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SHAPING TOMORROW'S FAÇADES

Designs, Materials & Technologies for Innovative Future Façades & Fenestrations

Face to Face

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Industry Speaks

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Façades for High-Performance Buildings

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Zero Energy Buildings: Key to Sustainable, Human-Friendly Future

Building construction and operations make up 38% of the world's energy-related CO_2 emissions, according to the 2020 Global Status Report for Buildings and Construction published by UN Environment Programme. To significantly decarbonise our buildings, one of the key innovations being actively explored by architects is the idea of a 'zero energy building', which has attracted much discussion across the building industry and academia and is now increasingly seen as critical for the future sustainable smart cities.

What are zero energy buildings? This article highlights some of Professor Lau's insights on the future of zero energy buildings in the hope of instigating its wider adoption.

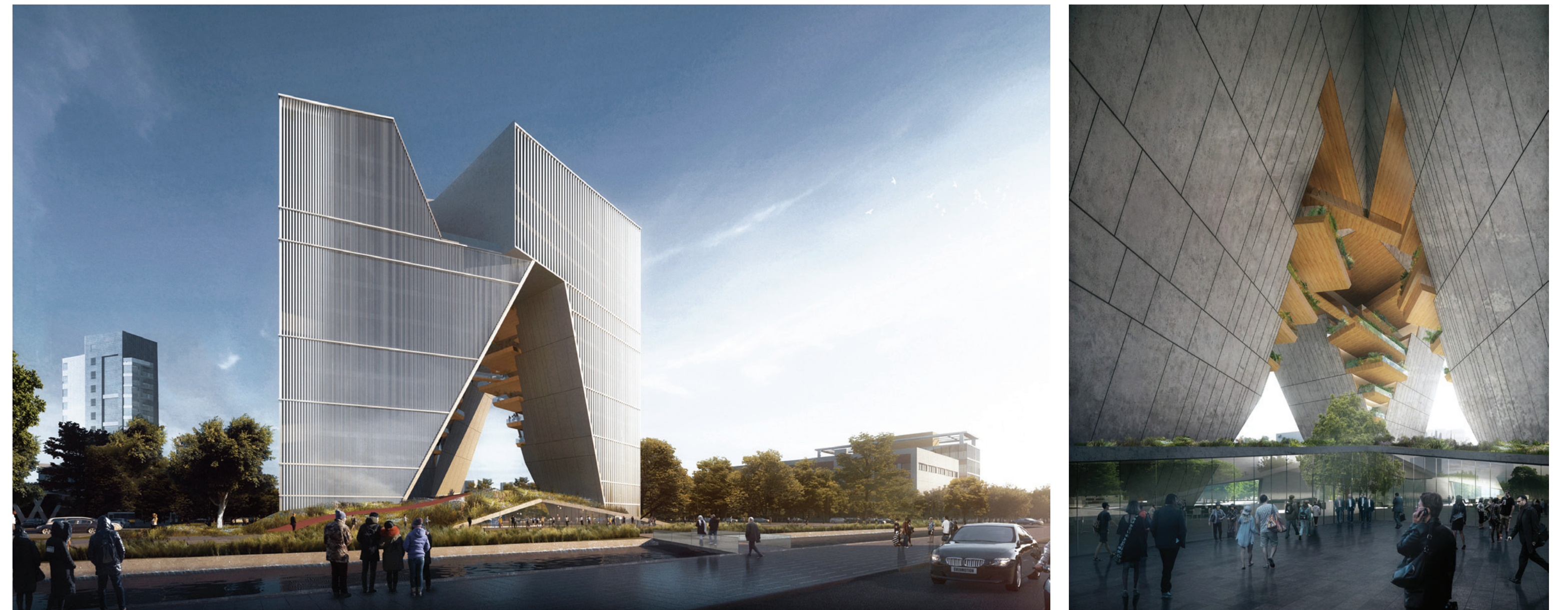
At its simplest, zero energy buildings generate as much energy on-site as it consumes, through renewable sources, on a yearly basis. This makes its energy consumption 'net zero'.

While there are different approaches to maximise energy-saving, passive design features often form the core of all, involving the building form and fabric, overhangs and shading devices.

Active designs like efficient HVAC and Internet of Things (IoT) systems are additional strategies working in conjunction with passive ones to enhance a building's capabilities of achieving zero energy consumption.

Renewable energy sources are another important element defining this kind of sustainable buildings. Solar power is now a popular choice for generating local energy. However, current limitations with the amount of energy produced by solar power mean that contemporary efforts can at most achieve 'nearly zero energy' consumption. Nevertheless, these attempts still provide lots of inspiration for architects and designers to advance their designs and more should be done to promote its adoption in future urban development.

In a competition proposal for an office building by LWK + PARTNERS, the architecture provides porous layers of experiential, landscaped spaces around the airy atrium



LWK + PARTNERS' design for an office building competition proposal allows natural light and strong summer wind through the openings of the building to the central void which centralises all shared facilities and communal areas while offices are allocated on the outer range

BUILDING FORM AND FABRIC

How a building is shaped and situated affects how much heat, natural lighting and wind it gets, while energy demand for cooling is the fastest growing end-use in buildings according to UN Environment.

Traditional box-like buildings consist of isolated enclosed spaces, which prevent the entry and circulation of natural wind in the building. On the contrary, breaking down the building mass into loosely stacked up horizontal planes allows cross-ventilation to happen, while each plane provides partial shading for the level below. A shallow composition depth makes this even more effective.

Each area can be oriented and configurated to create additional breeze corridors, pleasant outdoor terraces and communal hanging gardens where people can gather and socialise in a thermally comfortable setting. Cladding the building with insulating façade materials also helps lower air-conditioning demand, which are complemented by vertical or horizontal fins for shading.

Instead of lifts, placing a major staircase in the middle of the building spaces is a positive approach to save energy use, promoting wellbeing and a sense of community. These open structures encourage people to move around and engage with the space, enhance visual connections between floors and create more dynamic circulation flows, offering an active experience not possible in lift journeys.

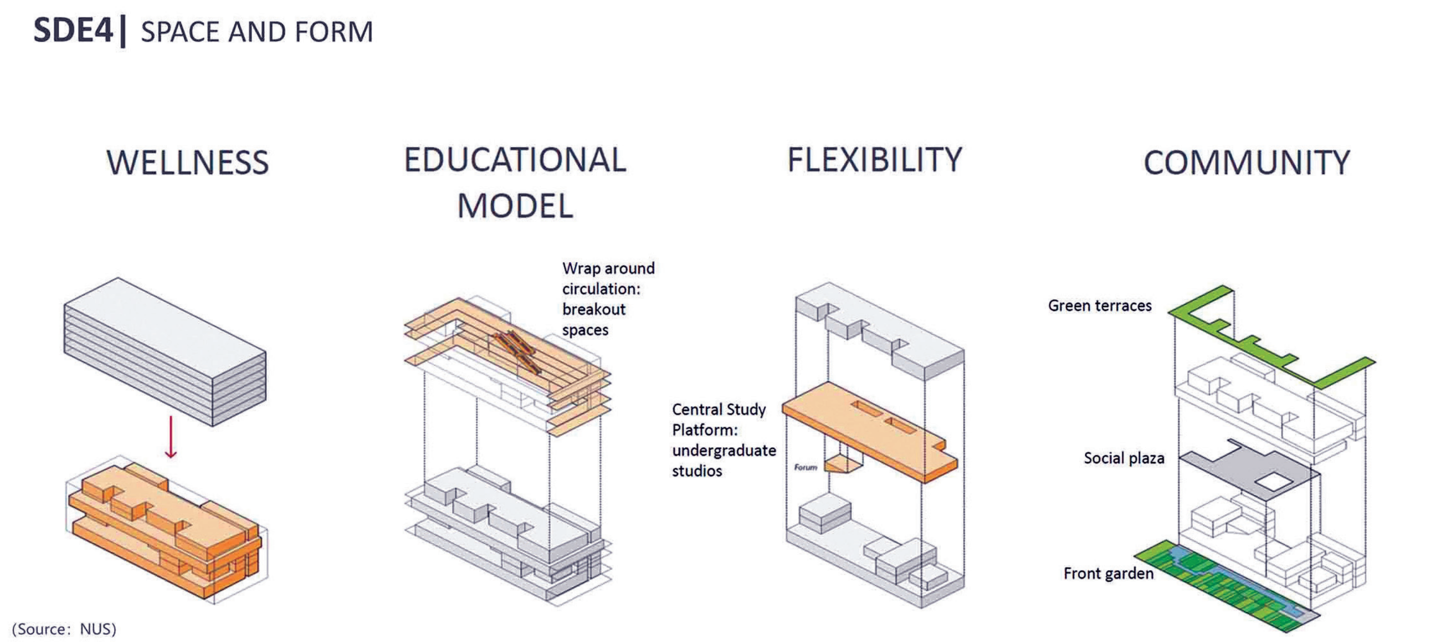
OVERHANGS AND SHADING DEVICES

To save the most energy, zero energy buildings should be designed in ways to avoid excessive sunlight exposure and maximise shading.

An over-sailing roof provides overall shading for the whole building, blocking out a substantial amount of direct sunlight and thus reducing overall energy demand. Photovoltaic panels can be installed on top to capture solar power, and should ideally be adjustable to face the sun at different times of the day to maximise catchment.

In the research by Professor Lau, the National University of Singapore School of Design and Environment 4 (SDE4) serves as a successful case study for 'nearly zero energy buildings', with energy generated by 1,225 solar photovoltaic cells installed on the roof. The renewable energy generated is made fit for building annual energy consumption. Surplus energy is supplied to the utility grid while energy is drawn back to the building in case of higher demand.

A combination of overhang and shading devices like louvres, perforated façades and blinds should be installed to minimise radiant solar heat gain. Depending on the angle of the sun, building



National University of Singapore's School of Design and Environment 4 as an example to illustrate massing strategies (Credit: National University of Singapore)

height and other site characteristics, calculations and testing need to be conducted to identify the best balance between the extent of different devices.

For example, for a 4/F enclosure at SDE4, it is found that the energy-saving effect is best with a two-metre overhang plus an internal screen and partially operable windows. It is also a good idea to allow occupants greater control over their immediate environment through openable windows and adjustable fan speeds. They lead to enhanced flexibility and encourage occupants to adapt to a wider range of thermal conditions than those configured by conventional thermal control systems.

SMART SENSORS AND RESPONSIVE ENVIRONMENT

Adapting to local climate has always been part of vernacular architecture. But as the devastating impact of climate change grows more imminent, climate responsiveness is now something not to be missed in any contemporary buildings across the globe. Smart building systems can be combined with local weather information to generate a responsive environment with optimised temperature.

For zero energy buildings, the ideal operative temperature is usually set at 27-28˚C compared with around 23˚C in conventional premium office buildings. This offers a pleasant user experience for most human activities while conserving energy resources for cooling.

To balance energy efficiency and user comfort, a key strategy is to employ an intelligent hybrid cooling system combining natural wind, smart fans and air-conditioning. Its effectiveness is powered by the incorporation of Internet of Things (IoT) sensors. For example, people opening windows may indicate that less air-conditioning is desired, so air-conditioning can be turned down automatically with more fans turned on.

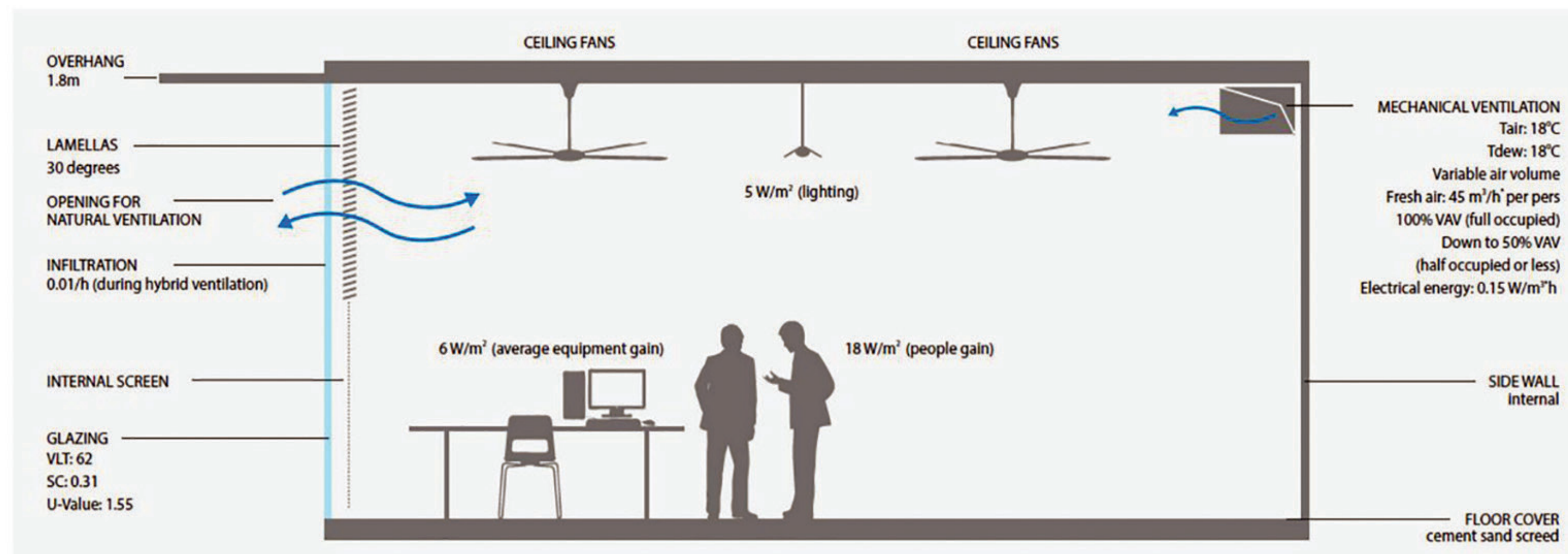
Other than temperature, these IoT sensors also capture a diversity of other real-time environmental data like air quality, light levels, water use, patterns of space occupancy, movement of people, etc, providing operators with useful analytics and insights on how to improve future energy efficiency, operational workflow and user experiences. These data can then be fed back to the building management systems to generate adaptive responses. For example, lights can go off automatically when the area is not in use. Besides, offering a range of light levels not only saves energy but also provides users with the most suitable environment according to the activities being carried out, depending on if people are working, socialising, exercising, dining or meditating.

HUMAN-ORIENTED POST-OCCUPANCY EVALUATION

In 2019, China authorities launched the Technical Standard for Nearly Zero Energy Building, which sets out the technical approach of 'Passive first, active enhancement, maximise renewable energy use'. LWK + PARTNERS Design Research Unit proposes a fourth element, which is 'human-oriented post-occupancy evaluation'.

Stairs form a key architectural feature at Tsuen Wan Sports Centre, Hong Kong, China designed by LWK + PARTNERS for the scenic harbour view

This competition proposal for an office building by LWK + PARTNERS features hanging social spaces for an open-air experience



Shading devices and hybrid cooling system at National University of Singapore's School of Design and Environment 4. (Credit: Transsolar KlimaEngineering)

LWK + PARTNERS' Green Shore Residence Phase II in Guangzhou, China adapts to the Lingnan regional climate with semi-open spaces filled with natural air and light

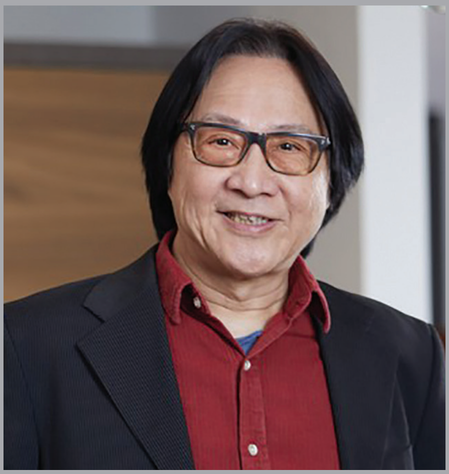
Canvassing real users' feedback on their subjective perceptions of using the building, these post-occupancy evaluations aim to assess the building's ability to deliver an ergonomic experience. These time-relevant data give operators a better idea of how to fine-tune their operations to provide the best comfort for users while boosting energy-saving performance, carbon reduction and cost-effectiveness. Architects can also use the data to inform future designs.

For example, in a study co-conducted by Professor Lau, his team surveyed students of a tropical university campus to understand their thermal comfort in learning spaces using different ventilation strategies. His results reflect that users adapt to a wider temperature range and become less sensitive to temperature change when they stay in spaces with hybrid cooling or natural ventilation. This suggests that the implementation of hybrid cooling or natural ventilation reduce users' demand for air-conditioning and therefore decrease energy demand. This provides valuable insights for future campus designers for similar climates.

TRANSITIONING TOWARDS NET CARBON ZERO

More than just energy-saving devices, zero energy buildings have a great potential to balance the needs of people and the environment. While the primary goal for designing such buildings is to carbon reduction, occupants will also benefit from a better user experience with the use of ergonomic technologies and eco-friendly structures that also serve as vibrant social hubs.

Architecture is key to realising a net zero future and zero energy buildings are certainly part of this. Not only are these green structures good for the environment, but they also foster a smarter, healthier landscape beneficial for people's health and wellbeing. With the use of artificial intelligence technologies, architects are set to build a fully responsive environment that helps people adapt to the age of climate change and evolving human needs.



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Professor Stephen Lau is the Design Research Director at LWK + PARTNERS. He has extensive research and practical experience in sustainable building design. Stephen Lau is leading the company's Design Research Unit and constantly evaluates the opportunities brought by zero energy buildings.

LWK + PARTNERS is a leading architecture and design practice rooted in Hong Kong. With over 35 years of growth, the diverse design team at LWK + PARTNERS shares expertise to provide a wide range of services including architecture, planning & urban design, interiors, landscape, heritage conservation, building information modelling (BIM), brand experience and lighting design.

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零能耗建筑是可持续人性化未来的关键推手

根据联合国环境规划署发布的《2020 年全球建筑建造业现状报告》，建筑建造行业占全球能源相关的二氧化碳排放总量的 38%。为实现建筑减碳，建筑师正积极探索“零能耗建筑”，这种新型建筑引起了整体行业及学术界广泛讨论，也确立了它在未来可持续智能城市发展的关键角色。

什么是零能耗建筑?
本文摘取了一些 LWK + PARTNERS 设计研究总监刘少瑜教授对未来零能耗建筑发展的观点，期望推动相关设计模式的前进发展。

零能耗建筑主张利用在地可再生能源，让建筑物自身发电，年产能等于或大于自身全年的用电量，以此达到净零能耗。

此类建筑多以被动式设计为重点策略，包括从建筑形态、布局、悬挑结构和遮阳装置等几方面着手提升节能效果。

其他设计策略包括主动式设计，例如高效的暖通空调、物联网（IoT）系统等设置，与被动式设计相辅相成，进一步提高建筑实现零能耗的能力。

另一个零能耗建筑的重要构成元素就是可再生能源应用。现时绿色建筑的在地发电主要利用太阳能，然而目前太阳能面对不少限制，因此近年看到的绿色建筑最多只能实现“近零能耗”，但这些先导项目依然具有宝贵的参考价值，让建筑设计同业在现有基础上进一步深化，广泛实现零能耗建筑，引领未来城市的可持续发展。

建筑形态及布局
建筑的外型和座向直接影响热能接收、采光和通风，而联合国环境规划署就指出，制冷相关的能源需求是建筑物最终用途之中增长最快的。

传统的矩形建筑多由一系列彼此分离的封闭空间组合而成，不但阻碍天然风进入建筑，也妨碍内部空气流动。相反，如将建筑体量分拆为多个虚疏叠起的水平面板块，便可产生对流通风，同时每个平面也为下面的楼层提供局部遮阳。如采用较浅的楼板空间，则效果更佳。

每处空间的面向和配置还可以进一步调整，建构通风廊道、露天平台和空中花园，为聚会及社交场所营造理想的热舒适度。利用环保隔热外墙物料也有助于降低空调需求，更可在外墙安装垂直或水平翅片，进一步阻挡日晒。

为减少使用电梯，可在建筑主要位置加入大型楼梯，以设计改变行为，除了省电之外，更同时促进用家健康和社区归属感。这些开放空间鼓励人们走动，与空间互动，加强楼层之间的视觉连接，刻划更有趣的人流动线，营造电梯难以取缔的活力体验。

悬挑结构与遮阳装置

为达至零能耗建筑的最佳节能效果，设计师会利用不同手法，避免或阻挡阳光直接照射到建筑空间之中。

大屋顶设计能为整幢建筑遮阳，阻挡大量阳光直射，减少了整体能源需求。屋顶更可加设光伏板以做到太阳能发电，如能在日间不同时段随太阳轨道而调整角度以面向太阳，就更为理想。

刘教授在其研究中以新加坡国立大学设计与环境学院 4（SDE4）为"近零能耗建筑"的一个成功案例。项目依赖屋顶的 1,225 块太阳能光伏电池发电，其可再生能源产量基本足以应付该建筑自身的全年能源消耗。剩余的能源可供给到附近的公用电网，而在用电需求较高的情况下，也可以安排电力回流。

建筑需要同时设置悬挑结构和遮阳设备，例如格栅、穿孔外墙和窗帘，才能互相补足，发挥最大效用，减少吸收太阳热力。最理想的是根据日照角度、建筑高度和其他场地特点，进行计算和测试，搭配不同设备，最终取得最佳协同效能。

以 SDE4 一个四楼空间为例，采用两米悬挑遮阳板搭配室内窗帘和可局部开合的窗户，节能效果最好。另外，让使用者自主控制窗户开合程度和风扇风速也能提高灵活性，同时增加人们对传统温控设置以外温度的体感接受程度。

智慧传感器与响应式环境

适应当地气候的设计元素一直见于各地乡土建筑。随着气候变化的威胁日益严峻，全球建筑都必须引入适应气候的功能。结合智能建筑系统和当地天气信息，有助创造温度舒适的响应式环境。

零能耗建筑的理想运营温度为 27-28°C，有别于传统高等级办公建筑的大约 23°C。这已足够应付大多数人们的活动，提供舒适的用家体验之余，能节约制冷资源。

智能混合冷却系统是平衡能源效益和用户舒适度的一个重要策略，结合自然风、智能风扇和空调，并需与物联网传感器配合使用。例如，若传感器探测到有人陆续打开窗户，这可能表示空间内需要较少空调，故可以自动关掉空调，并启动风扇。

除了温度调节，物联网传感器还可实时监测一系列其他环境数据，如空气质素、光照度、用水、空间占用模式、人员流动模式等，为运营方提供重要的数据分析和决策基础，改善未来的能源效益、工作流程和用家体验。这些数据更可以反馈到设施管理系统，触发系统自动回应。例如，无人区域可以自动关灯；调整光照度不仅可以节约能源，还可以根据现场使用者进行的活动，例如工作、社交、运动、用餐或冥想，以作出环境调节，提供最舒适的环境。

以人为本的建筑后评估

中国已在 2019 年颁布《近零能耗建筑技术标准》国家标准，为迈向零能耗建筑提出了“被动优先、主动优化、可再生能源最大化”的技术路径。LWK + PARTNERS 设计研究组对此作出提升和补充，提出闭环的第四个技术路径：“以人为本的建筑后评估”技术理念。

以人为本的建筑后评估意在收集使用者对建筑物体验的主观感受，评估建筑物在人性化体验方面的表现。这些实时数据让运营方了解如何调整他们的操作，为用户提供最舒适的环境，同时提升节能、减碳和成本效益。建筑师也可以善用这些数据来完善未来设计方案。

以刘教授另一个合作研究为例，他的团队在一所热带地区的大学校园进行调查，采集同学们的意见，了解不同通风策略对学习空间热舒适度的影响。结果显示，采用混合冷却系统或自然通风能够扩大使用者所接受的温度范围，并降低使用者对温度的敏感度，减少依赖空调，降低用电量。研究为类似气候环境下的未来校园设计提供重要参考。

迈向净零碳

零能耗建筑的重要性不仅在其节能效益，更在于平衡用家感受和生态保育。减少碳排放固然是发展零能耗建筑的主要目的，但透过人体工学设计和生态友好的活力公共空间，人们也因而享受到更优质的空间体验，促进人与自然和谐共荣。

建筑是实现净零未来的关键一环，而当中零能耗建筑作为未来绿建趋势，不仅对环境负责，更对推动健康、智慧的城市建设发挥积极作用，有利人们健康发展。加上人工智能持续发展，建筑师将逐步引入相关科技以建立全面响应式环境，助社会应对气候变化和人群不断转变的需求。