Passive design in Cambodian architecture:

A look at past and current use of passive cooling strategies

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Skyline of Phnom Penh -
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The principal authors of the report was Andeol Cadin with close collaboration of Kimberly Roseberry from ESCAP. The peer review were provided by Marco Duran and Manjeet Singh from UNEP, and valuable suggestions were provided by Jenin Mohammed Obeidat from ESCAP.

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Abbreviations and acronyms

°C	Degrees Celsius
CCAP	Climate Change Action Plan
CCCSP	Cambodia Climate Change Strategic Plan
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
LTS4CN	Long Term Strategy for Carbon Neutrality
NAP	National Adaptation Plan
NCAP	National Cooling Action Plan
NCSD	National Council for Sustainable Development
NDC	Nationally Determined Contribution
NEEP	National Energy Efficiency Plan
UNEP	United Nations Environment Programme

References to dollars ($) are to United States dollars unless otherwise stated.

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Chapter 01

The growing need for cooling

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Cooling, particularly space cooling, is transitioning from a luxury to an essential service in Cambodia. Cooling – in both active and passive forms – delivers thermal comfort, supports healthy environments and enables productivity in educational and workplace settings. As temperatures continue to rise with climate change, cooling in buildings and urban settings is playing an increasingly critical role in socio-economic development and the quality of people's daily lives.

Heat stress induces an annual loss in gross domestic product of at least US$1.12 billion in Cambodia (Sustainable Energy for All, 2023). The combination of shifting climate conditions and urban development is setting the stage for an amplification of cooling needs over time.

The market for air-conditioning systems has grown rapidly in Cambodia, spurred by burgeoning demand for new housing and infrastructure due to population rise, urbanization and increasing incomes. The demand for space cooling is projected to double in the next 20 years (Ministry of Environment and National Council for Sustainable Development [NCSD], 2022, p. 28).

Despite low penetration rates of air conditioners, used to keep indoor spaces thermally comfortable, cooling services already constitute an estimated 45 per cent of the nation's electricity use.

Solutions are needed to deliver cooling services while mitigating their impacts on energy systems and the climate. Passive cooling stands out as a building design and urban planning approach. It emphasizes the regulation of heat gain and its dissipation to enhance indoor and outdoor thermal comfort, all while curbing energy use.

The objective behind passive cooling strategies is two-fold:
1) to inhibit heat from permeating the interior spaces of buildings through shading and a protective exterior building envelope, and **2) to expel heat** from structures through natural ventilation. This document casts a light on the influential role of building design in Cambodia. The design of buildings can mitigate the demand for active mechanical cooling, such as fans and air conditioners. It also can leverage passive cooling approaches to realize energy savings, minimize emissions, and foster healthier and more liveable urban environments.

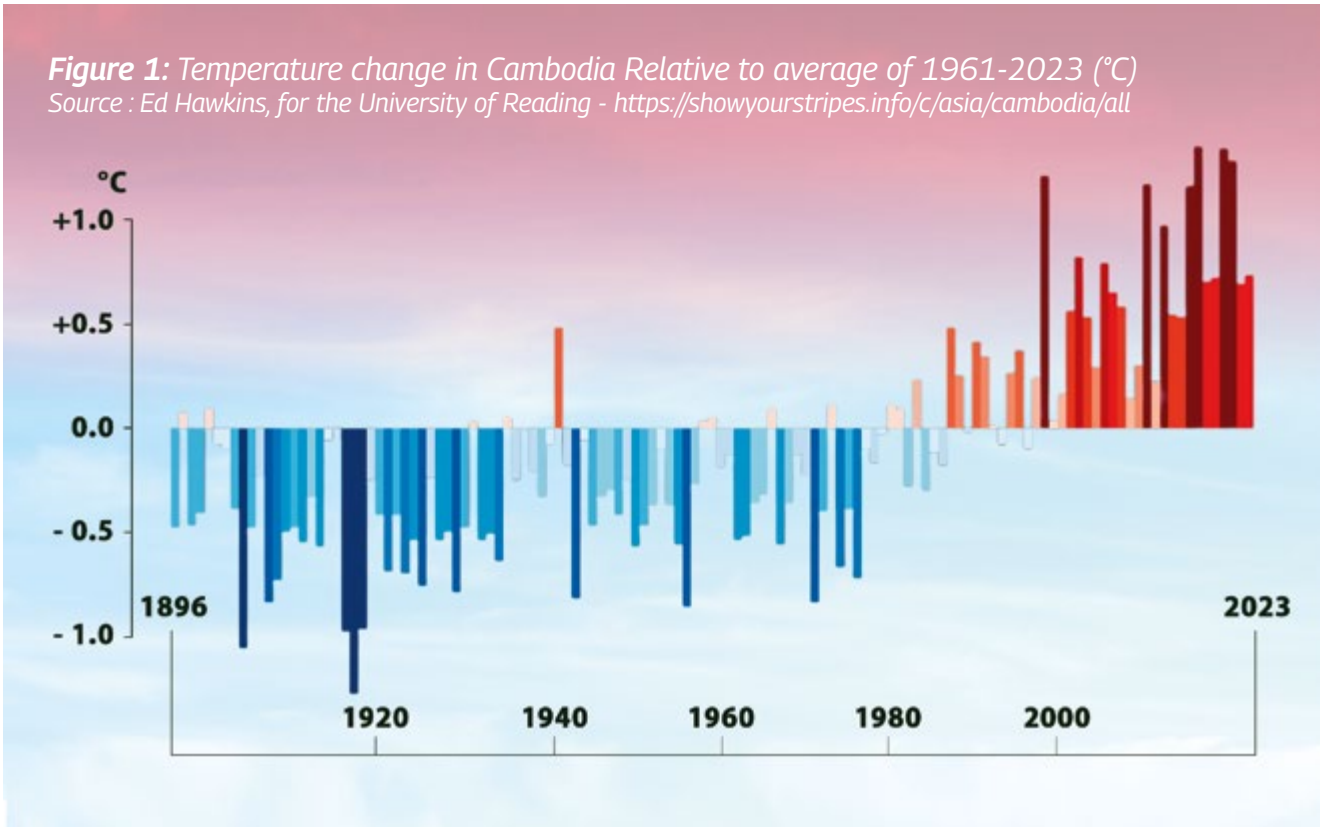

Figure 1: *Temperature change in Cambodia Relative to average of 1961-2023 (°C)*
Source : Ed Hawkins, for the University of Reading - https://showyourstripes.info/c/asia/cambodia/all

1.1 CAMBODIA IS GETTING HOTTER

Cambodia is characterized by a tropical climate and experiences two distinct seasons, influenced by the monsoon winds. The rainy season, spanning from May to October, is responsible for up to 90 per cent of the nation's yearly rainfall. The dry season begins in November, offering cooler temperatures until January, before a swift surge in temperature from March onwards.

During the hottest months of March and April, the people in the capital city of Phnom Penh, among other regions, are exposed to high levels of heat. Those without access to air conditioning face the greatest risks of discomfort and health risks.

Since the 1960s, Cambodia's average annual temperature has increased around 0.18 degrees Celsius (°C) per decade (World Bank and Asian Development Bank [ADB], 2021). Cambodia already has one of the highest average temperatures globally, with temperatures exceeding 35° C for 64 days a year on average (World Bank and ADB, 2021).

Temperatures are expected to continue to rise in the near future, leading to higher annual levels and increased frequency of heat stress.

Average temperatures are relatively uniform across Cambodia, but they soar highest in the early summer months of March and April (before the beginning of the rainy season), when peak temperatures often surpass 32° C. For the rest of the year, temperatures remain consistently between 25° C and 27° C.

From May through November, the onset of the wet season introduces the most substantial rainfall, especially in the southeast and northwest of Cambodia. The average annual rainfall fluctuates between 1,400 and 2,000 millimetres, with coastal and highland regions receiving more precipitation compared to their inland counterparts.

Populations in Cambodia are exposed to high levels of heat and humidity, underscoring the need for passive cooling strategies in building design and construction to improve thermal comfort and enable adaptation to a changing climate.

1.2 DEMAND FOR COOLING IS RISING, PARTICULARLY IN URBAN ENVIRONMENTS

Due to a combination of geographic, climate and socio-economic factors, Cambodia is recognized as being highly vulnerable to the impacts of climate change. This includes the increase in the frequency and intensity of heat waves that have been observed in recent decades (World Bank and ADB, 2021).

The effects of temperature rise and heat stress in urban areas are compounded by the phenomenon of the urban heat island effect. Lower ventilation rates in areas of high density – along with dark surfaces, thermal mass, air pollution and an absence of vegetation – can push temperatures higher than those in rural surroundings. Particularly high urban heat island levels have been reported in Phnom Penh, with daytime temperatures in the city climbing as much as 4° C higher than in surrounding rural areas (World Bank and ADB, 2021). Rising temperatures have far-reaching implications for various facets of urban living, adversely impacting the following:

- **Human health:** Elevated temperatures pose risks to both physical and mental well-being.

Figure 2: *Global horizontal irradiation, Cambodia, 2019.*
Note: Map published by the World Bank Group, funded by ESMAP and prepared by Solargis.
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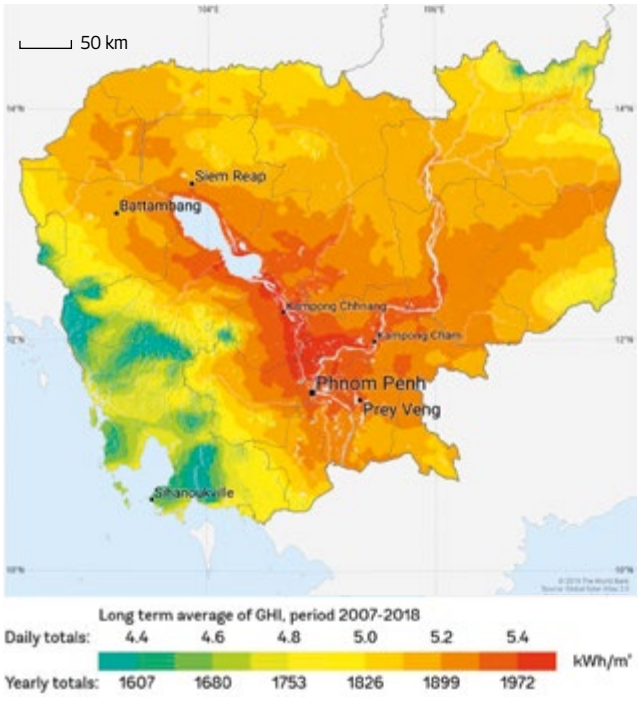

Figure 3: *Projected Average Monthly Temperature Anomalies in Cambodia for the 2030s and 2050s, Under the SSP3-7.0 Scenario.* *Source: World Bank's CCKP.*
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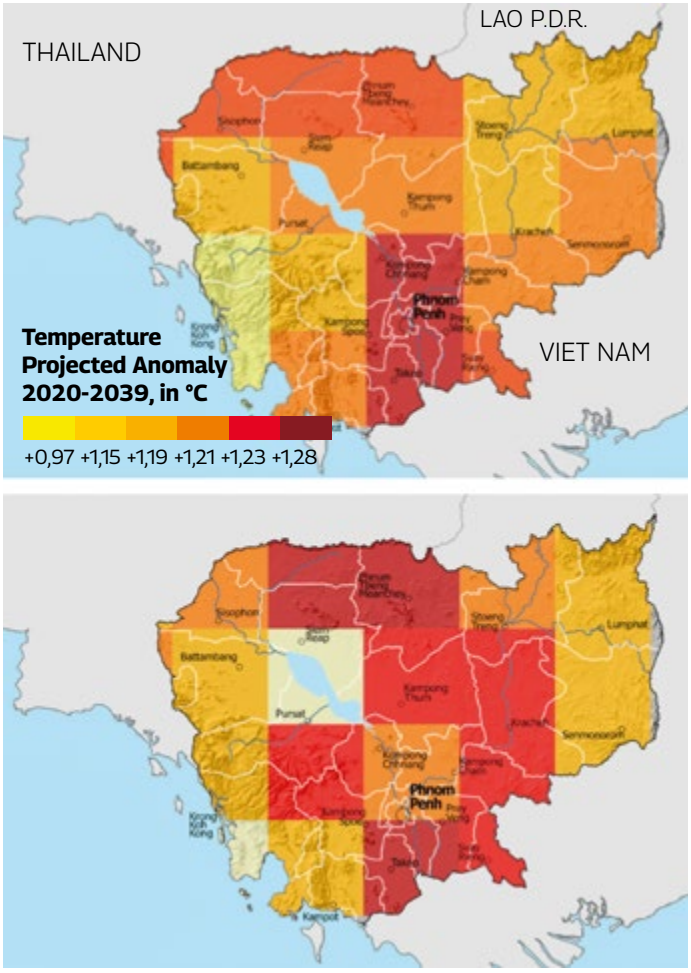

- **Productivity:** Students and workers have lower performance levels when they lack thermal comfort.
- **Energy demand and greenhouse gas emissions:** Increased use of mechanical cooling releases emissions associated with electricity and refrigerant consumption.
- **Power system strain:** Higher temperatures drive up energy use and peak energy demands.
- **Vulnerable communities:** The brunt of heat stress disproportionately affects impoverished and vulnerable populations.

Heat stress is expected to lead to increasing losses in working hours and productivity. Temperatures in Phnom Penh are already uncomfortable during the hot season, and in 2023 South-East Asia experienced a record-breaking heat wave that made international headlines.

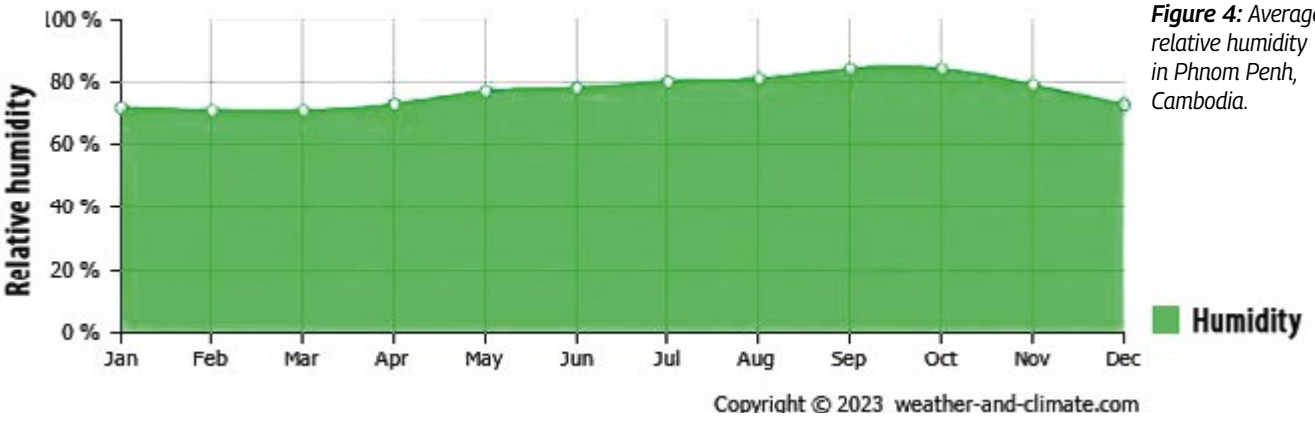

Figure 4: *Average relative humidity in Phnom Penh, Cambodia.*

Exposure to extreme heat carries high health and productivity risks for people who work outside – for example, as construction crew, street vendors or rickshaw drivers. At the same time, poorly cooled. or uncooled interiors negatively affect people in offices, factories, schools and homes. April and May are typically the hottest months of the year in South-East Asia, as temperatures rise before monsoon rains bring relief. In 2023, these two months registered heat levels never experienced before in most countries of the region *(Igini, 2023)*.

Climate change is altering weather patterns, with air temperature being a crucial element. In Cambodia, the health risks are further amplified and more dangerous when high temperatures coincide with elevated humidity levels.

1.3 HUMIDITY AMPLIFIES HEAT STRESS

Humidity, on top of extreme temperatures, makes it even harder for people to cool themselves.

To understand the health risks of humid heat, scientists often calculate the "feels-like" temperature – a single measure of how hot it feels to the human body when air temperature and humidity are both considered. Perceived heat is usually several degrees higher than observed temperature and gives a more accurate reading of how heat affects people. Across the year, Cambodia experiences elevated nighttime humidity, often surpassing 90 per cent. Throughout the dry season, humidity averages around 50 per cent or slightly lower, but it persists above 60 per cent during the rainy season *(Ross, 1987)*. The combination of high heat and humidity can compromise the human body's main cooling mechanism: sweating. The evaporation of sweat from the skin provides a cooling effect, but this is inhibited at higher levels of humidity, which curtails evaporative cooling *(Dr Kinnaleth Heat Stress Study, Cambodia Council for Sustainable Development)*. Consequently, individuals may encounter heat stress and related illnesses, and the outcomes can, at times, prove fatal.

The interplay of heat and humidity in Cambodia's climate therefore presents additional challenges for managing comfortable and healthy interior environments.

The combination of temperatures and humidity is putting factories workers under increased Heat stress, as climate warming is emphasizing the phenomenon. Photo: Khem Sovannara.

Photo: © Virak Kun - Unsplash.com

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Chapter 02

CAMBODIA'S expanding building sector and policy framework

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Photo of NCAP launch sharefolder stock. Photo: Mr LUN Lido

2.1 CAMBODIA'S BUILDING SECTOR GROWTH TRENDS

Cambodia is experiencing an urban transformation, and its skyline has been steadily redefined since 2010, reaching a construction peak between 2017 and 2019. Although the COVID-19 pandemic slowed construction, a full resumption of the sector's growth trend is expected.

In 2021 alone, the Ministry of Land Management, Urban Planning and Construction approved projects adding nearly 13 million square metres, with similar expansions anticipated annually for at least the next 15 to 20 years. The burgeoning construction outlook heralds a corresponding surge in energy demand for cooling these new spaces.

The buildings sector is the most significant final energy consumer in Cambodia, accounting for an estimated 52 per cent of final energy use in 2020 (United Nations Development Programme Cambodia, 2020).

The number of construction projects approved in Cambodia has increased significantly, with steady growth each year. In 2021 alone, MLMUC approved 4,302 new development projects covering 12,998,072 square metres. Residential real estate, especially in cities such as Phnom Penh, has seen a significant increase in supply" *(IPS Cambodia: Jennie B | April 2024)*.

A projection by GlobalData (2023) expects the construction industry to **expand at an annual average rate of more than 6 per cent** from 2024 to 2027, buoyed by investments in infrastructure and in the commercial and residential sectors.

Notably, the advent of a expanded, multi-mode transport system is poised to substantially drive construction demand. The new system is aimed at interconnecting Cambodia and its neighbours by 2030 and constitutes 330 transport infrastructure projects, with a cumulative investment by the Ministry of Public Works and Transport of $50 billion.

In 2022, Cambodia approved fixed-asset investment projects totalling $4.68 billion, marking a **7 per cent increase** from the preceding year, according to a Council for the Development of Cambodia (CDC) report (CDC, n.d.).

A considerable share of this is earmarked for construction and infrastructure. Given this backdrop, the scaled use of passive cooling strategies in new construction is pivotal – not

only to improve thermal comfort, but also to curtail the energy demand for space cooling. This is aligned with Cambodia's vision of moulding its cities into exemplars of clean, green and competitive urban centres, promising their inhabitants a secure and healthful living environment.

2.2 NATIONAL BUILDING SECTOR PRIORITIES AND TARGETS

Amid a burgeoning buildings sector, Cambodia is working to balance its urban expansion with sustainability through various policy adaptations and strategic plans.

However, the nation is still in the early stages of introducing construction and building energy codes, which provide a foundation for the introduction of passive cooling strategies.

Following is a list of the main policy and regulatory initiatives related to Cambodia's response to climate change, as well as initiatives that more specifically support the decarbonization of the buildings sector.

MINISTRY OF MINES AND ENERGY

THE CLIMATE CHANGE ACTION PLAN (CCAP) FOR THE ENERGY SECTOR 2021-2023 includes several measures to **support the decarbonization** of the construction sector (Ministry of Mines and Energy, 2020). Supporting policy and regulatory initiatives include the following documents:

NATIONAL ENERGY EFFICIENCY POLICY (NEEP) 2022-2030

Released in 2023, the NEEP:

- **Aims to curtail energy consumption** in residential buildings by 34 per cent and in commercial and public buildings by 25per cent through energy efficiency enhancement.
- Advocates for the **implementation of a building energy code** to endorse energy-efficient buildings.
- Calls for the **development and implementation of energy efficiency projects,** including standards and labelling programmes.
- **Establishes an energy management programme** for large buildings and factories and a voluntary scheme for small and medium enterprises.
- Supports capacity-building and awareness-**raising about energy savings** (National Committee on Energy Efficiency, 2022).

POWER DEVELOPMENT MASTER PLAN 2022-2040

Fig. 5: *Power Development Master Plan Cambodia 2022/2040. Source: Asian Development Bank / Kingdom of Cambodia*
Disclaimer: *the boundaries and names shown and the designations used in the maps showcased on this page does not implies official endorsement or acceptance by the United Nations.*

The master plan outlines plans to **enhance the country's electricity network**, add **more renewable energy** to the grid, advocate for energy efficiency measures, and provide affordable and reliable electricity (Ministry of Mines and Energy, 2023).

MINISTRY OF LAND MANAGEMENT, URBAN PLANNING AND CONSTRUCTION

CLIMATE CHANGE ACTION PLAN (CCAP) 2015-2018. The CCAP advocates the following:

- **Preparation of spatial planning guidelines** at all levels for climate change adaptation.

- **Integration of climate change** response measures into commune land-use planning.
- **Conducting of vulnerability assessments** for major urban areas to climate change and the development of climate safeguard principles.
- **Formulation and development of green infrastructure** and green building guidelines (Ministry of Land Management, Urban Planning and Construction, 2014).

Ministry of Environment and National Council for Sustainable Development (NCSD)

These government entities are involved in several climate and sustainable development initiatives, such as:

CAMBODIA CLIMATE CHANGE STRATEGIC PLAN (CCCSP) 2014-2023 ***(currently updated by a 2024-2025 Version, which includes recommendations on passive cooling).***

Among other initiatives, the CCCSP promotes: climate resilience through energy security, low-carbon planning and technologies to support sustainable development of the country, improvement of capacities and strengthening of institutional coordination for climate change responses (Royal Government of Cambodia, 2013).

National Adaptation Plan (NAP)

The NAP process, initiated in 2014, is used to identify and address climate-related vulnerabilities in key sectors, including infrastructure and energy. An ongoing NAP support project is including the outcomes of urban adaptation plans (Green Climate Fund, 2022).
The government is integrating green growth concepts into urban development and spatial plans through the NCSD-established **Technical Working Group on Sustainable Cities in 2015**, to respond to the need for sustainable development.

Chaktomuk Theater, Phnom Penh.
When traditional khmer architecture meets modernity, while integrating passive cooling strategies.
Photo: © A. Cadin & M.Tep

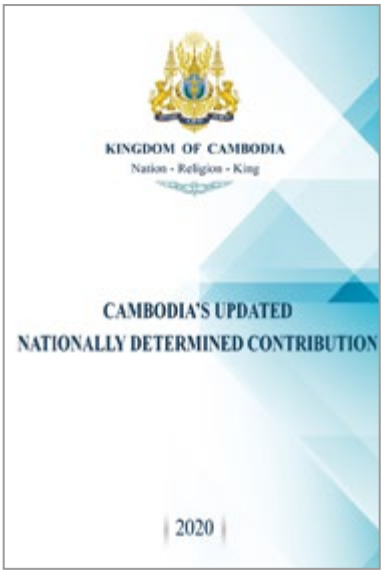
The Ministry of Environment and NCSD have also been collaborating with the Global Green Growth Initiative (GGGI) to develop a **Green City Strategic Planning Methodology** (NCSD et *al.,* 2016), which guides municipality, district, and commune officials, as well as national line ministries, in transforming Cambodia's cities towards greater sustainability and green growth.

Figure 6: *Sustainable City Plan for Phnom Penh 2018/2030. Source: Phnom Penh Master Plan*

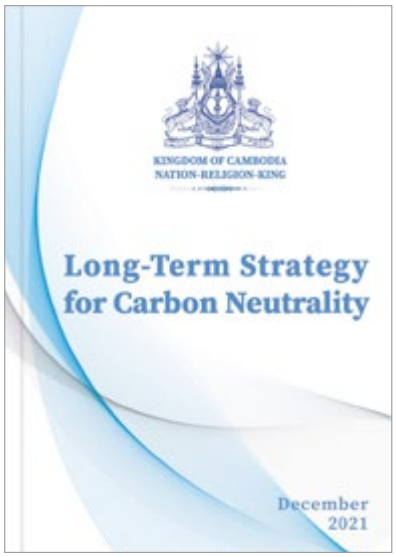
The collaboration has also led to the development of the **Sustainable City Plan for Phnom Penh 2018-2030**, which encapsulates objectives for improving the built environment, enhancing public spaces and green infrastructures, adhering to green building standards, and promoting building design to augment thermal comfort and curtail energy demands for cooling (NCSD, GGGI and International Centre for Environmental Management, 2018).

CAMBODIA'S UPDATED NATIONALLY DETERMINED CONTRIBUTION (NDC) 2020.

With the country's annual economic growth rate of 7.7 per cent, the associated rise in energy use is substantial. **Electricity consumption is projected to triple between 2025 and 2030. The NDC targets a 40 per cent reduction in energy-related greenhouse gas emissions by 2030** compared to a business-as-usual scenario. The construction sector is prioritized to achieve energy savings of 25 per cent through various measures (Royal Government of Cambodia, 2020).



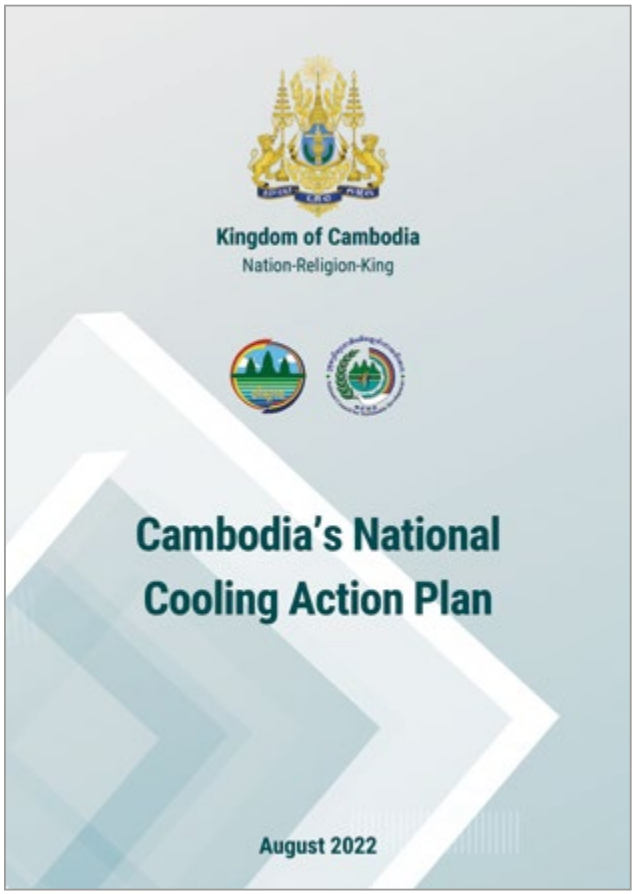
LONG-TERM STRATEGY FOR CARBON NEUTRALITY (LTS4CN)



The LTS4CN is intended to be a roadmap or vision document that is based on a comprehensive analysis and modelling of all relevant economic sectors. It outlines priority mitigation actions for each sector to achieve the country's goal of a carbon-neutral economy in 2050 (Ministry of Environment and NCSD, 2021). Its trajectory aligns with the Updated Nationally Determined Contribution.

CAMBODIA'S NATIONAL COOLING ACTION PLAN *(Ministry of Environment and NCSD 2022),* LAUNCHED IN MARCH 2023 *(see details in the following section)* fulfilling the NDC updated version call for formal development of national policies on cooling, the NCAP is supporting the current development of several related decree/sub-decrees.

However, comprehensive enactment of these strategies may span several years. The enormous scale and economic significance of the buildings sector offers a canvas of potential socio-economic benefits. Accelerating the adoption of passive cooling aligns well with several poli-



cies and commitments. Ensuring a seamless meld between Cambodia's rapid urban development and sustainable practices will be pivotal in navigating its future towards an environmentally conscious and economically stable nation.

Detailed construction and building energy codes are not yet in place (although they are under development, in consultation with multiple government ministries). However, unlocking the full potential of sustainable cooling will require comprehensive and integrated policy measures, including cross-sectoral collaboration and new forms of technical and financial support and investment.

Building Codes: Development and Challenges

Cambodia currently lacks established building codes, posing an initial challenge due to the absence of a foundational benchmark.

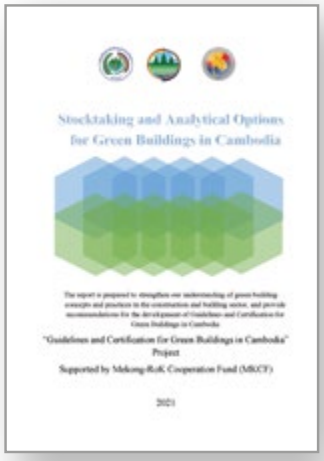
Local construction practices often align with regional and international standards, influenced by client preferences and investment origins. However, there is an opportunity to integrate sustainable design and construction components into the formation of a National Building Code.

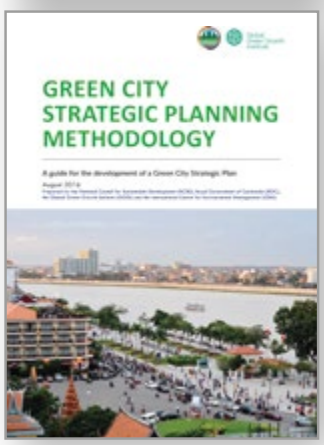
Market dynamics are evolving as considerations for operational costs and long-term implications gain importance. Balancing regulations with practical implementation and enforcement is crucial, given that a significant portion of the building stock is yet to be constructed, and the life cycle impacts connected to design and construction specifications are substantial.

Green Building Guidelines and Certification

The National Council for Sustainable Development (NCSD) within the Ministry of Environment has been actively developing a framework for green buildings in Cambodia.

A notable publication, *Stocktaking and Analytical Options for Green Building in Cambodia 2021*, outlines the background of green building projects, institutional frameworks, requirements and operational scenarios. Green Building Council Cambodia, although recent, has formalized the green building trend and generated private sector interest in sustainability recognition schemes.





Institutions are moving forward with green building and green cities guidance documents.
Source: © Cambodian National Council for Sustainable Development.

Green building certifications denote environmental sustainability, improved occupant well-being, reduced operational costs and increased property value over the long term. Passive cooling strategies are easily integrated into green building certification frameworks, and

as increased focus is given to green buildings, specific criteria for passive cooling could be considered under certification schemes.

Expanding passive solutions to industrial and commercial buildings

Factories in Cambodia expose many workers to heat stress, affecting their health and productivity. Affordable solutions such as sun reflection / heat insulation on roofs and optimizing air flow inside working areas can greatly benefit workers and factory operators. Advocating for passive cooling strategies in factories, supported by institutions, can have a positive impact on a large number of people with minimal financial investment.

Strengthening and leveraging existing policies

Cambodia has made substantial progress in developing a structured policy framework for sustainable development. Several comprehensive policy documents already integrate, or offer opportunities to integrate, passive cooling as a key strategy to realize positive development outcomes.

These include:

- **Energy Efficiency Low Carbon Buildings Road Map.**
- **Nationally Determined Contribution (updated in 2020).**
- **Long-term Strategy for Carbon Neutrality (LTS4CN)** *(aiming for carbon neutrality by 2050)*.
- **National Energy Efficiency Policy (2022).**
- **Power Development Master Plan (2022-2040).**
- **Cambodia National Cooling Action Plan (2023).**

To continue to strengthen the integration of passive cooling into the policy framework, across ministries, various government ministries are focusing on related topics. The Ministry of Environment, which hosts the National Cooling Action Plan (NCAP), can benefit from local data and insights related to passive cooling strategies.

As modern commercial places, heavy energy consumers are built, adequate policy support to allow efficients developments is needed. Photo: Aeonmallcambodia.com

The **Ministry of Mines and Energy** promotes energy efficiency and develops energy codes and standards, while the **Ministry of Land Management, Urban Planning and Construction** works on sustainable master planning and the resilience of buildings. Collaboration with these ministries can lead to practical policy recommendations.

Harvesting low-hanging fruit

Passive cooling presents an opportunity for the Cambodian buildings sector to design and implement energy-saving measures quickly and efficiently, often with minimal extra effort or investment.
These strategies can be integrated into both voluntary policies (green buildings) and mandatory policies (building codes, low-carbon resilient buildings). A progressive performance scheme can be gradually integrated into national policies, starting with simple, cost-effective technologies and progressing to more advanced innovations.

Supporting Cambodia's National Energy Efficiency Policy and Paris Agreement commitments

Cambodia's commitment to greenhouse gas emission targets, outlined in the **updated Nationally Determined Contribution (NDC)**, provides an avenue to integrate passive cooling strategies into buildings and cities.

The recent policy on energy efficiency highlights the government's willingness to support improved power consumption efficiency and draws attention to the potential for energy savings in the buildings sector.

As both building codes and green buildings policy frameworks progress, developing a minimum performance standard related to buildings and energy would be a very well-timed initiative. This is crucial as Cambodia's economy grows rapidly and as the population seeks modern thermal comfort, which is currently reliant on mechanical cooling in a warming climate.

2.3 Passive cooling in Cambodia's policy framework

Heat stress has conspicuous economic implications, causing an annual loss in Cambodia's gross domestic product of at least $1.12 billion (United Nations Environment Programme [UNEP], 2023).

Cooling services consume one third of the country's total final energy. In recognition of these trends, Cambodia is gradually steering its policy framework towards endorsing passive cooling in urban structures and planning.

Political support for energy efficiency and climate-related agendas has grown in recent years, complemented by enhancements in construction institutions and planning frameworks.

Although extensive progress is still to come, notable steps forward indicate a pathway towards the introduction of regulatory tools and energy codes.

These steps include the initiatives mentioned in the previous section and, more recently (in March 2023), the release of the **National Energy Efficiency Policy** and the launch of **Cambodia's National Cooling Action Plan**.

Insights into Cambodia's National Cooling Action Plan

The NCAP is the inaugural policy document that strongly encourages the integration of passive cooling strategies, complemented by energy efficient actives approaches, with urban planning development, projects conceptions, buildings design and construction. It puts forth several national objectives:

- **Fostering** climate-friendly and energy-efficient technologies and practices.
- **Investigating and evolving market mechanisms** to make cooling technologies accessible and affordable.

- **Augmenting stakeholder capacities and advancing public awareness**, alongside emphasizing stakeholder engagement on energy efficiency within the cooling sector.

Envisaging more hospitable cities, the NCAP also underlines the following measures:

- **Mitigating cooling demand** through improved urban planning and building designs that shield inhabitants from the sun by incorporating green spaces, green roofs and green walls (passive cooling strategies).

- **Safeguarding vulnerable populations** against the ramifications of extreme heat and unreliable medical and agricultural cold chains.

A COMMITMENT TO SUSTAINABLE BUILDING PRACTICES

Cambodia's dedication towards fostering and executing its updated NDC encompasses introducing low-carbon buildings, energy efficiency and building energy codes.
Launched nationally in March 2023 by the Ministry of Environment, Cambodia's NCAP prioritizes **reducing cooling demand** and **introducing energy-efficient space cooling** within buildings to reduce strain on energy systems and the environment while providing thermal comfort to building occupants.

The NCAP points to a number of key actions:

- **Introducing minimum performance standards** for passive cooling of buildings.

- **Releasing a compendium of passive cooling strategies** applicable in Cambodia and neighbouring regions.

- **Fostering collaboration on demonstration projects** to observe and evaluate passive design strategies in real-world conditions.

- **Undertaking microclimate modelling** and offering recommendations for mitigating the urban heat island effect.

- **Supporting the impact assessment** of embedding passive cooling strategies in the construction of new buildings, aligning with the country's 2020 updated NDC and greenhouse gas emission reduction targets.

Conclusively, positioning passive cooling at the forefront of policy frameworks could emerge as a pivotal strategy in maneuvering Cambodia's path towards sustainability, while mitigating economic losses attributed to heat stress and energy consumption by the cooling sector.

Integrating these strategies will necessitate a harmonized effort across various stakeholders and sectors, underscoring the importance of comprehensive policies, widespread awareness, and technical and financial support to actualize these goals.

Photo: Aerial Phnom Penh view -
Source: allphotosbangkok - Unsplash.com

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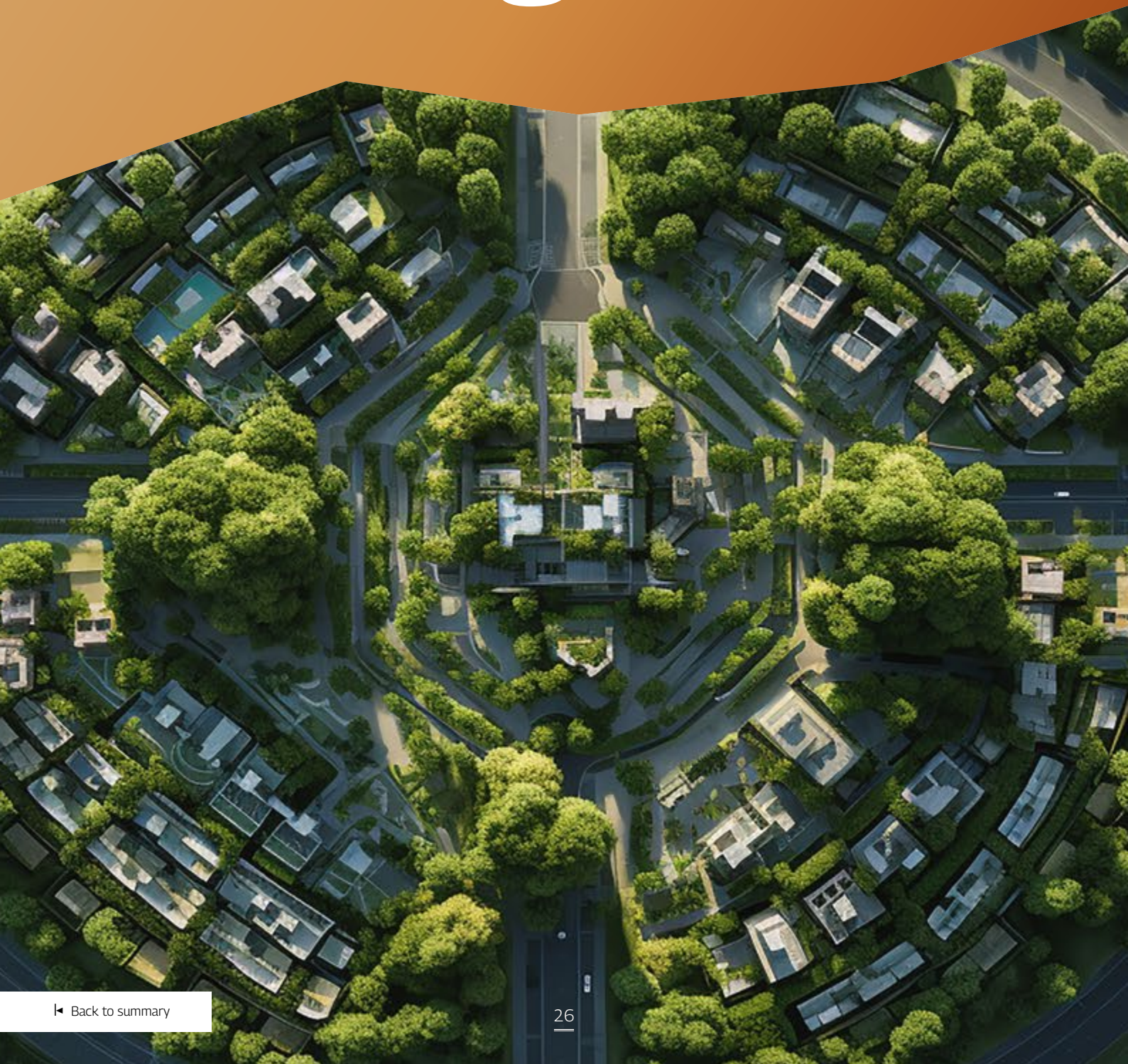
Chapter 03

Passive **cooling strategies**



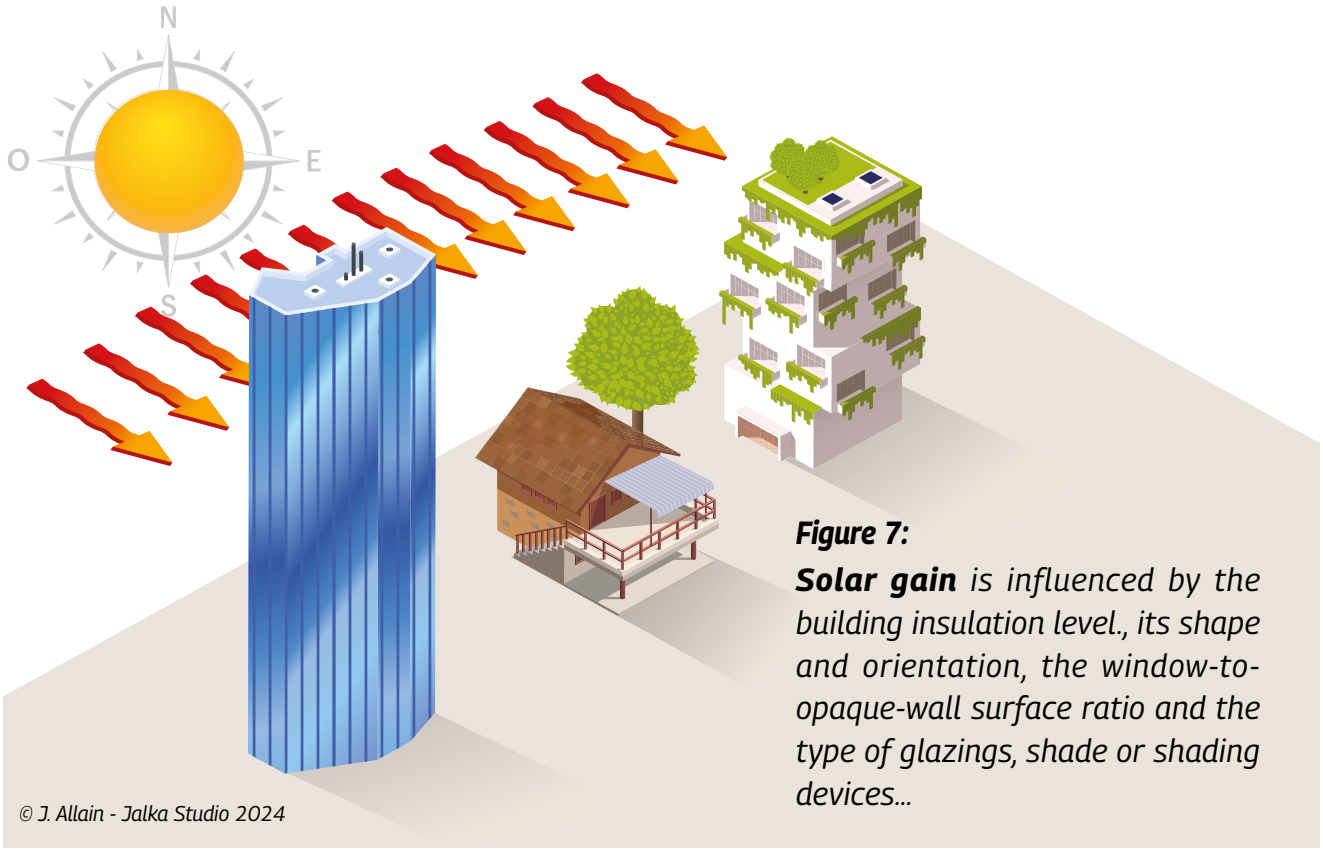


Figure 7:
***Solar gain** is influenced by the building insulation level., its shape and orientation, the window-to-opaque-wall surface ratio and the type of glazings, shade or shading devices...*

3.1 WHAT DO WE MEAN BY PASSIVE COOLING?

Passive cooling strategies serve as effective solutions to mitigate high indoor temperatures. Through the incorporation of passive design principles – such as optimal building orientation, shading, natural ventilation and insulate building envelopes effective use of thermal mass – buildings can greatly reduce dependence on mechanical cooling systems to provides thermal confort.

Passive cooling strategies manage surface and air temperatures and reduce the length of uncomfortably hot periods. They can help significantly decrease the need for mechanical cooling and thus the consumption of energy to operate space cooling equipment and fans. These strategies are customarily introduced through a blend of climate-responsive architectural features, which include building envelopes, reflective exterior finishes, high-performance windows, natural ventilation, optimal orientation and the use of nature-based solutions such as trees for shade. Studies suggest that the effective incorporation of these strategies can mitigate the need for mechanical cooling by 10 to 20 per cent (Cool Coalition, n.d.) at the low end, and 70 per cent or higher in best case examples. Passive cooling strategies enable a building to minimize heat gain and to dissipate heat. **Strategies differ according to climates.** In **some climates, buildings may be able to provide cooling in a fully passive manner.** For some locations, seasonal changes may mean that the building can operate passively at some times of the year, while other times will require active cooling. For some buildings, mechanical cooling may be required throughout the year, and passive design measures will be employed to reduce the demand on those cooling systems.

Incorporating passive cooling strategies at the design stage is most effective in terms of costs, long-term energy savings and improved sustainability. **Strategies can be organized into the three main categories outlined below** and should be selected based on local climate and site conditions, as well as the building's intended building operational mode(s).

SITE DESIGN

Shading and cooling can be introduced on the site with the incorporation of trees and vegetation. The management of ground treatment – with a preference for materials then

A combination of site level passive strategies to support air cooling, and building level features like vertical shading, allows to deliver adequate thermal comfort without relying on heavy energy consumption. Photo: A. Cadin & M.Tep

can either reflect the sun's radiation (cool pavements) or absorb it without transmitting the heat (grass) – are crucial to create a microclimate able to minimize heat gains from the sun's rays.

BUILDING DESIGN

Building orientation should account for location and surroundings, such as the sun's path, the existing landscape, water elements and natural wind corridors. Strategies include configuring the building to benefit from site "advantages" such as existing sources of shade and prevalent wind direction, while safeguarding against sun exposure.

Architectural design strategies include optimized window-to-wall ratios, insulated building envelopes, architectural shade elements (both fixed and operable) and, where natural ventilation is used, air flow and convection strategies, including the chimney effect. High-performance building envelopes are especially important for buildings that operate air-conditioning systems, and consider airtightness, healthy levels of ventilation and condensation prevention.

MATERIALS AND TECHNOLOGIES

Reflective and insulating materials used within the building envelope have a significant influence on its performance. Solutions include high-albedo roofing materials, reflective paints and cladding components, high-performance glazing, and wall and roof insulation strategies.

An in-depth look at passive cooling strategies is provided in section 3.2..

A lush garden around the building widely open is supporting natural wind flow and air cooling, making the place comfortable, without air conditioning installation. Coconut park, Koh Pick, Phnom Penh. Photo: A. Cadin & M.Tep

3.2 PASSIVE COOLING STRATEGIES IN BUILDINGS: CLIMATE-RESPONSIVE ARCHITECTURE

This section explores the technical strategies that can be used to create climate-responsive architecture through passive cooling strategies. Passive cooling strategies encompass a wide range of techniques and design concepts specifically tailored to hot climates. Their primary goal is to minimize heat gain in buildings while lowering reliance on energy-consuming systems such as air conditioning. These strategies consider natural principles such as convection, radiation and conduction to manage and reduce thermal exchanges within the building envelope. To maintain clarity and facilitate practical application, these strategies can be grouped into three main categories, as follows.

PASSIVE COOLING STRATEGIES AT THE SITE LEVEL

Site-oriented strategies focus on improving outdoor spaces to enhance the microclimate and capitalize on it to some extent. This involves integrating elements such as vegetation, water features (such as ponds and fountains) and climate-responsive outdoor surfaces (e.g. permeable surfaces, cool pavement). **The surrounding environment plays a crucial role** in supporting these microclimate enhancements. Strategies include optimizing wind flows, redirecting them and cooling them with water features. It is essential to work on globally exposed and shaded site areas in relation to the location of future construction. These principles can also be applied at the district or city level.

PASSIVE COOLING STRATEGIES AT THE BUILDING LEVEL

Building-level strategies, often referred to as design-oriented strategies, encompass techniques and design principles aimed at ensuring optimal indoor thermal comfort, achieved through managing heat (see Box 1).

A series of passive strategies adopted by the Architect Vann Molyvann, illustrating the potential of a climate responsive design, protecting buildings from the heat, providing natural air flow and sufficient day lighting, to ensure user thermal comfort. Photo: Shinkenchiku-sha - a+u

Once site-level opportunities have been identified, the building's design must incorporate passive principles. This can be achieved through considerations such as building orientation, managing solar radiation exposure and capturing prevailing wind flows. In hot, humid climates like Cambodia, maximizing shade and avoiding glass walls that face direct sunlight are advisable. Effective ventilation, oriented to capture breezes and reduce humidity, is another critical element.

The building's shape and openings should be designed to optimize ventilation while preventing direct sunlight exposure. Factors such as building mass and thermal inertia should also be taken into account, as they can greatly impact thermal performance. Spatial configuration plays a role in optimizing comfort and energy efficiency by aligning spaces with their functions, occupancy load, size and energy use.

BOX 1

BETTER BUILDING DESIGN CAN REDUCE THE NEED FOR COOLING

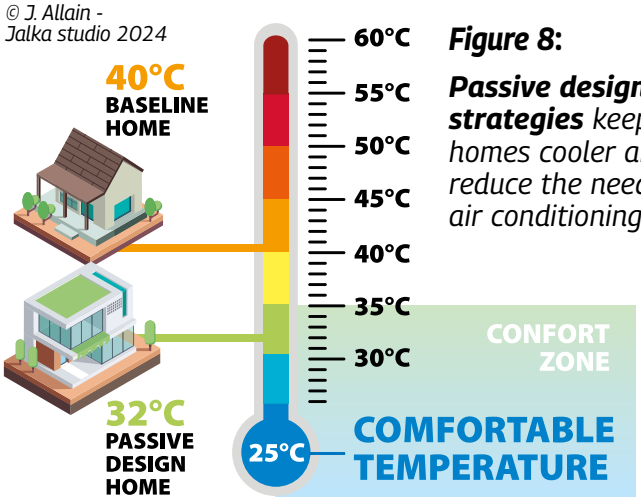


Figure 8:

Passive design strategies *keeps homes cooler and reduce the need for air conditioning.*

- **Passive cooling relies on designing building envelopes** (including walls, windows and roofs) to minimize daytime heat gain, maximize nighttime heat loss and encourage natural ventilation to the fullest extent possible.
- **Design approaches** that can greatly reduce cooling energy demand include:
- **Using high-quality white roof coatings** that reflect up to 80 per cent of the sun's energy, compared to black roofs that reflect only 5 to 10 per cent *(Global Alliance for Buildings and Construction and UNEP, 2020, p. 59)*.
- **Employing high-performance thermal building envelopes** (foundations, external walls, roofs and external doors) to reduce cooling demand by 30 to 50 per cent.
- **Installing low-emissivity glass** that reflects infrared solar radiation without affecting visible light entry, reducing cooling demand by at least 20 per cent compared to conventional glass.
- **Leveraging natural ventilation**, especially in humid climates, which can reduce the overall number of hours that air conditioning is needed by as much as 40per cent while maintaining indoor comfort levels. Analyses in office buildings in Thailand show that natural ventilation alone can reduce the energy demand for cooling by 8 per cent.
- **Designing landscapes** to incorporate trees and vegetation to lower site temperatures can save up to 25 per cent of the energy used for cooling.
- **Reducing cooling demand** requires reinterpreting traditional construction methods and adapting them to local needs and preferences.
- **Architectural design considerations** to maximize occupant comfort and need for active cooling include:
- **Adapting the floor plan** and building form to respond to the local climate and site conditions.
- **Properly zoning living and sleeping areas** in line with the climate.
- **Placing air-conditioned rooms** in thermally protected areas that are well-insulated, shaded and well-sealed.
- **Maximizing the use of natural ventilation where possible** using high-level windows and ceiling or roof vents, and optimizing ceiling design and furniture placement to enhance the efficiency of fans, cool breezes and convective ventilation.

Source: Programme for Energy Efficiency in Buildings 2020.

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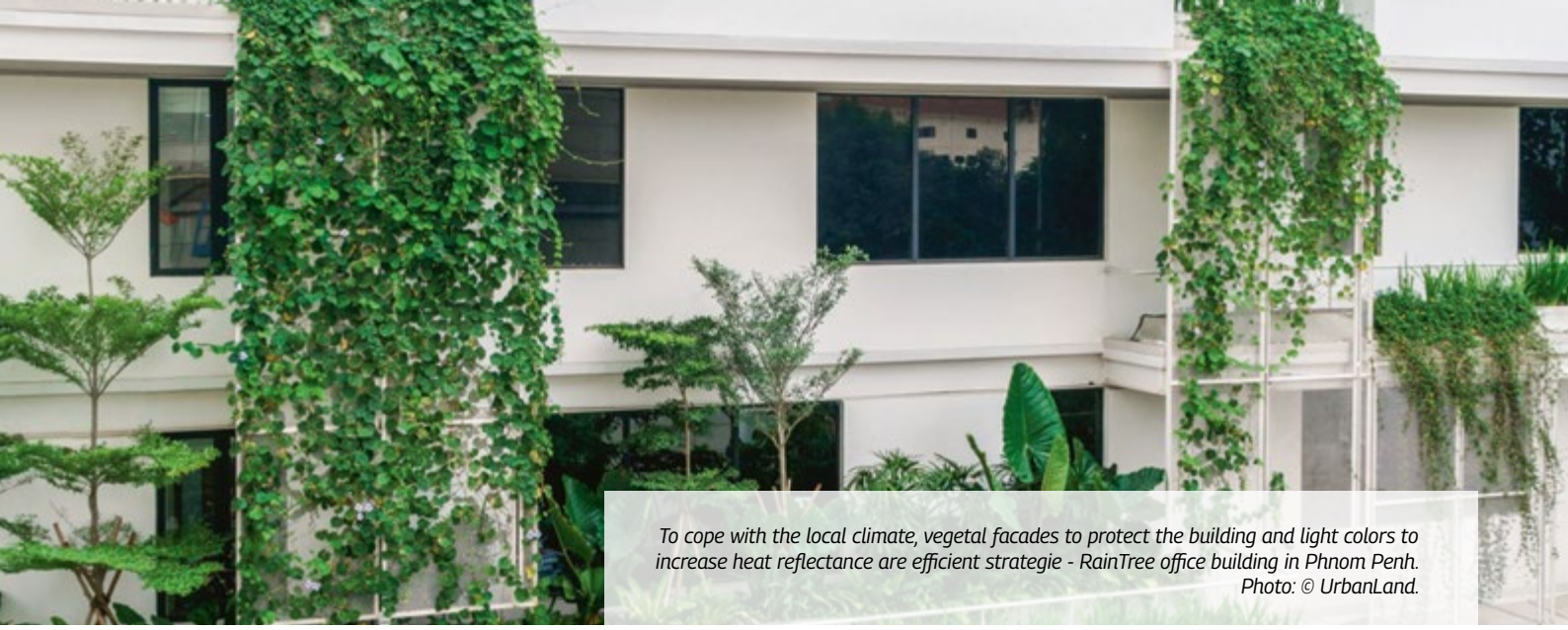


To cope with the local climate, vegetal facades to protect the building and light colors to increase heat reflectance are efficient strategie - RainTree office building in Phnom Penh. Photo: © UrbanLand.

Passive cooling materials and technologies

After considering site conditions and developing a building design, specific materials and technologies can be employed to enhance climate responsiveness.

- **Identifying key areas:** Start by identifying the areas of the building that will be exposed to the elements, including sun, wind and rain. Then, deploy appropriate technologies to address these factors, considering a list of relevant measures to be taken.

- **Prioritizing heat management:** Managing heat gain through the building envelope should be the top priority, taking into account the project's specific requirements and available budget, as well as future operation and maintenance considerations.

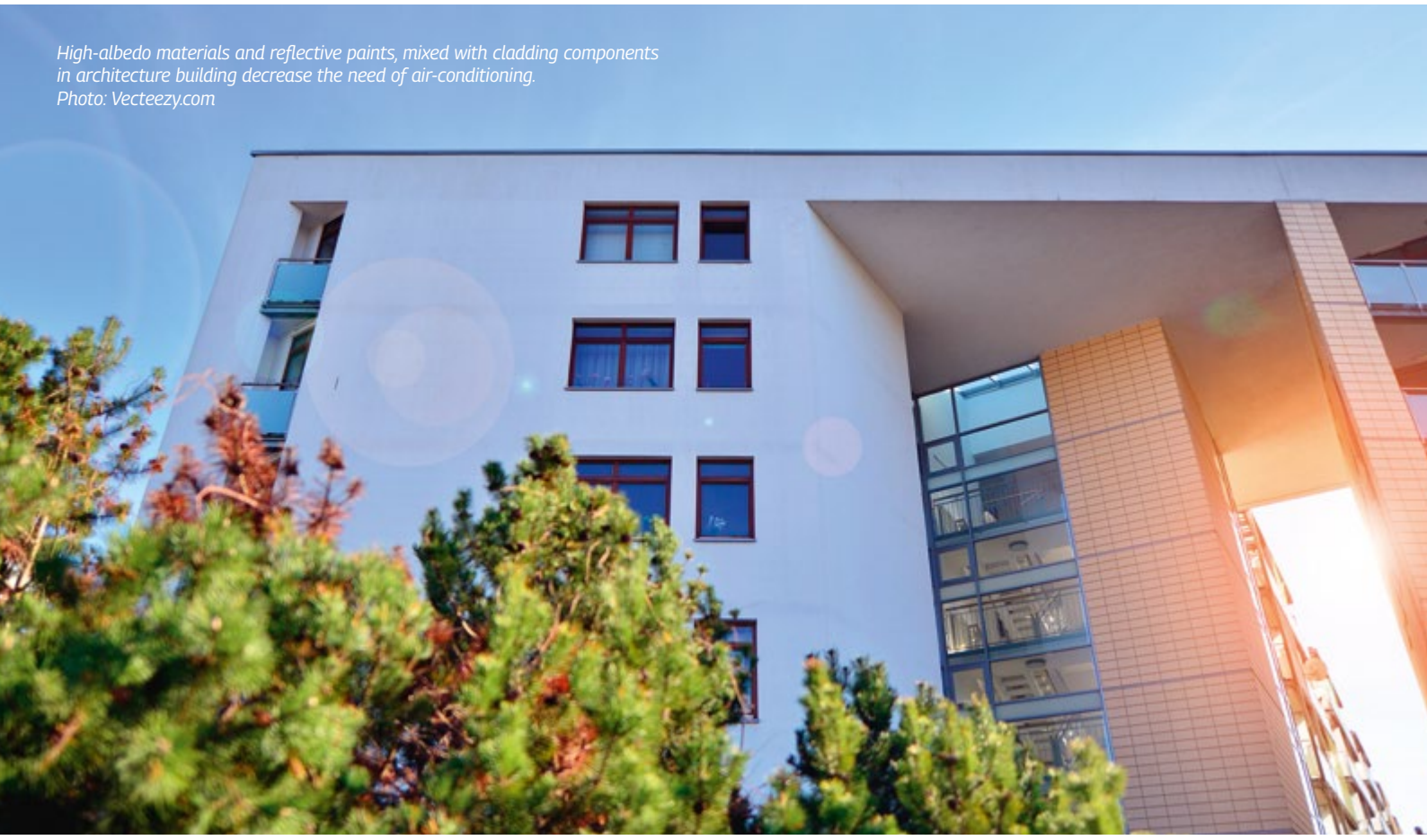
- **Local context considerations:** The local context within Cambodia plays a significant role in determining the final choices. This includes assessing the availability of local suppliers, considering the pricing and ease of importing materials to the project location, and ensuring that skilled professionals are available for implementation and ongoing maintenance.

- **Components supporting building solutions:** These building solutions should align with site parameters and building design strategies to fulfill specific functions, such as:

- **Insulation for walls:** This could involve using double rows of hollow bricks with a ventilated space in between them; cement-concrete hollow blocks; or autoclaved aerated concrete (AAC) lightweight blocks. Additionally, an extra layer of insulation such as blue foam board XPS may be added for specific areas or requirements, such as stabilizing cool temperatures in healthcare or information technology server rooms.

- **Reflective surfaces:** This entails using reflecting materials to lower the surface temperature of the building materials, reflecting solar radiation and preventing its absorption. As a result, the heat penetrating into the building is decreased, the indoor temperature is lowered, and the need for mechanical cooling is reduced. Practices that are helping to reduce surface temperatures include:

Roof tiles according their specific setup, color, and material property, can emphasize or on the contrary help to prevent part of the heat that is coming into a building. Photo: Vecteezy.com



High-albedo materials and reflective paints, mixed with cladding components in architecture building decrease the need of air-conditioning. Photo: Vecteezy.com

- **The use of high-albedo materials** is providing significant improvement for large surfaces exposed to the sun, such as roofs and façades. Lighter colors better reflect sunlight and minimize solar absorption by the building.

- **Using reflective paints and membranes** (often referred to as "cool roof" technologies) is delivering significant results for reasonable investment and is easy to implement.

- **Cladding components** that favour high sun reflection and low thermal conduction are also recommended.

- **Solutions for the building glazing,** such as low-e and high performance glazing, or solar films, offer a wide range of possibilities according to the project priorities and budget possibilities.

- **Shading devices:** Shading devices such as outside overhangs and louvers prevent direct sun radiation from reaching the building while preserving natural light and views.

- **Green façade components** can also be considered to insulate the building from the sun, support local microclimate cooling and provide other benefits. Properly designed and implemented, these components have minimal maintenance requirements and do not compromise the building's integrity over time.

- **Ventilation-supporting components:** Aerators can be installed in higher parts of the walls to allow hot air to flow outside.

Aerators features on top of building openings, let naturally the hot air escape from the indoor place, helping also to accelerate natural air movement . Photo: Vecteezy.com

An example of synergies: the new ACLEDA Business Institute, that combines site-level, building-level, materials and technologies to maximize occupants comfort and energy efficiency. The building has received the EDGE green building certification. Photo: ACLEDA Business Institute.com

Windows can be designed to be easily opened to control air flow, and can be either slightly or fully opened as needed.

The strategic placement of openable windows and fixed aerators to facilitate cross ventilation is crucial. Natural chimney effects can be considered that can effectively regulate temperature and humidity across the entire building, providing significant thermal comfort for a large part of the year.

These options are not only cost effective but also enhance comfort.

Synergies

Optimally combining these three categories of strategies – site-level, building-level and materials/technologies – can result in significant cooling benefits, maximizing cost-effectiveness, occupant comfort and energy efficiency. Experienced professionals should oversee the integration of these strategies to harness their full potential, as the right combination can yield exponential benefits.

3.3 Addressing the urban heat island effect in Cambodian cities

As cities grow, they concurrently radiate increased heat due to the amplified density and ongoing urbanization, a scenario further intensified by the consequences of climate change.

The accelerating warmth of urban areas, which are heating up at double the global average rate, calls for a meticulous reevaluation of urban planning strategies. The notion of passive cooling strategies surfaces as a pivotal methodology, not merely in architectural paradigms but extending into a comprehensive urban framework, bestowing a plethora of positive impacts across health, air quality and quality of life.

The mechanics of urban heat

Asphalt surfaces, characterized by their high heat absorption and retention capabilities, alongside concrete structures, contribute to

elevated temperatures in urban spaces.

The cumulative effect of these, in conjunction with air pollution haze – which hinders the dissipation of heat radiation – escalates the temperature within cities, manifesting what is widely recognized as the urban heat island effect (see Box 2).

Aspects such as density and landscape features are intrinsic to understanding and mitigating urban heat, influencing the thermal characteristics of urban microenvironments, and affecting localized heat intensity (Energy Sector Management Assistance Programme [ESMAP], 2020, p. 55).

The proliferation of "car-oriented" urban planning has become a pervasive trend globally, with Cambodia aligning with this trajectory.

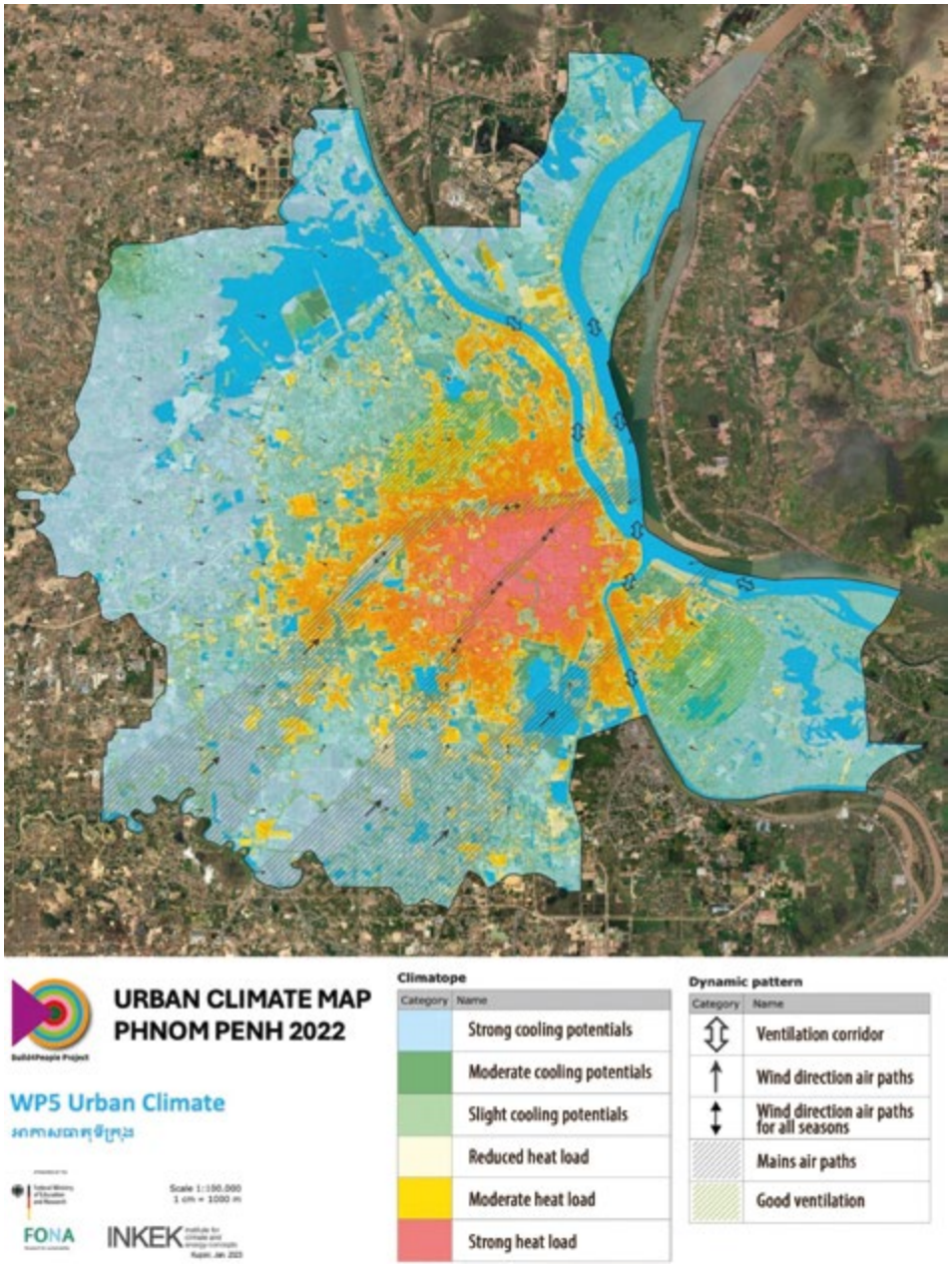


Figure 9: *Urban Climate Map Phnom of Penh. Source: INKEK - Build4People 2022*

Such planning patterns engender extensive asphalted surfaces for roads, highways, and parking, leading to thermal heat traps in urban spaces. This situation, coupled with the widespread use of concrete in buildings and dense urban configurations, further exacerbates the urban heat phenomenon.

Growing Cities, Shrinking Green Spaces

Urban expansion and densification usually coincide with escalating pressures on available urban land, which often result in the diminishing of vital green and blue spaces (vegetated spaces and water bodies). Poorly organized planning and lax enforcement of regulations often lead to the construction of buildings that obstruct natural wind channels, thus restricting air movement, elevating humidity levels, and intensifying the perceived heat, consequently compromising inhabitant comfort and health.

Comparative Urban Scenarios in Cambodia

In smaller or medium-sized Cambodian cities, the presence of substantial green spaces and water bodies – such as ponds, lakes and fountains – often mitigates the

intense heat, providing cooler microenvironments. Furthermore, these green and blue areas serve as stormwater buffers, preventing rapid flooding during intense precipitation events. Adequate greenery not only brings down temperatures but also facilitates wind flow, thus alleviating heat and reducing air pollution levels to an extent.

BOX 2

UNDERSTANDING THE URBAN HEAT ISLAND EFFECT

- Urban heat islands are a product of the prevailing construction practices within cities, which are typically 1° C to 3° C (National Geographic Education, n.d.) warmer than their peripheries annually due to factors such as dark, absorbing construction materials like concrete, scarce green spaces, designs obstructing natural wind flows, and heat emanations from cooling mechanisms, industrial procedures and vehicles.

DENSITY VERSUS URBAN HEAT ISLAND EFFECT

The question arises: Is city density intrinsically linked to the urban heat island effect? While many cities, predominantly following a car-oriented planning model, experience varying degrees of the urban heat island effect, evidence from the last two decades indicates that urban areas globally have initiated and adopted strategies to forge more thermally balanced environments. These strategies often involve the integration of nature-based solutions, such as trees, parks, rain gardens, and reservoirs, which are frequently integrated into pedestrian pathways and health promenade networks.

TOWARDS SUSTAINABLE URBAN THERMAL MANAGEMENT

There is an undeniable urgency to shift away from technologies, materials and designs that increase urban heat, prioritizing instead immediate, accessible and economically viable solutions. Nature-based strategies present themselves as a tangible, short-term remedy, capable of not only ameliorating urban temperatures but also enhancing overall urban livability and potentially elevating property values – thus bolstering city economies and fostering a more sustainable urban development model.

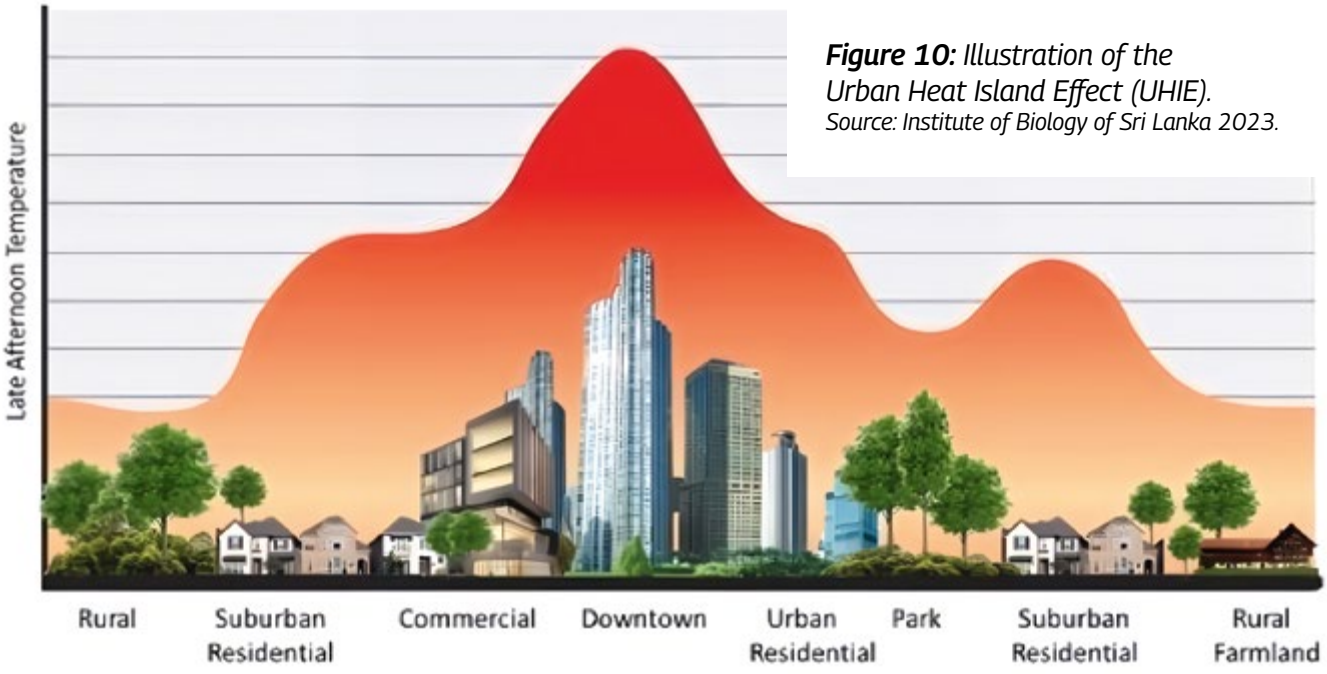


Figure 10: *Illustration of the Urban Heat Island Effect (UHIE).*
Source: Institute of Biology of Sri Lanka 2023.

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Preservating green spaces in the city helps to reduce urban heat island effect.
Park in Sangkat Tonle Basak, Phnom Penh, Cambodia
Photo: Axel Robert - Unsplash.com

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Protected from the sun by an attractive vegetal facade, additional planted rooftop, complemented trees at the street level. Baitong Hotel, Phnom Penh. Photo: A. Cadin & M.Tep

Site-oriented passive cooling strategies are design methodologies and techniques for outdoor spaces with a goal of managing the site's microclimate.

They encapsulate a multifaceted strategy involving the harmonization of vegetation, water features, permeable surfaces and cool pavements to create a wind-conducive, thermally comfortable environment.

By incorporating passive cooling strategies, Cambodia can foster a healthy, happy and productive population and paint itself as a forward-thinking county that integrates sustainable strategies within its urban development blueprint.

Site oriented passive strategies at Coconut Park, in Koh Pich, Phnom Penh, to improve site microclimate for the benefit of the occupants. Photo: A. Cadin & M.Tep

PIONEERING VISIONS: PHNOM PENH'S SUSTAINABLE CITY PLAN

Phnom Penh envisions a sustainable urban future through its Sustainable City Plan 2018-2030, aspiring towards a clean, green, and competitive city, embedding passive cooling strategies as an integral component in future building developments.

These standards, which are particularly vital for large-scale developments such as boreys and mixed-use projects, emphasize the **profound importance of passive cooling** within the urban development narrative (see Box 3).

BOX 3

PONDERING PASSIVE COOLING STRATEGIES

- Cooling services, which account for 45 per cent of national electricity use in Cambodia, present a sizable opportunity for cost and energy savings through passive cooling strategies (UNEP, 2023).
- With over one third of Cambodia's total final energy consumption being within buildings and a substantial fraction dedicated to cooling, passive cooling strategies offer an energy-saving potential of 10 per cent to 20 per cent.
- Passive cooling strategies, by diminishing carbon dioxide emissions, can propel Cambodia towards aligning with NDC commitments and multiple Sustainable Development Goals.
- Passive cooling strategies help people to improve their daily well-being and productivity, in addition to improve their income (active cooling solutions are very energy-intensive and electricity is expensive) and also make Cambodia a forward-looking country, integrating sustainable strategies into its urban development plan.

CONCLUSION

Navigating the challenge of rising temperatures **necessitates a paradigm shift in urban planning and design practices,** especially within the context of growing and evolving cities such as those in Cambodia.

Striking a balance between urbanization and density, and maintaining – or indeed enhancing – green and blue spaces is pivotal in averting pervasive urban heat island effects and in ensuring sustainable, comfortable and healthful urban living.

Photo: Vecteezy.com

Passive cooling strategies are central to building design and are a critical component in the broader urban design and planning realm. The amalgamation of traditional practices, innovative technologies and strategic planning creates a pathway towards not just cooler but also **sustainable, inclusive,** and **resilient urban futures**, thereby enriching the societal, environmental and economic tapestry of the city.

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Chapter 04

What lessons can be learned from **the past** and **adapted** for **the future??**

National Museum of Cambodia, Phnom Penh.
Photo: Magic Ketchup - VisualHunt.com

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Photo: © J. Allain - Jalka Studio 2024

Many lessons can be learned from traditional, vernacular architectural designs, which typically take advantage of the natural environment and local climate conditions. At the same time, architectural styles "imported" from different climatic zones may not perform optimally, while "modern" architecture often relies on mechanical cooling to provide thermal comfort.

Over time, the principles that guided traditional architectural design may be forgotten; therefore, now, as the world faces rising climate and urban pressures, is an ideal time to look to the past to see what can be applied to the future.

The architectural heritage of South-East Asia has often embraced open, naturally ventilated dwellings, especially in contexts of high humidity. These traditional designs, which amalgamate numerous openings and high ceilings, pave the way for a perpetual air flow, thereby mitigating heat accumulation and facilitating cooler indoor environments.

Buildings, when moulded to the intrinsic climatic attributes – hot and humid – can cultivate indoor comfort while simultaneously negating or diminishing cooling requirements. Imported and modern styles often eliminate the principles of natural ventilation found in vernacular architecture. This is an example of how appropriate design strategies have been left behind, but a look to the past could offer lessons for current architectural practice.

4.1 ANCIENT TIMES AND ARCHITECTURES

Passive cooling is an age-old practice, entwined with the history of human settlements. Throughout time, dwellings have been inherently adjusted to the prevailing climate and weather conditions to provide occupants with a comfortable interior environment.

Cambodia boasts a rich heritage of architectural adaptations designed to combat the region's formidable climate, including heat, humidity and the ever-present monsoons. In the grandeur of ancient temple complexes, intricate hydraulic networks served as cooling systems, while sheltered open-air walkways invited natural breezes.

For centuries, Cambodian homes have evolved to master thermal comfort throughout the day by harnessing the power of natural elements – embracing shade and natural ventilation (The Room Architecture & Design, n.d.). Below, we delve into some of these traditional structures and their integration of passive cooling techniques.


Photo: © Jalka Studio 2024

Pagodas

Pagodas, even when grounded, display towering ceilings that facilitate the rise and dispersion of hot air. Their brick walls maintain a cool interior during the day, and strategically positioned roof overhangs shield façades from the sun's harsh rays.

Well-placed window openings allow for the free circulation of natural air currents within these serene sanctuaries. Many pagodas further enhance their cooling with an additional layer of interior roofing, channeling rising hot air away from monks and devotees.

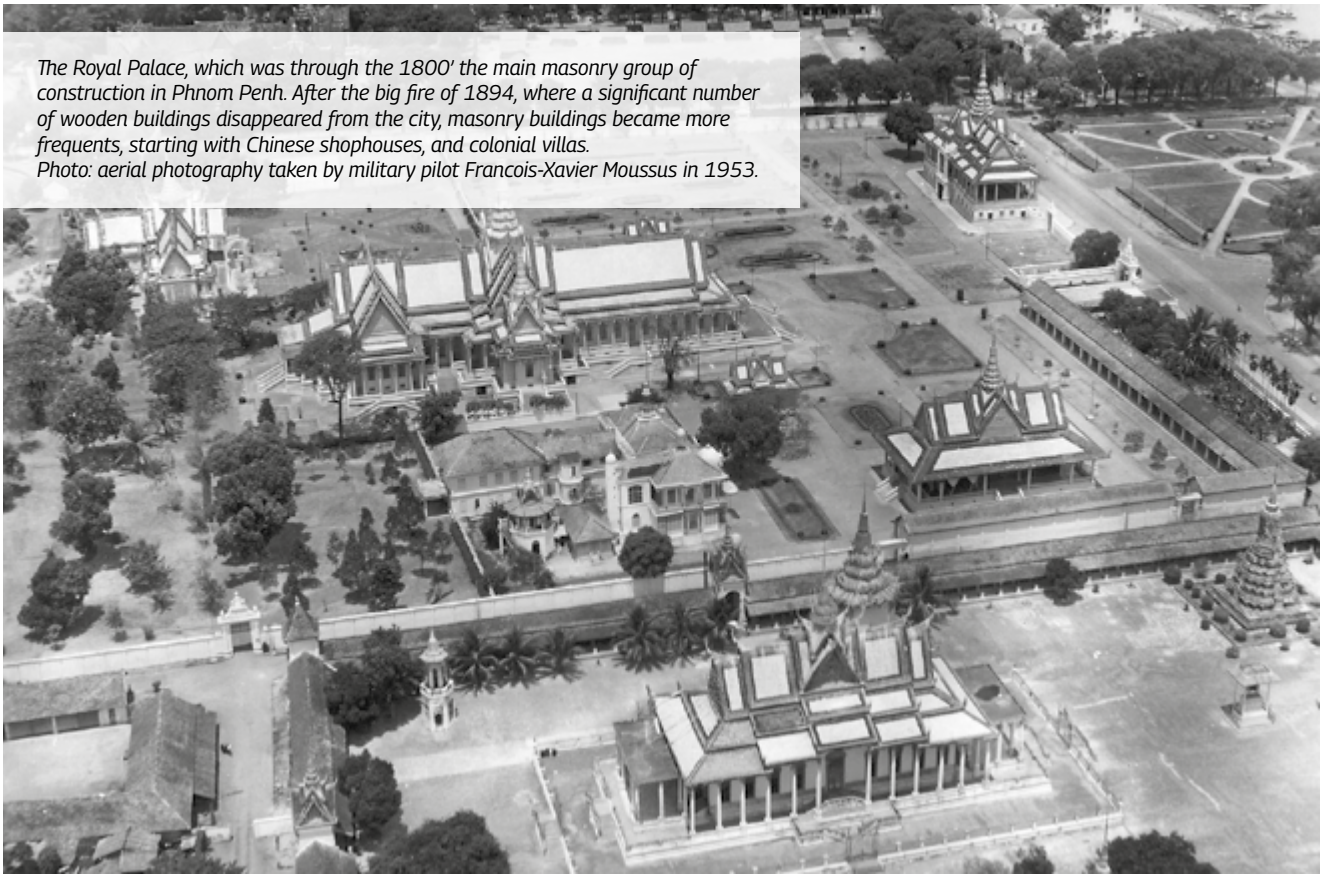
Notably, large sections of pagoda structures remain open, allowing for maximum air flow and natural light, while safeguarding the interior from direct sunlight. Given that, pagodas are predominantly active during daylight hours, the sun-warmed brick walls can disperse their retained warmth during the cooler nighttime hours when the halls are sparsely populated.

Traditional Khmer houses

Rural and traditional Khmer houses, some of which still grace urban areas today, consist of wooden walls and an elevated stilt architecture. This elevation serves a trifecta of purposes: enabling free air flow, safeguarding against floods and furnishing shaded areas for diurnal activities such as cooking. Additionally, adjustable blinds and awnings diligently ward off the sun's intense rays *(Collins and Sokal, 2022)*.


Photo: © J. Allain - Jalka Studio 2024

The homes feature steeply sloped roofs crowned with **terracotta tiles**, channelling rising heat away from the inhabitants below. **Wooden walls**, during the daytime, may absorb warmth but readily release it at night. Moreover, these structures ingeniously introduce cooler evening air through the floors, setting the stage for an ascent through the high roofs and ensuring that the warmest air hovers above the occupants. As the sun sets, the homes rapidly cool, providing a pleasant environment suited for rest.



The Royal Palace, which was through the 1800' the main masonry group of construction in Phnom Penh. After the big fire of 1894, where a significant number of wooden buildings disappeared from the city, masonry buildings became more frequents, starting with Chinese shophouses, and colonial villas.
Photo: aerial photography taken by military pilot Francois-Xavier Moussus in 1953.

4.2 OUTSIDE INFLUENCES AND THE COLONIAL ERA

The transformation of Khmer architecture bore the imprints of external influences, stemming chiefly from French colonists and Chinese settlers who arrived during the eighteenth and nineteenth centuries. A pivotal moment in Khmer architectural evolution unfolded with the construction of the modern masonry Royal Palace.

This introduction of contemporary materials gradually left its mark on urban residential buildings in Cambodia towards the close of the nineteenth century. The urban landscape of Phnom Penh underwent a significant shift following the Great Fire of 1894, which laid waste to the majority of wooden structures. This catastrophe gave rise to two novel residential prototypes: European-style villas and Chinese-style shophouses.

Masonry buildings of this era primarily adhered to two architectural trends: Indochinese and Art Deco. The Indochinese style married elements of European neo-classical design with local nuances, often weaving ornate European details together with indigenous components such as louvered shutters and steep-pitched roofs, a style exemplified by the Hotel Le Royal in Phnom Penh.

Chinese inspired, locally adapted shophouses, built during the first half of the 20th century, in Kampot, Cambodia.
Photo: A. Cadin & M.Tep

Passive cooling in colonial architecture (1880-1950)

Despite the divergence from local architectural norms, **colonial structures thoughtfully incorporated various passive design features** to ensure comfort within the tropical and monsoon climate. These architectural and design elements were **meticulously devised to encourage air flow.** The houses of this era featured soaring ceilings, sturdy masonry walls, and protective shutters and awnings adorning windows and doors. These shutters not only shielded against the sun but also provided respite from the torrential monsoon rains.

Deep verandas and open-sided walkways were standard, fostering natural cooling at the ground level while safeguarding entrances from the sun's rays. Many of these homes were ensconced within lush gardens, benefiting from ample shade. Drop curtains or blinds were a common addition, serving to thwart driving rain while permitting a continuous flow of air.

As an example, the Hotel Le Royal incorporated many passive cooling techniques reminiscent of traditional Khmer architecture. Its extended roof overhangs blocked the sun's incursion through windows while also shielding the masonry from the monsoon deluge.

Photo: Hotel Le Royal, Phnom Penh - Rlr.marcoms - Wikimedia Commons CC by SA 4.0

The inclusion of ventilation openings just beneath the roof facilitated the escape of accumulated interior heat. Additionally, deeply recessed balconies, covered walkways, internal gardens, thick masonry walls and adjustable window shutters provided further defense against the oppressive heat.

A private villa on Norodom Boulevard, constructed between 1915 and 1925 for a prosperous businessman, adhered to the Parisian model. Painstakingly restored, this architectural gem drew inspiration from various European styles while preserving high ceilings, steep roofs and terracotta tiles with generous overhangs to shelter the louvred-shuttered windows.
The interiors featured lofty ceilings, cool tiled floors and verdant gardens.

Old Villa combining colonial and local styles on Norodom Boulevard in Phnom Penh. Photo: A. Cadin & M.Tep

An Art Deco masterpiece, the Central Market or Psar Thmei, constructed in the 1930's under the stewardship of city architect Louis Chauchon (1878-1945), stands as a testament to innovation.

Inaugurated by King Monivong in 1937, it marked a radical departure from prior public edifices and continues to be a prominent city landmark.

The colossal dome and its four wings pushed the boundaries of reinforced concrete, cultivating a new generation of skilled artisans. Abundant openings welcomed natural light, crafting a latticed effect and ensuring exceptional temperature control.

An Art Deco masterpiece: the Central Market in Phnom Penh, built in 1937 under the french colonial era by Jean Desbois & Louis Chauchon.
Photo: Rik Schuiling / TropCrop-TCS - Wikimedia Commons CC by SA 3.0

4.3 POST-INDEPENDENCE CAMBODIA

Amid the rapid development of urban infrastructure, colonial Cambodia also bore witness to upheaval during French rule, particularly during World War II. This tumultuous period catalyzed the independence movement, with Prince Norodom Sihanouk emerging as the nation's leader. In 1953, following the attainment of full independence for the country, Prince Sihanouk embarked on a visionary path known as Sangkum, emphasizing modernity within Cambodia.

Cambodian architects embraced this new vision, fuelled by the prince's aspirations and guided by a cadre of contemporary architects with foreign training, including luminaries such as Vann Molyvann and Lu Ban Hap. The result was the birth of New Khmer Architecture, a fusion of contemporary modernist principles with Indigenous Khmer elements. This architectural movement was distinguished by four key attributes: the use of modern materials (particularly reinforced concrete), adaptations of traditional stilt homes, designs tailored for the tropical climate and the incorporation of Angkorian motifs. New Khmer Architecture rapidly permeated both public and residential structures across the country.

The New Khmer Architecture era (1953-1970)

Coined by authors Helen Grant Ross and Darryl Leon Collins, New Khmer Architecture represents a 1950s and 1960s Cambodian architectural movement that seamlessly blended elements of the Modern movement with two quintessentially Cambodian traditions: the grandeur of Angkor and the vernacular essence of domestic structures. While the early stages of this style bore foreign influences, architects within this movement, many of them schooled abroad, progressively infused their modern designs with traditional Cambodian elements.

The Central Market in Phnom Penh. View of under the dome.
Photo: trungydang - Wkimedia Commons CC by SA 3.0

Institute of Foreign Languages in Phnom Penh, also known as Vann Molyvann's Teacher Training College. Photo: Nov Povleakhena - Voice Of America - Wikimedia Commons

To combat the challenges posed by the tropical climate, public buildings were elevated on columns, creating natural cooling and ventilation, along with shaded spaces conducive to social activities. Other vernacular practices included the use of wall panels with double walls and roofs to shield against direct sunlight.

Inspiration from Angkorian traditions was evident in the incorporation of moats and raised walkways. Moats served as water reservoirs during the wet season and transformed into cooling mechanisms during the dry season. Striking examples of this approach can be witnessed in Vann Molyvann's Teacher Training College. Vann Molyvann, a prominent advocate of New Khmer Architecture, wielded a profound influence across Cambodia, spanning cities and rural areas, from independence in 1953 until the overthrow of Norodom Sihanouk in 1970. Other significant figures within this movement included Lu Ban Hap and Mam Sophana.

Vann Molyvann's Institute of Foreign Languages employed vertical shading devices to shield windows from direct sunlight. The building also featured a double roof design to capture breezes and harness evaporative cooling from surrounding ponds.

New Khmer Architecture was characterized by the adoption of innovative construction materials, notably reinforced concrete. It artfully integrated visual and structural elements reminiscent of traditional Cambodian building techniques, such as stilted structures, while demonstrating a profound understanding of the tropical climate through clever use of natural ventilation and shading.

Occasional ornamentation, chiefly bas reliefs inspired by Angkorean temple décor, added an extra layer of aesthetic richness.

In addition to drawing from Cambodia's existing architectural heritage, New Khmer Architecture embraced diverse international modernist influences. Architects and engineers from Japan, Europe, the former Soviet Union, the United States and beyond collaborated with Cambodian counterparts on numerous significant projects, featuring influential figures like engineer Vladimir Bodiansky.

4.4 INSTABILITY AND CIVIL WAR: 1970-1998

The eruption of the Viet Nam War cast a long and tragic shadow over Cambodia, leading to a series of tumultuous political transitions in the 1970s. These events, included the Khmer Rouge regime and the following Vietnamese occupation, lasted for several decades until lasting peace and stability finally emerged in 1998 (Charadine, 2020). Cambodian architecture evolution stoped during these times, and most of valuable design knowledge and construction knowhow were lost.

4.5 RESIDENTIAL BUILDINGS IN PHNOM PENH TODAY

LINK HOUSES (MEDIUM-DENSITY HOUSING)

A predominant feature of the urban landscape in Cambodia is the prevalence of **rowhouse structures, often following the "Chinese shophouse"** typology. These rowhouses are scattered throughout high to medium-density urban areas, serving as hubs for various commercial activities. Typically constructed with **two to five storeys in masonry, these houses are considered medium-density housing.** They are thoughtfully set back from the street and employ design elements such as awnings, balconies and ceiling vents to dissipate heat. **This architectural style, while continuously evolving, remains a popular choice, especially in middle-class borey developments,** some of which exhibit more contemporary interpretations. Link houses continue to dominate the market for new dwellings.

Link houses, Phnom Penh. Photo: A. Cadin & M.Tep

SHOPHOUSES

Shophouses, Phnom Penh. Photo: A. Cadin & M.Tep

Multi-story shophouse blocks have been repurposed into Western-style apartment complexes complete with public staircases, elevators, walkways, recreational amenities and, notably, communal courtyards. The shophouse typology, similar to medium-density link houses, remains popular and constitutes a significant segment of the construction industry.

Detached house, Siem Reap. Photo: Vecteezy.com

DETACHED HOUSES (VILLAS)

Detached houses, commonly referred to as villas, have historically been associated with the upper class. They are typically situated within garden compounds, both in city centres and on the outskirts. However, with the emergence of borey developments, villas have become more accessible to a broader population.

In residential areas, private villa designs have embraced a more modernized approach, often accompanied by a shift in style. Notably, New Khmer Architecture has contributed to privately owned dwellings by incorporating traditional decorative elements, such as Bayon Temple faces. In the general architecture of private villas, it is rare that their owners take into account the benefits related to passive cooling: most often, this type of housing, based on Western-style architecture is not adapted to tropical climate and cheap materials is very energy-intensive and requires active air conditioning. Environmental concerns are nevertheless experiencing a revival of interest in the Cambodian population and an "ecological certification" for a building is beginning to present a real added value for an increasing number of buyers.

While larger detached houses, including some colonial-era survivors, were once prevalent in Phnom Penh, they have become increasingly scarce since the 1990s, due primarily to soaring land costs. The trend of individual single villas, outside of boreys or communities, has also waned in recent years, due in part to the availability of more turnkey housing solutions and escalating land prices, especially near the city centre.

4.6 PASSIVE COOLING IN CONTEMPORARY CAMBODIAN DEVELOPMENTS (1990 TO PRESENT)

BOREYS

Starting in the 1990s, cluster houses, commonly known as "boreys," were introduced to the public and have since become a highly popular housing choice. In contrast to the exclusivity of French colonial and Sangkum-era dwellings, today's boreys cater to the middle-class market and are mass-produced on the outskirts of the city.

Rapidly rising land costs in urban areas have led to the construction of compact units along wide paved roads, with minimal greenery and shade in most cases. Their popularity is attributed to a combination of market-driven factors, mainly price and aesthetics.
Thermal comfort is typically provided by powerful air-conditioning units (see Box 4). Recent challenges such as rising energy costs and more informed customers are creating opportunities for strategies that can deliver improved comfort, well-being and energy savings.

A new residential project, Borey Chankiri, by UrbanLand in Phnom Penh, where concepts of sustainable architecture and healthy lifestyles have been proposed. Illustration: © Urbanland.com

A building full of active air-conditioning units. Photo: © Vecteezy.com

BOX 04

HAS AIR CONDITIONING LED TO THE END OF PASSIVE COOLING?

The majority of urban dwellings, including high-rise towers, villas, and boreys, incorporate minimal passive cooling strategies, resulting in heavy reliance on mechanical cooling systems. In many cases, the lack of clear understanding about architectural design related to solutions, performance and living quality led to having sealed openings, with air conditioning being seen as a modern comprehensive solution that suffices by itself.

The operations phase in most real estate projects is not well structured, and it favours management-free options. Therefore, many of these developments feature surfaces covered with heat-absorbing materials such as concrete, with limited shading, exacerbating the cooling challenge. The combination of these trends is creating additional pressure on national electric power systems, and is **increasing the urban heat phenomenon.** This will contribute to making the urban environment hotter, which, in addition to a warming climate, will challenge affordable access to cooling and put an additional burden on cities' resilience potential.

Investment in Cambodia's construction and real estate sector reached $5.2 billion in 2024 *(Source: Phnom Penh Post, 2024)*. However, very little of this building stock will meet the actual housing needs of urban dwellers. These new buildings were designed to attract investors, but little attention is being paid to the specificity of the local context and their operational costs, especially the high cooling energy costs. **Unfortunately, passive cooling seemed to be forgotten during this period of high-return investments** in real estate, as property has become the new gold. The focus has shifted from providing shelter to constructing high-rise buildings inspired by towers from other cities, adopting an international style intended to represent wealth and success to clients or investors. The high cost of cooling has either not understood or ignored when the business model did not prioritize optimized operational costs.

Many buildings place poor-performance glass façades directly in the sun's path, amplifying exponentialy the already strong heat, which create spaces that are very challenging (and very expansive) to cool down. The current building codes and architectural standards are not yet comprehensive enough, and don't provide much practical advice on sustainable design to prevent this challenging outcome.

High rise building in Koh Pich, Phnom Penh.
Photo: allphoto-bangkok - Unsplash.com

HIGH-RISE BUILDINGS

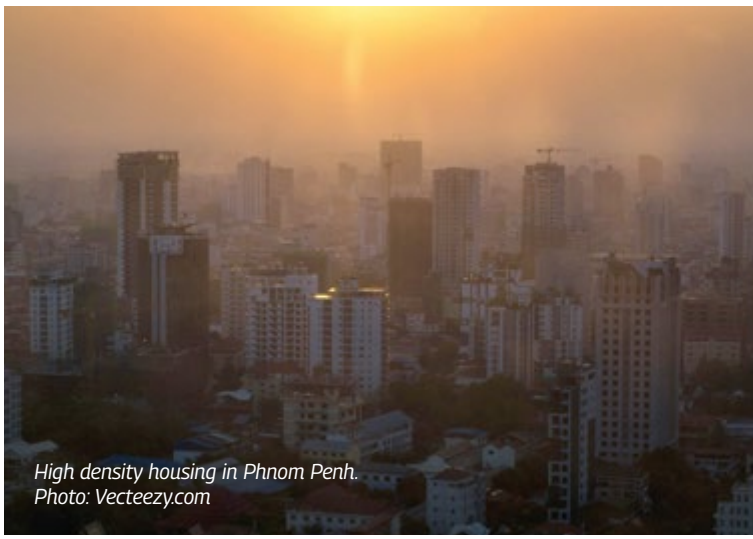
Since the 2010s, urban centres in Cambodia have witnessed the emergence of modern high-rise buildings, with some soaring beyond 30 storeys.

Many of these tall structures are primarily commercial or mixed-use, while numerous mid- to high-rise condominiums and apartments (ranging from 15 to 30 storeys) have been constructed, mainly targeting investors or expatriates. However, a substantial portion of these buildings remains unoccupied, held largely by foreign investors. These high-rises adopt various styles to attract investors and maximize returns with minimal investments. Façades, lobbies and sometimes rooftops are designed to align with international trends and customer preferences. However, **budgets often prioritize immediate cost and profit considerations over global design standards and quality investments.**

It is important to note that in this case, the lack of regulations and codes of the real estate market of construction, the absence of strict environmental laws as well as a lack of financial and human resources for government agencies building quality control to check the compliance of the buildings with the market standards plays a major role in the general lack of quality that can sometimes be observed on some real estate projects (as the accident observed in Sihanoukville in 2019, resulting in 17 deaths and 24 workers injuried, with a building collapse).
Although aesthetics, marketing, and short-term costs have dominated considerations, more recent mixed-use high-rises tend to incorporate better-quality design materials and equipment, as they aim to attract tenants with international expectations. **Meeting client expectations in Cambodia's competitive market is driving improvements in design and performance, rewarding innovation.**

HIGH-DENSITY HOUSING

High-density housing often takes the form of medium-rise apartment buildings scattered throughout cities like Phnom Penh. **These structures rely heavily on mechanical**



High density housing in Phnom Penh.
Photo: Vecteezy.com

Informal housing in Phnom Penh.
Photo: © Milei Vencel - Unsplash.com

cooling and are often excessively exposed to solar radiation due to large, non-openable windows and a lack of shading. The forthcoming green building codes are expected to enhance energy efficiency and cost-effectiveness in designing and operating new structures.

INNER-CITY INFORMAL SETTLEMENTS

Inner-city informal settlements are constructed by the urban poor and frequently lack proper structural support, access to clean water and electricity, and, most importantly, land titles. Scattered across various parts of major cities, these dwellings are typically made from materials such as corrugated iron and scavenged items. Informal settlements are densely populated, with each household residing in a confined space that offers little room for cooling breezes. **The structures are highly susceptible to heat** due to their density, lack of shade, limited natural air flow and use of exposed corrugated steel. This underscores the urgency of developing sustainable, affordable cooling strategies.

MODERN VILLAS

Modern villas, often symbols of wealth and success, tend to prioritize form over functionality. Many new homes in Phnom Penh showcase various styles and ornamentation to highlight the owners' affluence, but passive cooling strategies and shade are often overlooked.

Private modern villa in Phnom Penh.
Photo: A. Cadin & M.Tep

4.7 LATEST TRENDS EXPECTED TO GREATLY IMPACT CAMBODIA'S BUILT ENVIRONMENT

The influence of global urban styles in architecture continues to rise, and even in rural areas, traditional stilt houses are being replaced as household incomes improve. Modern styles that incorporate masonry, tiles and cement floors are preferred.

A modern style house in Siem Reap, with the 1st floor in bricks. Photo: © J. Allain - Jalka Studio 2024

In smaller towns, new houses are constructed with rendered brick walls and sloped cement-tiled roofs, often adorned with different ornamentation reflecting the owner's wealth or aspirations. The result tend to be a cumulation of modern features (cement tiles, concrete roof, big fixed glazed opening...) without consideration of the building relation to its environment (site landscape, sun path...) which often makes it uncomfortable and difficult to cool down.

However, climate change and the increasing frequency of extreme heat pose challenges. Vernacular passive cooling features are no longer sufficient to maintain a comfortable interior during the hottest parts of the day. Older buildings designed for natural ventilation will need to be retrofitted to enable the efficient use of air conditioning, which includes air sealing.

Cities are experiencing rapid growth, expanding into areas that were once countryside. In these new suburbs, individual landed dwellings and boreys have been oversupplied due to the combined effects of: the lack of professional market analysis, a ripple effect ported by the **highly speculative nature of the real estate market during the second half of the 2010s**, and justified concerns regarding the **poor quality of the construction** in many of these operations.

Although real estate demand slowed during the COVID-19 pandemic, these types of housing nevertheless remain the most popular. Retrofitting all these poor quality constructions to make them energy efficient later on is already a significant challenge which needs to be urgently hold on. With buildings quality standards related to their minimum energy performance.

At the institutional level, larger, even landmark buildings are moving to the city edges because space is scarce and extremely expensive in the city centre. Some of these new structures are now considering passive cooling strategies to enhance energy efficiency and lower operational costs.

In the retail sector, there is a growing trend towards large modern shopping malls that offer a range of recreational spaces and relief from the heat. These malls feature shops, food courts, cinemas, performances, and playgrounds, all within family-friendly air-conditioned spaces.

While the growth of such malls slowed during the COVID-19 pandemic, there are several planned developments in new suburbs. Recent mixed-use large-scale projects with retail malls on the lower floors are preferred by tenants.

The wave of mid- to high-rise single-activity buildings that thrived from 2016 to 2021 has now subsided, with many of these developments far from fully occupied. This previous model was largely based on foreign speculation rather than market demand.

The Vattanac Tower in Phnom Penh, first tower to be Gold LEED green building certified in Cambodia, completed in 2014, with facade shading "scales" among other features. Photo: Wikimedia Commons CC by SA 1.0

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Chapter 05

REINTRODUCING passive cooling strategies into **modern Cambodian** architecture

Back to summary

Recent Mixed-use development incorporate passive cooling features such as green walls, waterfalls, and open ventilation, creating more attractive spaces for people within and around these innovative structures. Photo: © A.Cadin & M.Tep.

5.1 MODERN CONTEXT

In 2016, the World Bank reclassified Cambodia as a lower middle-income country. This coincided with the beginning of a construction boom centred on Phnom Penh, with forecasts indicating a doubling of its urban population (World Bank, 2017).

Construction forecasts for the next decade indicate continued growth. Considering the current construction volume, which exceeded 10 million square metres per year in 2021 (Realestate.com.kh, 2022), this will create a significant additional demand for energy to cool spaces.

Cambodia's modern real estate sector has experienced rapid growth, striving to establish a local identity in the twenty-first century amid international trends. This journey has been marked by trials and experiments. Recent years, characterized by booming speculation followed by the shock of the COVID-19 economic downturn, have prompted more mature considerations.

The post-COVID landscape has witnessed an increase in the quality of developments, with a focus on adaptability to local environments, demands and needs. Some projects are now investing in design and features that prioritize well-being and energy efficiency. This shift is driven by the necessity to offer a quality product to attract customers in a more competitive market.

There are signs of hope for the increased use of passive measures, as some developers are investing in nature-based solutions and creative passive cooling strategies to distinguish themselves from competitors. These strategies make their developments more appealing to international tenants.

This approach signifies a new era of real estate development in Cambodia, where green architecture serves as both an effective marketing tool and a source of cost savings, while providing health and comfort benefits that endure, enhancing the long-term value of the property and attracting a new generation of clients.

Many cities are now promoting cooling solutions, and some of these examples can be found in the **ESMAP Knowledge Series' Primer for Cool Cities**, with a focus on passive measures (ESMAP, 2020). Just as rising heat is diminishing the quality of life in cities, there are many benefits and methods that can cool down urban temperatures through a combination of design, planning and nature.

Box 5 provides some recent examples in urban Cambodia.

BOX 05

NEW CONTEMPORARY CONCEPTS FOR PASSIVE COOLING

Hospitality places are saving energy thanks to their green facades, which is also attractive for their clients.
Photo: A.Cadin & M.Tep

Local trends of sustainable design are integrating open common areas with natural ventilation and building green facades.
Photo: A.Cadin & M.Tep

Modern local trends combining direct sun exposure prevention, natural ventilation and daylighting.
Photo: A.Cadin & M.Tep

New commercial building with climate protective facade features.
Photo: A.Cadin & M.Tep

New commercial building cumulating trees at street level and vegetal facade feature preserving the building from excessive heat, and increasing well being for users and neighbors.
Photo: A.Cadin & M.Tep

Recessed facade, vertical shading, balconies vegetation, and trees preservation at street level, are keeping the building cooler than surrounding outside ambiant air. - Hotel Baitong, Phnom Penh. - Phnom Penh city center. Photo: © A.Cadin & M.Tep.

5.2 RE-LEARNING LESSONS FROM THE PAST

There are numerous vernacular strategies that can be integrated into modern architectural trends, offering not only energy efficiency but also a sense of cultural grounding within the context of modern urban mass development. While these initiatives are still relatively novel, they have gained traction, especially within the hospitality industry, where they generate significant savings and enhance the appeal of buildings to foreign tourists and expatriates, who constitute their main clientele.

CULTURAL PERSPECTIVES

As described in section 3, Cambodian architecture has a rich tradition of employing passive designs and cooling strategies. Developed over centuries, these architectural styles offer practical and affordable solutions tailored to the local way of life, harmonizing with natural weather patterns and resources to create comfortable living and dwelling spaces. Religious and spiritual places, social spaces and homes alike have been crafted to harness nature's benefits and counter climatic challenges.

Modern coffee with cultural integrated architectural style. Photo: © A.Cadin & M.Tep.

WAYS OF LIVING IN AND OCCUPYING BUILDINGS

Traditionally, Cambodians lived in homes with elevated sleeping areas in traditional Khmer

houses, which enhanced air flow and cooling. During the hottest part of the day, activities took place in the shaded areas under the stilt houses. Daily routines were often tied to agricultural tasks, with people rising early in the morning (around 4 to 5 a.m.) to take advantage of the natural coolness and to engage in physical labour until lunchtime (around 11 a.m.). During the hot afternoon, most activities, including rest, occurred under the house, with people emerging later in the day to tend to cattle or complete other tasks. Dinner was typically consumed at nightfall, followed by families retiring upstairs.

The regularity of sunrise and sunset throughout the year in Cambodia meant that the rhythm of life was fairly consistent, with seasonal variations such as the rainy season (when stilts protected homes from flooding) and harvest seasons being the primary deviations. However, urban environments in cities do not always align with these natural rhythms, and most people no longer adhere to climate-adaptive routines. **Due to densification, offices in major cities often lack the capacity to allow everyone to benefit from natural breezes.** Urban living has come to mirror international standards and pace rather than adapting to seasonal changes.

Add climate change to this lifestyle, and living comfortably year-round without mechanical cooling becomes increasingly challenging. Urban environments are already creating conditions that necessitate mechanical cooling, and some workers must wear uniforms that are ill-suited to the climate. Today, in Cambodia's urban landscapes, it is impossible to rely solely on passive solutions. Nevertheless, there are ample opportunities for improvement in the current situation. Spatial planning can be optimized, and nature-based solutions can be implemented.

Integrating passive cooling strategies within contemporary commercial edifices can bolster thermal comfort and productivity while carving out **energy savings of 10 per cent to 20 per cent,** thus tapering operational costs (Cool Coalition, n.d.). Buildings, when moulded to the intrinsic climatic attributes – hot and humid – can cultivate indoor comfort while simultaneously negating or diminishing cooling requirements.

Passive design components and concepts

Traditional architectural strategies and design concepts have long been employed to support passive cooling in response to climate pressures. As noted previously, these include:

Orientation: Traditional buildings were oriented to optimize wind exposure while shielding against direct exposure to the sun's hottest path.

Ventilation: Open designs or material patterns and component arrangements facilitated and encouraged air flow, reducing heat.

Pre 2000s commercial constructions featuring natural ventilation aerators as well as sun protective louvers. Photo: © A.Cadin & M.Tep.

Traditional house, low thermal mass wooden walls, allow the place to become cooled quickly after the sunset, making it comfortable for sleeping inside. - Katie, Cambodia. - Photo: Keith Kelly.

Shading: Overhanging roofs, awnings, or vegetation provided shade, minimizing direct sunlight.

Thermal mass: Traditional stilt houses, with their low thermal mass wooden walls, did not absorb excessive heat during the day and cooled quickly after sunset. In contrast, pagodas had higher thermal mass, with brick walls retaining evening coolness and releasing absorbed heat during cooler nights when the building was not in use.

Reflectivity: Light colours, sloped roof and the use of reflective materials were employed to deflect heat away from buildings.

Insulation: Ceiling insulation is particularly important to keep the hot sun from overheating the home – and painting the roof a light colour will reflect sunlight, meaning that less heat penetrates through the roof. Solar-treated glass on the windows, additionally, will help keep the heat out in summer, but will also reduce solar gain in the winter.

MATURING A MODERN CLIMATE-RESPONSIVE ARCHITECTURE

Passive cooling has been an integral part of Cambodian architecture, from ancient times up to recent history. It was deeply intertwined with local culture, lifestyles and the specific Cambodian microclimate. Thus, measures that can reconcile a rich cultural heritage with modern living and working practices – leveraging traditional, well-adapted, climate-responsive concepts – have to be explored. A distinctive Cambodian architectural culture can once again re-integrate passive cooling strategies while embracing modern design and smart technologies.

Paint of traditional wooden Khmer houses. Photo: radkuch.13 - VisualHunt.com

New residential development Chankiri 2 of Urbanland : a project that is integrating passive strategies supporting its sustainable design approach. - Photo: © urbanland.com

5.3 INTRODUCING MODERN PASSIVE COOLING STRATEGIES

ADVANCES IN BUILDING MATERIALS

The availability of new building materials is transforming the way architects and builders approach passive cooling. These materials offer increased insulation, reflective properties, affordability and a range of benefits that contribute to creating a more appealing and comfortable environment.

MODERN WINDOW GLAZING

Contemporary glass technologies provide better heat insulation while allowing a high degree of natural light to enter buildings. Low-emissivity (low-e) glass is one such example, available in various performance grades suited to different budgets and local conditions. However, the relatively higher cost of low-e glass and the need for further research on local climate conditions have led to it being less preferred at the moment. Due to its high price, double glazing solutions is considered as a premium, and rarely seen in the country developments.

AUTOCLAVED AERATED CONCRETE (AAC) BLOCKS

AAC blocks consist of 80 per cent air, offering excellent insulation properties. Their lightweight nature simplifies construction, reducing costs, especially for support structures and foundations. With their numerous minuscule air vents, AAC blocks are highly effective at insulating against heat transfer, greatly reducing monthly air-conditioning expenses. Additionally, they have higher fire resistance and comply with international codes while preventing mould-related issues.

An example of AAC block texture. Photo: © Vecteezy.com

In Phnom Penh, a few buildings associated with international stakeholders have begun to incorporate AAC light blocks and low-e glazing. However, challenges to wider adoption include their relatively new introduction, perceived additional costs and the need for new construction skills.

Cool roof technologies

Innovative cool roof technologies use specific paints, membranes and coatings to reflect solar radiation, reducing the heat transmitted into buildings and more broadly cooling technologies for the building enveloppe (roofs, walls...), are using specific paints.

Modern green roofs

Green roofs have evolved to become lighter and require less maintenance, and they have become more cost-effective. Although not yet widely affordable, they offer substantial insulation benefits, contribute to biodiversity and effectively mitigate the urban heat island effect.

New technologies

While **passive cooling strategies are often associated with simplicity, modern technologies can further optimize these methods.** For example, smart sensors and control systems can manage shading devices or window openings based on real-time weather conditions.

Building design can be optimized through advanced engineering and architectural software such as Building Information Modeling BIM) and Computational Fluid Dynamics (CFD). These tools simulate air flow, utilize natural wind corridors, and manage sun exposure based on building openings and functions, ultimately enhancing sustainability.

Nature-based solutions

Modern design increasingly embraces nature-based solutions, also known as biophilic design, to enhance passive cooling. Green roofs and walls offer shading and evaporative cooling benefits, improving indoor temperatures while providing aesthetic and mental health advantages.

Nature-based solutions can offer affordable cooling options, even for high-rise buildings. Strategic outdoor landscaping around buildings, including the placement of trees for shade and sun protection or the creation of wind channels, plays a significant role in passive cooling.

Modern local brands are developing an architectural style closer to nature, inspired by local culture, supporting customers comfort and project aesthetics. - Toul Kork Brown Coffee, Phnom Penh. Photo: © A.Cadin & M.Tep.

Innovative design

Passive cooling strategies can be incorporated through innovative structural design.
Examples include:

- **Solar chimneys,** which create an airflow draft through a building.
- **Earth-sheltered designs,** which use the thermal mass of the earth to manage heat.
- **Building form and orientation,** which are critical in reducing solar heat gain and promoting natural ventilation – and deserve more attention.
- **Building systems design:** Flexible options and multifunctional spaces can reduce overall cooling loads.

Synergizing tradition and modernity

New developments offer exciting possibilities to blend traditional local climate-responsive architectural strategies with modern technologies and approaches to passive design. The potential for complementarity and synergy between these historical strategies and modern design approaches creates a unique form of modern architecture that is not only sustainable but also well-suited to its specific environment. This approach combines the best of both worlds, drawing from the rich heritage of Cambodian architecture while embracing contemporary advancements in construction and design.

5.4 Leveraging current business trends

Green building movement

Cambodia's green building movement has gained momentum, with support structures and active participation from various stakeholders in the private sector, including architects, engineers, construction companies and certification providers. While the ecosystem still requires a more comprehensive framework, with strong certification and rewards systems, it is maturing and is poised to deliver more sustainable design projects in the coming years.

Some local trends are combining passive strategies with great aesthetics. Photo: A.Cadin & M.Tep

Green building certification

Green building certifications offer several benefits for developers and businesses, including reduced operational costs from energy savings, increased property values and an enhanced public image. They can provide measurable benefits, including data on return on investment, the portion of additional upfront costs for green features, higher occupancy rates and faster sales.

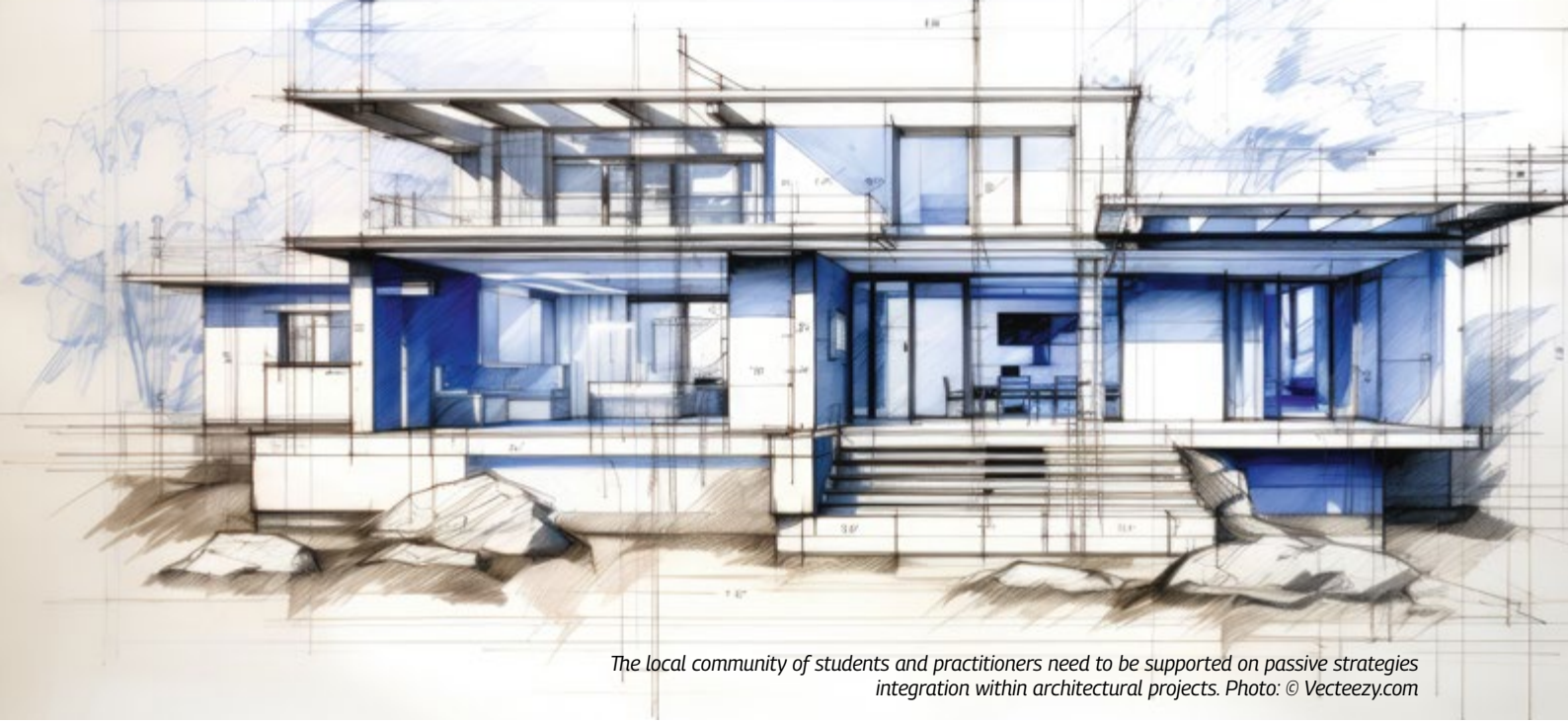
Changing market dynamics and increasing expectations, driving positive change

While earlier developments focused on short-term returns on investment, there is now a growing awareness of the lifetime cost of a building's operation. This awareness is expected to increase as new regulations and guidelines (see section 4.6) are put into practice.

Real estate market response to local demand
The Cambodian real estate market is experiencing shifts in certain sectors, driving the need for more innovative and environmentally conscious solutions.

The years of speculative property investment have been interrupted by the COVID-19 pandemic, resulting in growing oversupply in segments such as mid-quality office buildings and mid-range borey developments. With the economic downturn following the pandemic, major real estate projects have become scarcer, with some on hold or cancelled. New developments will need to demonstrate responsiveness to local needs and to compete to attract buyers and renters. Energy prices are now a significant consideration for operational costs, and these costs are expected to rise further.

Cambodia's real estate market has the potential to incorporate passive cooling features into new building projects. While this may entail additional costs, they need not be prohibitive. At the same time, developers may be able to transfer the modest extra expenses to buyers, who will ultimately benefit from more sustainable living environments.



The local community of students and practitioners need to be supported on passive strategies integration within architectural projects. Photo: © Vecteezy.com

Raising awareness among consumers about the benefits of passive cooling and creating institutional support for structured incentives are crucial steps.

5.5 RAISING AWARENESS AND INFLUENCING PUBLIC ATTITUDES

RAISING GENERAL AWARENESS WITHIN THE BUILDINGS SECTOR

At the building scale, there are numerous opportunities to integrate passive features such as ventilated roofs, insulated ceilings, and simple outside louvers, which can significantly lower indoor temperatures with a modest investment. However, these opportunities are often missed due to a lack of technical knowledge, available materials and organized methods for implementation. Practical demonstration projects, handbooks on materials and technologies, and capacity-building workshops and training are needed.

To promote passive cooling strategies effectively, building sector professionals need to become more familiar with their benefits and how to integrate them successfully. An important step would be to introduce passive cooling strategies to architectural students and to integrate them into the curriculum. Policy makers must also be well-informed about the potential levers they can use to encourage and support sustainable buildings.

Learning from examples from other countries and how they use building codes and certifications can offer valuable insights into promoting passive cooling strategies and fostering sustainable development in Cambodia's construction sector, by adapting global practices to Cambodia's unique context.

Education and formal courses, workshops, online resources, and public campaigns and competitions involving academic institutions, professional associations, non-governmental organizations and governmental bodies are potential avenues for delivering information, training and capacity-building.

RAISING THE VISIBILITY OF PASSIVE COOLING SOLUTIONS

Passive cooling can improve the quality of life for people, reduce greenhouse gas emissions, mitigate urban heat, and optimize resource consumption, including energy savings. The local and global benefits and practicality of passive cooling should be communicated to the general public through awareness-raising events that showcase local examples, to demonstrate its potential and how it can enhance people's quality of life.

Bringing passive cooling strategies to the Cambodian public requires pragmatic and credible vectors of performance. Tools such as energy labels that display energy savings, or

local/regional/international building certifications, can support public visibility. Communication channels, including newspapers and social media, can be used to raise awareness, and public visibility of demonstration projects and successful local examples can make passive cooling more tangible and relatable.

The concept of passive cooling may not face resistance, especially if it offers various business benefits and aligns with local climate-responsive practices. However, positive case studies need to be showcased to industry professionals. Highlighting the cost-saving opportunities associated with passive cooling can further drive its adoption in Cambodia's construction and real estate sector.

Leveraging incentives

To encourage the adoption of passive cooling, incentives for materials providers, developers and building owners can support uptake. Incentives could, for example, include tax rebates, preferential loans for building projects that integrate passive cooling, and green mortgages.

5.6 Leveraging demonstration projects

Demonstration pilot projects are crucial when introducing new practices. These projects serve various purposes, from testing new technologies or practices, gathering on-site data, and verifying information, to offering tangible examples for people to observe and interact with.

Demonstration projects build credibility for new concepts, making it easier to advocate for the integration of new approaches into national policies and regulations. Moreover, they support cost-benefit analysis and the incorporation of various stakeholder perspectives, which are essential for building trust, transparency and engagement.

This recent commercial building in Phnom Penh, uses open spaces, deep overhangs and greenery to promote air flow and protect the exterior walls from absorbing too much heat. - Photo: © Chip Mong Group - Chip Mong Retail

ODOM Tower, a high rise Green building certified development by ULS; currently under construction on Norodom boulevard, in Phnom Penh. Photo: ULS

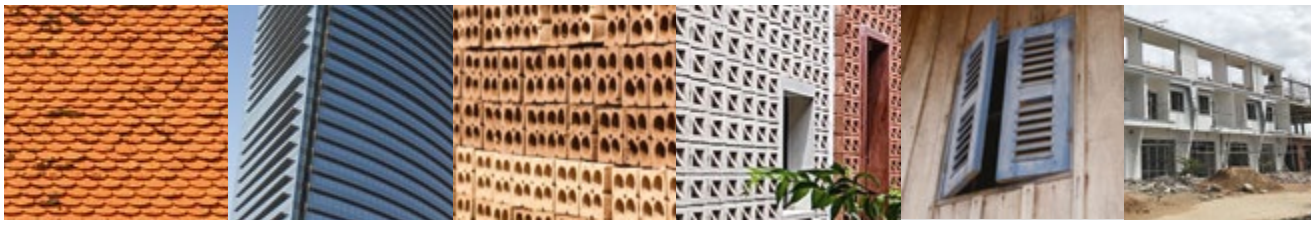
Demonstration pilots for passive cooling strategies should encompass diversity, representing different building types, market segments (residential, commercial, etc.), and product categories (affordable, mid-range, etc.). They should also involve on-site analyses at various scales, from individual units to entire cities. Collaboration with the private sector, especially in real estate and construction, enhances understanding of market dynamics, stakeholders' constraints, and expectations, and building performance within private real estate developments.

By offering a clear understanding of the advantages and practicalities of implementing passive cooling strategies, these demonstration projects serve as a foundation for policy development, target-setting and market adoption.

The Penh House: an inspiring hotel building close to the royal Palace in Phnom Penh, that integrates many passive strategies in its design. Photo: A.Cadin & M.Tep

Chapter 06

Conclusion



This study reviews the historical and modern application of passive cooling strategies in Cambodian architecture.

It also presents thoughts on a transformative pathway, where the integration of passive cooling strategies can contribute significantly to sustainable development, the achievement of national policy objectives and international commitments, and improvement of the interior environment in which people live, work and study.

The strategies outlined here offer a blueprint for multi-stakeholder collaboration, innovative implementation, and strategic policy integration, outlining the way for a greener, more resilient future for Cambodia.

By adopting passive cooling strategies, Cambodia can strike a balance between development goals and environmental considerations, while increasing people life quality, contributing to a resilient and sustainable future for generations to come.

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A look at past and current use of passive cooling strategies

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