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High Performance Buildings: A Primer

DOI
https://doi.org/10.24943/HPBAP11.2024

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High Performance Buildings: A Primer

What are High Performance Buildings?

High-Performance Buildings (HPBs) are designed to maximise resource efficiency and cost-effectiveness, optimising energy, water, and indoor environmental quality throughout their life-cycle. These buildings outperform benchmarks established by Indian standards, such as the Energy Conservation Building Code (ECBC) and the National Building Code (NBC), consuming 50% (Factor 4) to 25% (Factor 2) of typical energy and water usage. HPBs adhere to stringent requirements for indoor air quality (IAQ), waste management, and resilience. Furthermore, they undergo continuous monitoring and performance verification to ensure sustained efficiency and long-term sustainability.

HPBs utilise technologies such as high-performance windows, advanced insulation, efficient lighting, HVAC systems, smart controls, water-efficient systems, and integrated building management systems. Together, these technologies improve thermal comfort, IAQ, and overall resilience throughout the building's life cycle.

These efficiencies and outcomes make a compelling business and ESG (environmental, social, and governance) case for real estate developers to build HPBs at scale, for building buyers/ tenants/ occupants to strongly embed building performance parameters in their decision-making, and for policymakers and financial sector leaders to consider enabling measures to support HPBs.

Terms like "green buildings" and "high-performance buildings" are often used interchangeably in the field of sustainable construction. Both concepts aim to reduce environmental impact and energy consumption and improve occupant comfort, but differ in their methods and outcomes.

Green buildings are a fundamental step towards sustainability, with certification programmes playing a crucial role in their development. Their key areas of concern are energy efficiency, water conservation, and materials sourcing. HPBs elevate these ideas by striving for peak efficiency in every aspect of their form and function. From energy and water use to occupant health and comfort, HPBs are designed with specific, measurable goals to achieve results. They use advanced technologies and smart design strategies to continuously track their performance metrics, ideally in real time.

Energy Performance Index values for different building standards

Building Typologies	Standard Building	Energy Efficient/ Green Buidings	High Performance Buildings
Office: New	125-150	90-110	70-75
Office: Retrofit	150-175	150-175	100-125
Institutional	150-175	75-90	70-75
Healthcare (24 hr)	325	225-275	190-200
Hospitality (24 hr)	325	275-300	200-225

Sources: *Griha 2019 Manual, ECBC 2017, National building codes*

A Sustainability Outlook of India's Real Estate Sector

Indian Real Estate Sector:
7–8% of GDP

Annual Commercial Building Stock Addition:
1 billion sq ft until 2030

Projected Sector Growth:
5x by 2030

Potential Energy Cost Savings by 2030:
USD 432 billion

Share of Emissions: 21–22%

Job Creation Potential:
10 million green jobs

Commercial Building Energy Use:
150–200 kWh/m² annually

GHG Emissions Reduction Potential:
600 million tCO_2-eq

Residential Building Energy Use:
30–70 kWh/m² annually

Public Energy Investments Reprioritisation Potential:
USD 1.1 billion

* Benefits projected based on the assumption that 50% of the projected commercial building stock is constructed or retrofitted following HPB principles

Why HPBs?

India's real estate sector, large and rapidly growing, is a significant contributor to carbon emissions and requires transformative interventions. Currently, the sector accounts for approximately 7–8% of the nation's Gross Domestic Product (GDP) and is projected to grow fivefold from 2021 levels by 2030. Additionally, it contributes 21–22% of India's total emissions.

The case for intervention is especially strong in commercial buildings, which typically consume far more energy (150–200 kWh/m² annually) than residential buildings (30–70 kWh/m² annually).

Resource-efficient HPBs present a game-changing opportunity to meet business, climate, sustainability, innovation, and job creation goals. India is expected to add approximately 1 billion square feet of commercial building stock annually until 2030. If even half of this projected commercial building stock is constructed or retrofitted following HPB principles, the benefits could include significant energy savings, reduced emissions, enhanced economic growth, and a shift towards more sustainable public energy investments. The benefits could include:

- Saving businesses USD 432 billion in energy costs.
- Creating 10 million permanent and skilled green jobs.
- Avoiding 600 million tonnes of CO_2 equivalent (tCO_2-eq) of GHG emissions.
- Reprioritising USD 1.1 billion in public sector energy investments.

With thoughtful planning, HPBs can be built at no additional cost. In rare instances where higher initial costs are incurred, the operational savings from HPBs on energy and water bills, reduced maintenance costs, and potential tax incentives lead to an attractive return on investment.

In addition to a strong return on investment over a building's lifespan, HPBs present other valuable opportunities for businesses, including:

- Improved property value for buyers and tenants who prioritise operating efficiencies, occupant comfort and health, and corporate citizenship in alignment with evolving regulations and disclosure requirements.
- Policy and regulatory support, including tax deductions on energy-efficient investments, incentives for installing renewable energy systems, faster approvals, concessional loans for green-certified buildings, property tax rebates, and higher floor area ratios (FAR).
- Access to climate finance and ESG investment, driven by HPB's significantly reduced carbon footprint.

Atal Akshay Urja Bhawan, New Delhi. *Source: Edifice Consultants Pvt. Ltd.*

Infosys Crescent Building – exterior view, Electronic City, Bengaluru. *Source: IIHS Media Lab, 2024*

Examples of HPBs

Several HPBs have recently been constructed in India, each incorporating innovative design and technology solutions that prioritise energy efficiency, sustainability, and occupant comfort. These buildings highlight how sustainable practices can be effectively integrated to minimise environmental impact while achieving operational efficiency. Below are examples of such exemplary structures.

1. **Indira Paryavaran Bhawan, New Delhi**: The Ministry of Environment's headquarters is designed as a self-sustaining, energy-efficient structure that minimises environmental impact through a combination of passive and active sustainable features. The building's East-West orientation, with blocks separated by connecting corridors and a large central courtyard, maximises natural ventilation and airflow, reducing the need for mechanical cooling. This layout also allows for 75% utilisation of natural daylight, significantly decreasing energy consumption for lighting. Energy efficiency is further enhanced by an innovative chilled beam HVAC system that provides cooling through convection by circulating chilled water directly to diffuser points, achieving around 40% energy savings compared to conventional systems.

Sustainable building materials, such as fly ash bricks, regionally sourced components, high-recycled-content materials, high-reflectance terrace tiles, and rock wool insulation on external walls, contribute to the building's green profile. UPVC windows with hermetically sealed double glazing, along with recycled-content ceiling tiles and grass paver blocks, help reduce heat gain and enhance sustainability. Water conservation measures include low-flow fixtures, on-site wastewater recycling through a sewage treatment plant, and rainwater harvesting.

2. **Atal Akshay Urja Bhawan, New Delhi**: A net-positive energy building functions as the headquarters of the Ministry of New and Renewable Energy (MNRE). The building's north-south orientation, with a central atrium and angled south wing, maximises natural light and minimises heat gain by separating functional areas on the east from service zones on the west. Its high-performance envelope includes a GFRC-shaded west facade, a solar wall on the south, and double-glazed windows, while 90% of the floor area receives ample, glare-free daylight during working hours, ensuring cross-ventilation and thermal insulation. The east facade features a double wall constructed with ACC and filled with 200 mm thick glass wool insulation, providing superior thermal protection.

The building employs a hybrid cooling system that combines traditional chillers and radiant chillers, utilising water-cooled screw-chillers and ceiling pipes for efficient, uniform cooling through radiant and convection heat transfer. The fresh air system uses toilet exhaust to pre-cool fresh air, delivering 100% fresh air through a three-stage evaporative cooler and heat recovery wheel-based system with both high-temp and low-temp coils. A smart building management system optimises power use, including demand-controlled ventilation with CO_2 and temperature sensors, limiting energy load and refrigeration capacity.

3. **The Infosys Crescent Building, Bengaluru**: This building exemplifies sustainable design and high-performance efficiency. It employs a range of green technologies, including 75% of the area daylit to reduce reliance on artificial lighting by approximately 30%. Passive cooling strategies minimise energy consumption by up to 20%, and energy-efficient fixtures lead to a reduction in operational costs. The air-conditioning system uses a radiant cooling system that operates on 100% fresh air with floor-wise Air Handling Units (AHUs). Additionally, a fully automated demand-based control system enhances energy efficiency, while a rainwater harvesting system collects over 500,000 litres annually, significantly reducing water usage.

IIHS, Bengaluru City Campus Annex II Building – exterior view, Sadashivanagar, Bengaluru. *Source: IIHS Media Lab, 2024*

4. IIHS, Bengaluru City Campus Annex II Building: A 11,000 sq. ft., three-storied, leased building to be used as a teaching and learning facility, was transformed into a high-performance building through a meticulous retrofit, to improve energy efficiency, occupant comfort, and sustainability. The retrofit process included layout redesigns for classrooms, faculty workspaces, and multi-functional areas such as dining and exhibition spaces. Key modifications included installing efficient HVAC and BLDC fans to reduce cooling energy, IoT instrumentation for real-time monitoring of energy, water and indoor environmental quality, and water-saving fixtures.

Thermal comfort was managed despite challenges with the south-facing glass facade, which increased heat gain, by applying sun-control films and installing an energy-efficient VRF (Variable Refrigerant Flow) HVAC system combined with BLDC fans. This setup allowed occupants to adjust fan speeds and AC usage, maintaining comfortable conditions while reducing energy consumption. Sustainable materials like recycled wood, lightweight AAC blocks, and uPVC windows were selected to minimise embodied energy. The retrofit achieved a Factor 4.1 improvement in energy efficiency, along with a 40% reduction in water usage. This project demonstrates how strategic retrofitting can create functional, resource-efficient spaces aligned with sustainability goals.

Each example reinforces the core HPB benefits: significant energy savings, reduced environmental footprint, improved occupant comfort, lower operational costs, and enhanced resilience—making HPBs a sustainable choice for modern urban development.

Policy and HPBs

Energy and water efficiency, and the resulting reduction in load on public infrastructure, are central to policy-making for HPBs. Many governments are actively promoting energy-efficient buildings as part of their climate strategies.

The European Union's 'Green Deal',[4] which targets climate neutrality by 2050, mandates energy-efficient building designs and retrofits. Germany's KfW Bank[5] supports energy-efficient projects with low-interest loans, while Denmark's strict BR18 building codes[6] provide incentives for HPB practices. In the U.S., programmes tied to the Energy Star[7] rating offer tax incentives for both commercial[8] and residential[9] buildings.

Energy data disclosure ensures transparency and creates healthy competition in the real estate market. Several states and local governments in the U.S. have mandatory energy data disclosure requirements[10], often as a prerequisite for real estate transactions. In Singapore, building owners are required to submit building information and energy consumption data, which is then used to establish national building energy benchmarks.

In India, there have been some initiatives to promote energy-efficient buildings through initiatives under the 'National Action Plan on Climate Change'[11]. The green building movement has made some headway with voluntary adoption of sustainable building practices by building owners and developers. The 'Green Rating for Integrated Habitat Assessment' (GRIHA)[12] lists more than 3,000 registered projects focusing on sustainable practices and lowering carbon emissions. The Indian Green Building Council (IGBC)[13] promotes energy-efficient designs, with more than 14,000 certified projects covering 12.5 billion sq. ft.

Despite these advances, mandatory regulations for HPB implementation for new construction and retrofits have lagged. Although the Energy Conservation Building Code (ECBC)[14] was introduced in 2007, enforcement remains almost nonexistent at the local level.

Incentive programmes that encourage voluntary compliance with codes and rating systems have shown mixed results. Cities like Hyderabad, Noida, and Pune offer higher floor area ratios and other incentives for buildings that meet ECBC standards, resulting in a noticeable increase in green registrations and significant energy savings. International support has also contributed, such as Germany's KfW Bank, which offered a credit line to the State Bank of India for green financing, and the International Finance Corporation's EDGE programme, aimed at reducing buildings' energy, water, carbon footprints.

While mandatory compliance of energy codes in India may still be fraught due to inconsistent local enforcement issues, there are several policy areas that could bring momentum to scaling up the design, construction, and operation of HPBs:

- Mandatory energy data disclosure that is enforceable at the local level.
- Green financing and tax incentives linked to ongoing energy and water performance metrics.
- Performance validation and aggregation methods to enable building energy efficiency to enter the carbon markets.

How to get to HPBs?

Creating HPBs involves some key practices, including integrative design, lifecycle-based material choices, efficient energy and water management, performance monitoring, and climate resilience. These principles collectively deliver buildings that are sustainable, efficient, and equipped to meet both environmental and operational demands. Here is how policymakers and real estate sector stakeholders can drive the adoption of HPBs:

Integrative Design: The core of achieving HPBs at little or no additional cost is an integrative design approach. It ensures energy, water, lighting, HVAC, and envelope systems work together efficiently and are sized optimally. This collaborative process involves architects, engineers, sustainability experts, and building owners working toward clearly defined performance goals. Through digital twinning and performance modelling, teams can optimise system sizing and make data-driven decisions early in the design phase. This process ensures that design options are assessed using a lifecycle approach at each stage. For example, passive design strategies introduced at the concept stage help minimise thermal loads, thereby reducing the size and cost of cooling and ventilation equipment.

Material Selection: Durable, energy-efficient, low-carbon materials not only improve occupant health but also enhance building performance over time. Life cycle assessment (LCA) is employed to evaluate the environmental impacts of building materials, ensuring sustainable choices. Low-emission interior materials improve indoor air quality, creating a healthier environment for occupants and contributing to overall building performance. Building materials, lighting, electrical and HVAC equipment are evaluated with a Life Cycle Cost (LCC) analysis. For instance, IIHS conducted a 50-year LCC for its upcoming campus in Kengeri, Bengaluru, to evaluate comfort, durability, and cost of envelope materials and their impact on cooling equipment size and energy use. Finance teams reviewed the LCC to ensure the material and equipment choices were cost-effective.

Energy Management: Energy efficiency in HPBs include both passive design and active measures to reduce energy demand. Passive strategies include maximising natural light and ventilation to reduce the use of artificial lighting, heating, and cooling. Active strategies involve energy-efficient appliances and smart technologies like automated lighting controls and occupancy sensors, environment and energy sensors with active dashboards that allow for real time monitoring and optimisation. Infosys' Hyderabad campus, for example, was the first in India to install radiant cooling technology[15] complemented by daylighting controls and task lighting, which immediately reduce energy consumption. HPBs also strive for net-zero energy (NZE) or net-positive energy performance, generating as much or more renewable energy as they consume, ensuring resilience in times of power outages.

Water Management: HPBs include comprehensive water management strategies that focus on conservation, reuse, and quality. Efficient fixtures like low-flow faucets and dual-flush toilets reduce water demand, while rainwater harvesting systems collect rainwater and recharge groundwater. Greywater is recycled on-site for irrigation and flushing, and blackwater is treated with biological systems like constructed wetlands or sewage treatment plants before discharging it from the site. Additionally, HPBs incorporate green infrastructure elements, such as permeable paving and bioswales, to manage stormwater and mitigate urban heat island effects. Infosys campuses in India exemplify this with their zero-discharge campus status,[16] utilising a discharge water management system and aerobic membrane bioreactor (MBR) to recycle 100% of wastewater for irrigation and cooling.

Performance Monitoring: Advanced monitoring systems in HPBs allow real-time tracking of energy and water use, as well as indoor environmental quality. This enables facility managers to detect faults, identify inefficiencies, and implement corrective measures. Continuous performance monitoring helps validate design assumptions and improve future projects, ensuring that buildings not only perform as intended but also contribute positively to environmental impact. With a robust performance monitoring system, the Infosys operations team tracks the performance of all their campuses, buildings, and building systems. The IIHS Bengaluru City Campus – Annexe II building, has implemented IoT-based monitoring and piloted AI-driven controls to optimise thermal regulation. Live dashboards allow users and facility management to effectively monitor the building performance. This has helped transform an existing building into a HPB with Factor 4 efficiency.

Resilience: HPBs are engineered to withstand climate-related risks, such as extreme heat, flooding, drought, and storms. Through careful site selection, flood protection measures, and durable material choices, these structures are built to last. Renewable energy systems provide backup power, while water resilience is achieved through rainwater harvesting and on-site treatment systems, ensuring water availability during scarcity. Onsite energy storage and demand management help ensure that critical processes remain operational even in challenging conditions. This multifaceted approach makes HPBs future-proof.

The Way Forward

To drive sustainable urban development in India, scaling HPBs offers a powerful solution. HPBs use advanced technology and smart design to significantly reduce energy and water use, while creating comfortable and healthy indoor environments. This model of construction supports India's economic and environmental goals, reducing the load on public infrastructure, enhancing property values, and attracting climate-conscious investments. HPBs also support India's goals to lower carbon emissions, save resources, and create green jobs.

In rapidly growing cities, HPBs provide resilient infrastructure, ensuring buildings are ready for the future. When developers, investors, and policymakers work together to set supportive policies, incentives, and financing, HPBs can become the foundation for sustainable urban spaces that enhance the quality of life. This collective push can help create a lasting model for resilient, sustainable cities that benefit everyone, now and for generations to come.

Frequently Asked Questions

Are HPBs more expensive to build?
With care and attention, HPBs can be built with no additional cost. In rare instances where higher initial costs are incurred, the operational savings from HPBs on energy and water bills, reduced maintenance costs, and potential tax incentives lead to an attractive return on investment.

Does the O&M of HPBs require a different type of facilities and operations staff?
Maintaining HPBs often requires specialised facilities and operations staff due to advanced technologies and systems adopted. Staff need expertise in energy management, building automation, and sustainability practices to effectively operate and maintain these systems.

Are HPBs heavy on digitisation?
Yes, HPBs embrace digitisation to enhance efficiency and sustainability. Through advanced digital technologies like smart controls, real-time monitoring, and building management systems, HPBs optimise building performance, creating a more responsive and efficient environment for occupants.

What are the benefits of HPBs to real estate developers?
HPBs boost property value and appeal by offering overall building performance efficiency and lower operating costs, leading to higher rental rates and occupancy. They are attractive to tenants who seek to lower their Scope 2 emissions to meet their ESG and sustainability goals. Further, they ensure compliance with evolving regulations and enhance developers' marketability and branding.

What are the benefits of HPBs to their occupants?
HPBs provide occupants with improved comfort through better daylighting, thermal control, and air quality. This enhances occupants' health and productivity. Additionally, it also lowers environmental impact and offers greater resilience to extreme weather, aligning with occupants' commitment to sustainability and conservation.

If they are so good, why isn't everyone building HPBs?
HPBs aren't more widespread because of the myths around higher upfront costs, lack of awareness of their benefits, lack of the specialised knowledge for design-construction-operations.

Glossary

Factor 4: Aims to achieve double the productivity using half the resources (materials and energy), resulting in a fourfold improvement in efficiency. Alternatively, practices that maintain the same productivity with only a quarter of the resources, or achieve four times the effectiveness with the same resources, also meet this goal.
Source: Sustainability Dictionary

Greenhouse Gases: The release of gases such as carbon dioxide, methane, and nitrous oxide into the atmosphere. These gases trap heat, contributing to global warming and climate change. Major sources include fossil fuel combustion, deforestation, and industrial processes.
Source: Intergovernmental Panel on Climate Change (IPCC)

Indoor Air Quality (IAQ): The condition of air within buildings, impacting the health and comfort of occupants. It is influenced by pollutants like volatile organic compounds (VOCs), dust, mould, and carbon dioxide. Poor IAQ can lead to respiratory issues, allergies, and other health problems.
Source: U.S. Environmental Protection Agency (USEPA).

HVAC: Stands for Heating, Ventilation, and Air Conditioning. It refers to the systems used to regulate temperature, humidity, and air quality in indoor spaces. HVAC systems provide thermal comfort and maintain air quality by circulating and filtering air, controlling temperature, and ensuring proper ventilation.
Source: U.S. Department of Energy.

Life Cycle Assessment (LCA): A method used to analyse a product's environmental impact throughout its entire lifespan, helping to improve resource efficiency and reduce potential risks. This approach can assess the environmental effects of a specific product or the function it serves. LCA includes three main components: (1) identifying and measuring environmental inputs, such as energy, raw materials, emissions, and waste; (2) evaluating the possible environmental impacts of these inputs; and (3) exploring strategies to minimise these environmental impacts.
Source: European Environment Agency

Life Cycle Cost (LCC): An approach that accounts for all expenses associated with purchasing, using, and disposing of a product, service, or project over its entire lifespan. It includes the initial purchase price and related costs (such as delivery, installation, and insurance), ongoing operating expenses (including energy, fuel, water, spare parts, and maintenance), and end-of-life costs, such as decommissioning or disposal, or any potential residual value from resale.
Source: European Commission

Building Management System (BMS): A centralised digital platform that automates the control of energy efficiency and enhances occupant comfort. It oversees and manages various electrical and mechanical services, including heating, ventilation, and air conditioning systems, as well as lighting. Additionally, it can integrate other essential services, such as security, access control, elevator operations, and safety systems.
Source: Department of Climate Change, Energy, the Environment and Water, Australian Government

Brushless Direct Current (BLDC) Fans: A type of fan that uses a brushless DC motor with permanent magnets. This design allows the fan to consume significantly less energy, while still delivering comparable airflow. BLDC fans offer additional advantages, including reduced noise, lower electricity consumption, and a longer lifespan, as the motor generates less heat.
Source: Ministry of Consumer Affairs, Government of India

Variable Refrigerant Flow: A technology that adjusts the amount of refrigerant circulated to match the specific heating or cooling demand at any given time. This approach allows users to control multiple air conditioning zones independently, enabling customised climate settings across different areas simultaneously.
Source: Daikin

Radiant Cooling: A technology that works by absorbing heat emitted from the surrounding space through cooled surfaces such as floors or ceilings. When the cooling system is applied to the floor, it is known as radiant floor cooling, while cooling via the ceiling is typically achieved using radiant panels, often found in residential settings.
Source: U.S. Department of Energy

Net-Zero Energy (NZE) Building: A building that achieves net zero energy consumption by reducing energy demand and meeting the remaining energy needs through on-site renewable energy.
Source: World Green Building Council

Passive Design: A design approach that uses natural methods, like sunlight and air flow, to keep a building cool and well-lit without relying on air conditioning or electric lights. It helps save energy, reduce costs, and improve the building's ability to handle power outages or disruptions.
Source: WRI India Ross Center

Green Financing: Loans or investments that support activities benefiting the environment, such as buying eco-friendly products, funding sustainable projects, or developing green infrastructure.
Source: UN Environment Programme

Energy Conservation Building Code (ECBC): A building energy code that sets energy performance standards for different building components, tailored to specific climatic regions. By applying these standards, a building's energy demand is reduced without compromising occupant comfort, health, productivity, or the building's functionality.
Source: Bureau of Energy Efficiency, Ministry of Power, Government of India

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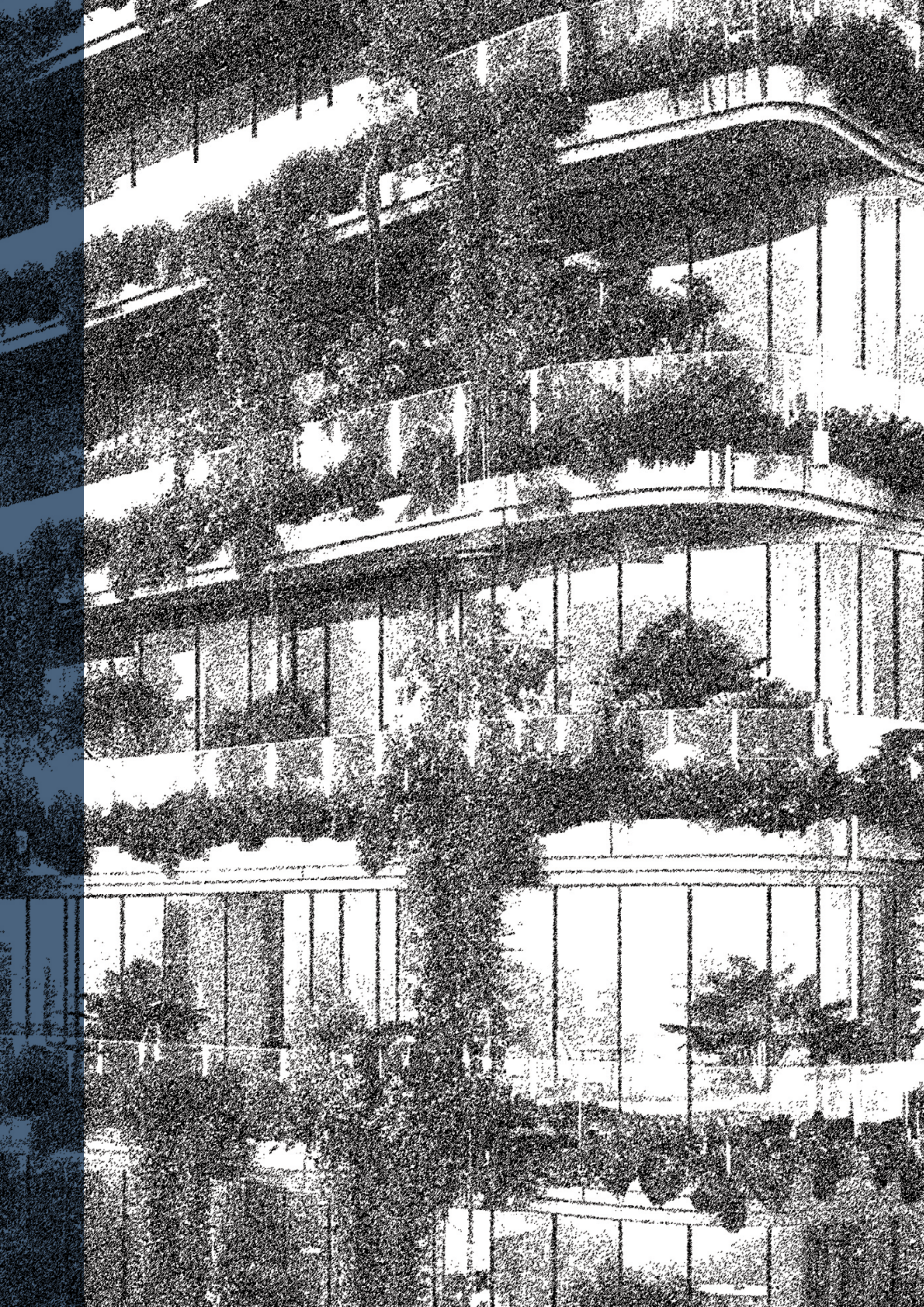

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