The Republic of Korea, On the Other Part, https://eeas.europa.eu/sites/default/files/framework_agreement_final_en.pdf
42. https://ec.europa.eu/clima/news-your-voice/news/eu-launches-eu35-million-emissions-trading-cooperation-project-korea-2016-07-08_en
43. https://www.gfa-group.de/projects/EU-Korea_Climate_Action_3902187.html
44. <https://europa.eu/capacity4dev/eu-korea-climate-action-project#:~:text=Project%20Description&text=The%20EU%2DKorea%20Climate%20Action,successfully%20completed%20in%20October%202021>
45. <https://www.gov.uk/guidance/funding-for-innovative-smart-energy-systems>
46. Including: demand-side response (DSR), vehicle-to-grid (V2G), flexibility markets, system integration and energy storage systems.
47. <https://cp.catapult.org.uk/project/uk-republic-of-korea-innovation-twins-programme/>
48. The Agreement on the Establishment of the Trilateral Cooperation Secretariat(TCS) was officially signed and ratified in Seoul in September 2011.
49. <https://www.chinadaily.com.cn/a/201911/25/WS5ddb2cb2a310cf3e355799f3.html>
50. <https://www.tcs-asia.org/en/data/publications.php>
51. <https://www.globalconstructionreview.com/decarbonising-construction-six-things-industry-cou/>

Chapter 8.

1. <https://www.statista.com/statistics/1122999/singapore-nominal-gdp-breakdown-by-sector/>
2. <https://www.cnn.com/2022/02/07/singapore-property-prices-rents-to-rise-in-2022-but-at-a-slower-pace.html>
3. <https://www.singstat.gov.sg/modules/infographics/population>
- 4 & 5. <https://www.hdb.gov.sg/about-us/history>
6. <https://www.globalpropertyguide.com/Asia/Singapore/Price-History>
7. <https://www.ura.gov.sg/Corporate/Media-Room/Media-Releases/pr21-02>
8. <http://cbre.vo.llnwd.net/grgservices/secure/Singapore%20Market%20Outlook%202021.pdf?e=1642440697&h=4b2e110eaaf19d6091c95974a40931e2>
9. <https://www.mse.gov.sg/resource-room/category/2021-11-06-press-release-on-cop-26/>
- 10 & 11. <https://climateactiontracker.org/countries/singapore/>
12. https://eresources.nlb.gov.sg/infopedia/articles/SIP_1370_2008-11-22.html
13. <https://www.greenplan.gov.sg/splash>
- 14 & 15. <https://www.mse.gov.sg/policies/climate-change/cpa>
16. <https://www.nccs.gov.sg/singapores-climate-action/carbon-tax/>
17. Sources: https://www1.bca.gov.sg/docs/default-source/docs-corp-buildsg/sustainability/20211027-carbon-criteria_simplified_r1-1.pdf
18. <https://www.joneslanglasalle.co.jp/en/trends-and-insights/research/singapore-riding-the-esg-investment-growth>
19. <https://www.spglobal.com/platts/en/market-insights/latest-news/energy-transition/082621-singapore-exchange-proposes-mandatory-climate-reporting-in-key-sectors-from-2023>
20. <https://www.channelnewsasia.com/business/mas-green-investment-programme-climate-change-sustainability-1844036>
21. <https://www.mas.gov.sg/development/sustainable-finance>
22. <https://www.straitstimes.com/singapore/budget-2021-govt-to-issue-some-19b-of-green-bonds-on-select-public-infrastructure-projects>
23. <https://www1.bca.gov.sg/buildsg/sustainability/green-mark-incentive-schemes/green-mark-gross-floor-area-incentive-scheme-gm-gfa>
24. <https://www.temasek.com.sg/en/news-and-resources/stories/sustainability/coming-together-to-build-a-net-zero-future>
25. <https://www.straitstimes.com/business/companies-markets/nea-raises-165-billion-from-maiden-green-bond>
26. https://www.capitaland.com/international/en/about-capitaland/newsroom/news-releases/international/2020/may/500million_susty_loan_11_susty_report.html
27. Source: https://www.capitaland.com/international/en/about-capitaland/newsroom/news-releases/international/2020/may/500million_susty_loan_11_susty_report.html
28. Source: <https://www.capitaland.com/international/en/about-capitaland/newsroom/news-releases/international/2020/aug/Ascendas-Reit-prices-maiden-green-bond-100-million.html>
29. <https://www1.bca.gov.sg/buildsg-emag/articles/the-myth-of-costly-green-buildings>
30. <https://www.bca.gov.sg/zeb/whatiszeb.html>
31. <https://www.bca.gov.sg/zeb/whatiszeb.html>
- 32 & 33. <https://www.keppelland.com/intl/en/special-features/keppel-bay-tower-a-green-building-of-the-future.html>
34. <https://cdl.com.sg/newsroom/cdl-pledges-net-zero-operations-by-2030-first-singapore-real-estate-developer-signatory-of-world-gbc-commitment>
35. <https://www.frasersproperty.com/home/frasers-corporate/essentials/shared/dataitems/press-releases/2021/january/frasers-property-commits-to-net-zero-carbon-by-2050>
36. <https://www.lendlease.com/it/media-centre/media-releases/lendlease-embarks-on-ambitious-road-to-absolute-zero-carbon-by-2040/>
37. <https://www.capitaland.com/sites/SustainabilityReport/2017/environment-tracking-system.html>
38. <https://solarquarter.com/2021/03/15/hdb-singapore-launches-sixth-solarnova-tender-with-smart-electrical-sub-meters-to-optimise-energy-use/>
39. <https://sbr.com.sg/economy/in-focus/vcs-bet-big-esg-startups>
40. <https://earthjournalism.net/stories/singapores-carbon-emissions-targets-hinge-on-reducing-gas-dependency>
41. <https://www.blackrock.com/corporate/newsroom/press-releases/article/corporate-one/press-releases/temasek-and-blackrock-launch-decarbonization-investment-partnership>
42. <https://home.kpmg/xx/en/home/insights/2021/09/nzri-singapore.html>
43. <https://www.tunneltalk.com/Career-Moves.php>
- 44 & 45. <https://news.mongabay.com/2021/10/for-companies-eyeing-net-zero-carbon-emissions-no-clue-how-to-get-there/>

