

SINGAPORE'S GREEN BUILDINGS



GUIDING PRINCIPLE 5: RESOURCE EFFICIENCY AND CIRCULARITY

Circularity and the use of sustainable technologies and construction materials should be planned and designed into infrastructure systems to minimize their footprints and reduce emissions, waste and other pollutants.



BACKGROUND

Singapore is one of the most densely populated countries in the world (United Nations Department of Economic and Social Affairs [UNDESA] 2019). As a city-state occupying just over 720 kilometres² of land, it also faces considerable natural resource constraints (Chew 2010, p. 196). Yet Singapore has one of the most carbon efficient economies in the world, and it seeks to green at least 80 per cent of its buildings by 2030 (Singapore, Building and Construction Authority [BCA] 2010, p. 3). To fashion a clean, efficient and liveable city, and reduce

reliance on natural resource imports for construction, Singapore has introduced a series of innovations since 2005 to integrate environmental sustainability into its built infrastructure. Singapore's "green buildings" (including offices, university buildings, public transport buildings and other facilities) have adopted principles of circularity, using recycled materials and green technologies for building design. Importantly, these innovations are made possible at scale through an enabling environment which strives to promote the adoption of sustainable construction materials and practices.

INCORPORATING CIRCULARITY INTO CONSTRUCTION

The first key technical measure that characterizes Singapore's green buildings is the use of green and recycled materials for construction. For example, a Mass Engineered Timber (MET) construction system was used for a 12-storey academic block at the Eunoia Junior College (Singapore, BCA 2020a). MET is harvested from sustainably managed forests (Programme for the Endorsement of Forest Certification 2019) and MET buildings have a lower carbon footprint and net carbon emissions compared to steel or concrete buildings (Singapore, BCA 2020b). Another example is the Tampines Concourse, which is a three-storey office building built with green concrete. The green concrete uses less sand⁵ by partially replacing it with copper slag, recycled concrete aggregates (RCA) and ground granulated blast furnace slag (GGBS) (Chew 2010).

Singapore's buildings incorporate circularity throughout the lifecycle, including the decommissioning or demolition phase. BCA established a Demolition Protocol which was later incorporated into the Singapore Standard - a set of procedures that, among other policies, maximize the recovery of waste materials for beneficial re-use or recycling (Singapore, BCA 2020c). These materials can potentially be used for other projects, such as the Samwoh Eco-Green building, made of concrete with RCA derived from construction and demolition waste.

GREEN DESIGN AND TECHNOLOGIES

Complementing the use of green construction materials, the Singapore Government also encourages use of sustainable building designs and green technologies to minimize environmental impacts and maximize total building performance. These are promoted through the BCA Green Mark certification scheme, a framework for assessing the overall environmental performance of a building, including energy, water efficiency and indoor environmental quality, and environmental impacts over the entire lifecycle.

Accounting for the tropical climate, passive design strategies are frequently adopted for buildings and spaces, in order to reduce energy use and carbon emissions. For example, individual buildings have vernacular designs with careful orientation to maximize daylight or avoid direct heat gain from the sun. To bring nature into a dense urban environment, an increasing number of buildings are also incorporating ample greenery and trees, which provide shade and

minimize urban heat island effects. Many have sun-shading exteriors such as overhangs to block solar exposure (Eco-Business 2011). Green roofs, with layers of planted vegetation, further mitigate solar heat gains. They provide a nature-based alternative to, and reduce the need for, "grey" solutions.

In terms of energy efficiency, the Zero Energy Building (ZEB) on the BCA Braddell Campus and the recently completed National University of Singapore (NUS) School of Design and Environment 4 (SDE4) building provide notable examples. ZEB@BCA Academy was Southeast Asia's first net-zero energy building, achieving nearly ten consecutive years of zero energy consumption since 2009. It functions as a test bed for the integration of green building technologies in existing buildings (Singapore, BCA 2020d). Customized for tropical conditions with careful attention to façade, orientation and massing, the NUS SDE4 features a "hybrid" cooling system with fans instead of a standard air conditioning system, resulting in a higher set point and lower energy consumption, while achieving the same thermal comfort. Since its opening in 2019, careful energy management paired with a sizeable rooftop solar PV array have resulted in net-positive energy performance. The Housing and Development Board has also introduced "smart" technologies, including "Smart Fans" at its Punggol Northshore development, which are activated in response to temperature, humidity levels and human movement (Singapore, Housing and Development Board 2015). These various solutions reduce the consumption of energy and natural resources, while making buildings more comfortable and useable from an occupant's perspective.

Other constructions such as Tuas Nexus exemplify circularity through integration of different sectors. Tuas Nexus will represent the world's first integrated waste and water treatment facility, housing the Tuas Water Reclamation Plant by Singapore's Public Utilities Board and National Water Agency, and an Integrated Waste Management Facility by the National Environment Agency. The construction will harness synergies across the water-energy-waste nexus to optimize energy and resource recovery while minimizing land take. For example, electricity generated by the waste-to-energy process will be used to power the operation of the facility as a whole, and excess electricity will be exported to the grid. Tuas Nexus will be energy self-sufficient as a result of the integrated approach. This is expected to result in carbon savings of more than 200,000 tonnes of CO₂ annually, equivalent to taking 42,500 cars off Singapore's roads (Singapore, National Environment Agency 2020).

⁵ Sand is an increasingly scarce resource associated with high levels of greenhouse gas emissions and negative environmental impacts, such as coastal erosion through its extraction.

AN ENABLING ENVIRONMENT

Critically, to support green building systems, the Singapore Government has provided an enabling environment with strategic policies and incentives, in order to achieve the target of greening 80 per cent of buildings (by gross floor area) in Singapore by 2030.

The Green Mark Incentive Scheme aims to “accelerate the adoption of environmentally friendly building technologies and building design practices through cash or gross floor area incentives” (Singapore, BCA 2020e). The scheme was complemented by legislation requiring all new buildings and existing buildings that undergo major retrofitting to meet a minimum environmental sustainability standard. The “Super Low Energy” programme is the next wave of Singapore’s green building movement. Launched in 2018, it includes a suite of initiatives developed by the government in partnership with industry and academia to encourage the design and adoption of cost-effective Super Low Energy buildings (60 per

cent improvement in energy efficiency over the 2005 building codes) (Singapore, BCA 2018, p. 10).

In addition to the environmental sustainability benefits, buildings designed with “Green Mark” standards reap net positive savings throughout the lifecycle⁶. Some have shaved 11.6 per cent off operating expenses (Yale University 2013). Other schemes include the “Building Retrofit Energy Efficiency Financing Scheme”, the “Skysrise Greenery Incentive Scheme” and the “Quieter Construction Innovation Fund” (Green Future 2020), addressing a range of economic, environmental and social considerations relating to buildings. Alongside these measures, Research & Development (R&D) was jointly identified and promoted by government institutions as a key enabler for improving resource efficiency in Singapore’s buildings (Eco-Business 2011), leading to the establishment of an integrated Green Buildings Innovation Cluster to advance energy efficient solutions and practices.



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⁶ An independent consultancy study on the BCA Green Mark Incentive Scheme was commissioned in 2019 (Singapore, BCA 2019). The study includes a detailed review and lifecycle cost analysis of 40 Green Mark projects.

REPLICABILITY

With an additional 2.5 billion people expected to be living in the world's cities by 2050 (UNDESA 2018, p. 1), continuing innovation to provide homes, jobs, public amenities and a clean environment for a growing urban population remains a crucial challenge. The success of Singapore's green buildings and broader urban infrastructure is often viewed as a model by other cities. Observers frequently refer to Singapore as a "City in a Garden" (UNEP 2018).

Singapore is testament to how a city and country can build a strong economy, while preserving a clean and green environment. Despite natural resource and land constraints, a series of technical and policy measures have enabled the design and implementation of sustainable infrastructure systems that serve human

needs, while respecting environmental imperatives. Going beyond the "City in a Garden", Singapore now envisions a "City in Nature", that will require holistic planning and implementation to further integrate ecosystems with sustainable infrastructure in urban areas (Singapore, Public Service Division 2020).

As a high-income city-state, Singapore's case may appear to be unique, but its success does not rely solely on advanced technologies. Sound planning has prioritized sensitivity to the environment from the very start: the country decided early on that it could not afford to "pollute first and clean up later". It illustrates how, with appropriate policies and a commitment to principle, a densely populated city can achieve a high quality of life, foster a competitive economy and maintain a sustainable environment for present and future generations.

KEY INSIGHTS

- > Singapore's population density and natural resource constraints have accelerated the government's adoption of innovative resource- and energy-efficiency measures. The result is a sustainable and nature-positive built environment that minimizes resource use.
- > Green construction materials, designs and technology incorporate circularity in the infrastructure lifecycle. Singapore Standards are in place to guide builders to maximize waste material recovery for re-use or recycling, closing material loops.
- > The country has established an effective enabling environment with a combination of incentives, certifications, standards, targets and R&D initiatives.

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