

SUSTAINABLE INFRASTRUCTURE: PUTTING PRINCIPLE INTO PRACTICE

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.

CASE STUDY: CIRCULARITY AND CLIMATE RESILIENCE IN SINGAPORE'S GREEN BUILDINGS

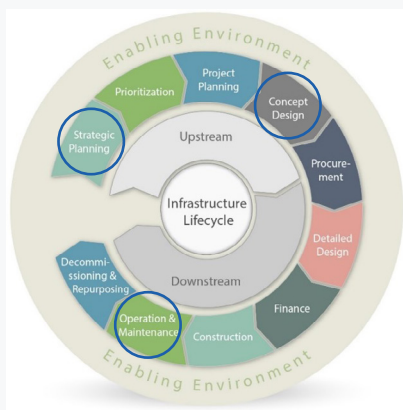
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Singapore places great emphasis on the city's liveability. The Landscaping for Urban Spaces and High-Rises (LUSH) program has encouraged pervasive greenery in an urban setting, making streetscapes more hospitable and visually appealing, while reducing the urban heat island effect. (Source: Woha)



Need for Infrastructure Project/System:

Building operations account for 14-15% of Singapore's greenhouse gas (GHG) emissions. The government has sought to reduce energy use and emissions associated with buildings, while maintaining a vibrant construction industry—an integral part of the Singaporean economy—and fostering a liveable urban environment. The challenge of using space and natural resources judiciously is especially pertinent for the island nation: it is one of the world's most densely populated countries, with a relatively limited land area of 720 km².

Project Description:

The Inter-Ministerial Committee on Sustainable Development previously set a national goal for "at least 80% of the buildings in Singapore to be green by 2030," measured by total gross floor area. This target addressed both new buildings to be constructed, as well as the large stock of existing buildings. Over the years, the Building and Construction Authority (BCA) and the Singapore Green Building Council have worked together to author a number of Green Building Master Plans, in consultation with industry and community stakeholders. The master plans aim to embed sustainability practices and encourage the buildings sector to reach energy efficiency targets.

Under the most recent Green Building Master Plan, there are three key targets, dubbed “80-80-80 in 2030”:

- 1. Picking up the pace to green 80% of buildings by 2030, measured by total gross floor area (GFA).** By the end of 2020, 43% of Singapore’s buildings were considered to have been “greened,” in comparison to their energy performance in 2005, when the first Green Building Master Plan was released. In December 2021, BCA raised mandatory standards for **new buildings** and for **existing buildings that undergo a major retrofit**, including more stringent minimum energy performance requirements and greener construction practices. Following renovation, buildings must be at least 40% more energy-efficient compared with 2005 levels, up from 25% under current rules.
- 2. Aiming for 80% of new developments or major retrofits to be classed as “Super Low Energy” (SLE) buildings from 2030** onward, measured by gross floor area. The SLE standard is defined as achieving “at least 60% improvement in energy efficiency, compared to 2005 levels.” This involves mainstreaming SLE in public sector projects, while driving voluntary adoption in private projects.
- 3. Achieving 80% improvement in energy efficiency for ‘best-in-class’ green buildings by 2030.** At present, buildings considered best-in-class can achieve more than 65% improvements in energy efficiency, compared to 2005 levels.

These targets have since been incorporated into the Singapore Green Plan 2030, released last year, which articulates national sustainability goals in several domains.

The government’s Green Mark certification program is an important tool for evaluating buildings’ environmental impact and performance. Developed as a green building rating system for the tropics and sub-tropics, the program is periodically refreshed to tighten energy efficiency standards and to encourage more sustainability considerations. Access to financing for energy retrofits, monetary incentives, and greater floor area allowances, have all spurred participation by property developers. The government also requires new public buildings—or those undergoing major retrofits—to attain certain Green Mark levels.

Adaptations suited to Singapore’s tropical climate are being incorporated into building designs. For example, the National University of Singapore’s School of Design and Environment building (SDE4) features large overhangs to decrease solar gain; a hybrid cooling system using chilled water and mechanical fans to maintain thermal comfort, while reducing energy costs; and rooftop solar PV generating enough electricity on-site to make it a net-zero building.

In construction, project developers in Singapore have explored the use of more sustainable materials, such as mass engineered timber (MET), which is far less carbon-intensive option than either steel or concrete. Another innovation is Prefabricated Prefinished Volumetric Construction (PPVC), a modular building approach that allows most construction to take place off site, before final installation. PPVC reduces labor, produces less construction waste, and minimizes construction noise and dust. The world’s tallest project built using PPVC techniques is in Singapore.

When buildings are decommissioned and demolished, the government encourages the resulting construction waste to be reused or recycled.

Challenges to Making Infrastructure Sustainable:

Technical and/or Programmatic Challenges – Developing green building certifications for diverse building typologies, including new and existing buildings, can be complex and time consuming. The process requires consultation with industry and community stakeholders, and must be refreshed over time as available technologies and best practices improve. Solutions can be inspired by buildings and infrastructure systems in temperate climates, but



cannot simply be copied and pasted; they must be adapted to local conditions in the tropics.

Governance and/or Political Challenges – Companies are frequently reluctant to act without common regulation. More sustainability-minded firms are concerned about cost disadvantages, while conventional firms may see no need to voluntarily take on extra obligations. Government intervention may be needed to level the playing field, encouraging and rewarding market leaders and spurring action by those lagging behind.

Financial and/or Economic Challenges – Challenges include activating the private sector to contribute to sustainability/resilience initiatives; fostering innovation and improving productivity in a sector that can be conservative or reluctant to change; and raising consumer demand for green buildings, so there is stronger financial pull for companies to develop sustainable projects.

Outcomes and Lessons Learned:

- Government commitment to address GHG emissions and energy consumption is crucial. Draw on energy efficiency as a core strategy. Set and update standards to guide industry toward more sustainable practices.
 - Minimum requirements, aspirational “reach” targets, and performance benchmarks that are scientifically sound—and easily understood—can help all parties to measure progress and track improvements over time. Both existing buildings and new buildings must be addressed to have broad impact on the built environment sector.
- Success relies not only on deploying advanced new technologies, but on bringing energy efficiency best practices (and other sustainability strategies) that are already feasible and commercially viable, into standard practice.
- Governments can use public sector buildings to provide proof of concept, encourage innovation, and “lead demand.” In addition to encouraging voluntary adoption, making sustainability requirements more stringent over time can bring along the rest of the sector.

For Further Information:

- [Sustainable Infrastructure: Resource Efficiency and Circularity webinar recording \(starts at 36:20\)](#)
- [Singapore, Centre for Liveable Cities. \(2019\). Urban Systems Studies: Preparing for a Climate Resilient Singapore](#)
- [Singapore, Centre for Liveable Cities and Urban Land Institute. \(2020\). Building Climate Resilience in Cities Worldwide: 10 Principles to Forge a Cooperative Ecosystem](#)
- [United Nations Environment Programme. \(2021\). International Good Practice Principles for Sustainable Infrastructure. Nairobi](#)
- [United Nations Environment Programme. \(2021\). ‘Singapore’s Green Buildings’, in: Integrated Approaches in Action.](#)



Opening in 2019, the SDE 4 building at the National University of Singapore is the first new-build net-zero energy building in the nation. It features the use of efficient HVAC systems, solar photovoltaics, and architectural designs suited to a tropical environment. (Source: Kevin Hsu)