# Smart technology supporting traditional and bioclimatic building functions in reducing cooling energy demand in Cambodia



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# FUTURE OF CITIES

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# DIGITAL INSIGHTS

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# SMART TECHNOLOGY SUPPORTING TRADITIONAL AND BIOCLIMATIC BUILDING FUNCTIONS IN REDUCING COOLING ENERGY DEMAND IN CAMBODIA




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KIMNEH TAING

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Cambodia has been experiencing significant urbanisation, economic and population growth over the last decade with projections showing that this trend will continue until 2035 and beyond.[1] Moreover, buildings are responsible for one third of the total final energy consumption in Phnom Penh[2] and with increasing housing needs, no intervention will inevitably lead to an exponential increase both in energy consumption especially for cooling, and in related emissions. Furthermore, despite the low penetration rate of air-conditioning (AC) in the country, according to the International Energy Agency, AC sales have doubled between 2015-2018.[3]

Smart buildings can save energy by using advanced sensors and automated controls in heating, ventilation, and air conditioning (HVAC), lighting, plug loads, window shading technologies, as well as data analytics. In the same direction, sustainable building strategies can help users control their energy use and at the same time provide a highly efficient, healthy and comfortable living environment. A first step towards such strategies can be supported by existing technologies such as indoor environmental monitoring systems using data loggers as input devices to evaluate the existing conditions.

A related methodology has been developed as part of the sustainable building research conducted within the Build4People project. Indoor environmental conditions are being monitored for in-use residential buildings in Phnom Penh using Wi-Fi connected sensors recording and transmitting indoor temperature, humidity and $CO_2$ concentration data. This method enables us to have real time data of the actual conditions and along with app-based questionnaires, we can have a deep understanding of the building's operation as a starting point to design strategies for helping users deal with the pressing climate conditions of the location.

Based on this work an overview of climate related smart-building solutions and the possible benefits of building control and room automation are presented and discussed.

The total population of Phnom Penh has increased significantly over the last 30 years. According to the National Cambodian Census data and population estimations in the Cambodia Socio-Economic Survey, the population within its municipal boundaries has increased from 1.36 million to 2.28 million between 2010 and 2019.[4] The population increase is largely based on a period of strong growth between 2010 and 2019, during which the labour force increased by 53 percent, and which continued but declined between 2014 and 2019.[5]

Since the '00s, this growth has been characterised by significant investment activities in the construction sector and a steep increase in land prices all over the city, that led to a change in building design, and a consequent rise in the electricity

1. United Nations, Department of Economic and Social Affairs, Population Division, "Word Population Prospects - Key Findings WPP 2015, Key Findings and Advance Tables. Working Paper No. ESA/P/WP.241", 2015.
2. Asian Development Bank, *Cambodia: Energy Sector Assessment, Strategy, and Road Map*, Asian Development Bank, 2018.
3. IEA, The Future of Cooling in Southeast Asia, https://webstore.iea.org/the-future-of-cooling-in-southeast-asia.
4. National Institute of Statistics (NIS), *Cambodia Socio-Economic Survey 2007, Housing Conditions*, Phnom Penh, 2008; National Institute of Statistics (NIS), Cambodia Socio-Economic Survey 2010, Phnom Penh, 2011; National Institute of Statistics (NIS), *Consumer Price index*, Phnom Penh, https://www.nis.gov.kh/nis/cpi/Jul2019.htm; Cambodian Cencus, "Final-Leaflet-Census-Report-2019-Eng", 2019.
5. National Institute of Statistics, Ministry of Planning, "Cambodia Labour Force Survey 2019", 2019.

consumption per capita from about 46.9 kWh in 2004 to 659.5 kWh in 2019.[6] In this context of rapid economic growth where incomes and consumption levels are rising, greenhouse emissions are rising along with them.

Cambodia's footprint has been increasing drastically since the beginning of the 1990s. Emission levels increased from0.21 tnCO² per capita in 2005 to 0.92 tnCO² per capita in 2020.[7] The emissions growth has been particularly strong during the years of high Gross Domestic Product (GDP) growth rates. This increase is of course related to increasing energy consumption, with the building sector being the largest final energy consumer after transport and industry, with an estimated share of 40 percent.[8] In a report from the United Nations Development Program (UNDP) on energy efficiency, it is estimated that the energy consumption of Phnom Penh's buildings will more than double by 2040 due to new construction following the high economic growth and the increasing demand for cooling due to Southeast Asia's hot and humid climate.[9] The same report estimated household energy consumption, showing that the main energy use appliances in residential buildings are lamps, electric cookers, refrigerators and air conditioners. This is expected to change, as with increasing income levels the penetration level of electrical devices is also very likely to increase.

Regarding AC use in Cambodia, an interesting finding of the study is that people who do have air conditioners in their home use them on average 14 hours per day, mostly at night time when they come back from work and need maximum comfort when they sleep. While at the same time it is predicted that air conditioner and refrigerator sales will most likely skyrocket in the upcoming years. From studies in hot humid countries, it has been shown that households spend 35 percent to 42 percent more on electricity when they use AC[10] but that in addition, that having an AC unit strongly improves how satisfied Cambodians are with their thermal environment.[11] Increasing demand for thermal comfort and thus for cooling will inevitably contribute significantly both to a further increase of energy use and to greenhouse gas emissions, due to emissions of Hydrofluorocarbons (HFCs), $CO_2$, and black carbon from the mostly fossil fuel-based energy that power air conditioners and other cooling equipment. Besides the environmental impact, there are going to be social impacts too if climate change makes indoor cooling essential for the health and safety of the majority of the population, since 27 percent of the total households in Cambodia are currently energy insecure.[12]

Apart from the predicted increase of AC ownership and need for comfort, a surge in energy demand will be driven by the foreseeable population growth in Phnom Penh. The Phnom Penh Urban Transport Master Plan, developed by the Japan International Cooperation Agency (JICA), projects that Phnom Penh's population will reach 2.9 million inhabitants by 2035. The United Nations (UN) expects an increase to 2.6 million inhabitants by 2030. At the same time, the national urbanization level is expected to increase to 26 percent. According to the UN, Cambodia will be one of the most rapidly urbanising countries between 2018 and 2050 with an annual rate of urbanization of 1.8 percent.[13]

As these trends continue, regional policy makers should prepare to meet the future demands and challenges that come with this extraordinary rhythm of urbanisation. Implementation of smart building technologies in Cambodian cities could provide some long- and short-term solutions for improving the overall quality of life (QoL) of the urban population, as a study done by the McKinsey Global Institute (MGI) states that technology solutions could improve QoL within Southeast Asian cities by approx. 30 percent.[14]

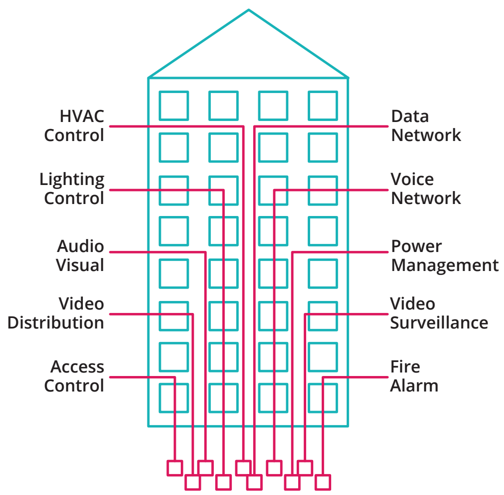
As put into the ASEAN Smart Cities Network framework, smart cities in ASEAN can apply innovative solutions to enhance the overall welfare of their citizens and to address all of the above-mentioned issues.[15] Smart cities in ASEAN can invest in smart infrastructure to deliver multiple benefits across various stakeholders, whether private, public or corporate. These can include: (i) smart utilities such as energy, water and wastewater treatment; (ii) smart mobility and transportation; and (iii) smart buildings and construction.[16]

## But What Is a Smart Building?

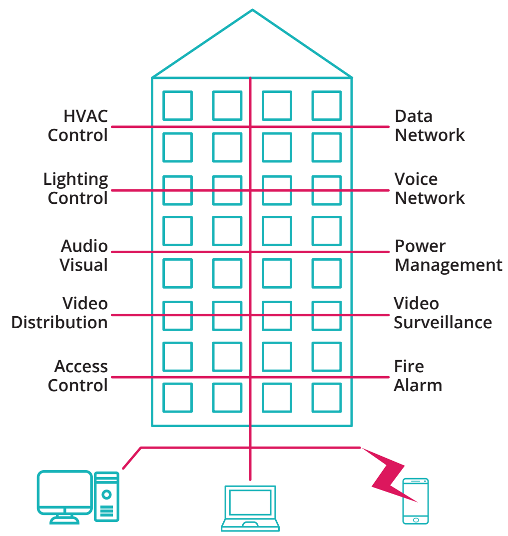
A smart building is one that uses automated processes to control the building's systems i.e. HVAC systems, lighting, electric devices, security systems etc. Smart buildings use automation to make a building grid flexible, healthy, productive, energy and cost efficient.

The most common definition of smart buildings focuses on the combination of energy-saving systems and intelligent technologies with the aim of finding a balance between comfort levels for occupants and energy consumption. The term also implies the ability of a system to operate autonomously from users and suggest, or to a certain degree perform actions. However, the intelligence of a modern smart home is considered to be, in addition to the degree of evolution and automation of a system, the degree to which its system serves the needs of a 'green' home (i.e., energy-saving mechanisms should be included in its operation). In any case, a smart building should contain energy efficiency mechanisms in its design, as well as adaptation or "training" mechanisms to adapts its operations parameters to the prevailing conditions. For example, by applying pre-selected scenarios or automation algorithms;and/or prediction of future operations-processes. To this end, it shall include energy saving systems that go beyond its intelligence. For example, a green building, which takes full advantage of the use of renewable energy in its operation with a practically zero balance sheet, may not be intelligent, but it is in fact 'smart' in the way it uses energy - something that a truly smart/intelligent building may not be able to achieve.

6. countryeconomy.com, *Cambodia - Electricity consumption 2019*, https://countryeconomy.com/energy-and-environment/electricity-consumption/cambodia.
7. Hannah Ritchie, Max Roser, Pablo Rosado, "$CO_2$ and Greenhouse Gas Emissions", *Our World in Data*, 2020.
8. International Energy Agency (IEA), United Nations Environmental Programme (UNEP), Global Alliance for Buildings and Construction (Global ABC), *2019 Global Status Report for Buildings and Construction, Towards a zero-emission, efficient and resilient buildings and construction sector.*, 2019.
9. United Nations Development Programme (UNDP), *Energy Efficiency in Buildings, Accelerating Low-carbon Development in Cambodia*, Phnom Penh, MDPI, 2020.
10. Teresa Randazzo, Enrica de Cian, Malcolm N. Mistry, "Air conditioning and electricity expenditure: The role of climate in temperate countries", *Economic Modelling*, Vol. 90, 2020, 273–287.
11. BELDA Database, "State of residential energy consumption in Southeast Asia", 2017.
12. Randazzo, Cian, Mistry, *Air conditioning and electricity expenditure: The role of climate in temperate countries;* Han Phoumin, Fukunari Kimura, *The Impacts of Energy Insecurity on Household Welfare in Cambodia: Empirical Evidence and Policy Implications*, 2019.
13. United Nations, Department of Economic and Social Affairs, Population Division, *World Urbanization Prospects The 2018 Revision*, New York, 2018.
14. McKinsey Global Institution, "The future of Asia: Asian flows and networks are defining the next phase of globalization", 2019.
15. ASEAN, "ASEAN Smart Cities Framework", 2018.
16. Ibid.




**Management Consoles for Individual Systems**




**Local and Remote Multifunction Management Consoles**

In short, we can distinguish five levels of operation of a smart building. The smart building:

- Provides basic connectivity/ communication (internet etc.).
- Responds to simple operation control commands inside or outside the home.
- Controls its operation from within or outside. Local or remote control can include various types of control (door opening and closing, control of windows - doors that are open, user control of lighting, etc.). The control depends on the level strictly on the user.
- Automated operation (lighting on/off at a predetermined interval, programmed operation of heating or cooling systems, security systems, etc.).
- Detects presence & health & safety parameters. The system operates or under-operates based on the human presence in a room or indications related to the optimal QoL of people.
- Information Analysis - Decision Making and Action. The system provides information on energy consumption to one or more users, generates reports for residents, managers or providers, makes changes to automated functions (based on prescribed behaviours/ options or algorithms that vary the system operation according to different parameters) in order to achieve optimal overall operation.

In addition to the above-mentioned functions, a smart home can provide other functionalities such as providing information, reminders and suggestions to the users relevant to their daily life and schedule, 'answer' their questions or act on behalf of them.

## How Does Smart Building Technology Work?

One of the methods to make a building smart is the Building Energy Management Systems. A building energy management system (BEMS) is a way to monitor and control the building's energy needs, for instance energy data from heating, ventilation, and air conditioning (HVAC) systems. Then, depending on the collected data, the system identifies the building's energy consumption patterns and creates more efficient energy consumption plans.[17]

According to Global Industry Analysts, Inc., Asia-Pacific ranks as the fastest-growing market for BEMS with an annual growth rate of almost 20 percent over the period analysed.[18] This reflects the growing need for such systems by developers and governments. All this leads to increasing opportunities for collaboration between technology companies and energy stakeholders to drive smart transformation in the region.

The main necessary step towards both a smart city and smart transformation is data. For such a development data cannot be considered as costly or redundant. Instead, they must be viewed as a necessary source of information for any level of planning. Cities with lower capacities could kick-start their strategy development by creating open portals that make raw data available to the public, and which the private sector could use to develop innovative smart solutions. Urban planners should should also raise awareness of the sources of this data, as well as the global innovations they feel could be applied to their own cities. This requires minimal public investment but could serve to improve the quality of life for citizens in the long run.[19] Moreover, lower budget cities should prioritise practical technologies over high-end, 'trendy' ones.

## Smart Devices

A way to acquire building and city data are smart devices, which are electronic devices that have the ability to connect to other devices or (intelligent) networks via different protocols (Bluetooth, NFC, Wi-Fi, 3G) and can operate to a certain extent interactively and autonomously. These devices will in the long term replace conventional household appliances as a key feature of 'smart homes'. Smart technologies are also a major factor in shaping what is called the Internet of Things. The term 'smart device' can even refer to a technologically advanced computing device that has advanced capabilities and/or elements of AI. The basic idea behind smart devices is the ability to provide the user to operate them locally or remotely via wireless communication.

Smart appliances fulfil the objective of home building automation by having a sufficient (or high) degree of independence from the user and a minimum (or maximum) degree of intelligence. For example, an automated building ventilation system can monitor the amount of carbon dioxide (CO2) and can vary the amount of airflow in occupied areas without over-ventilating others, saving considerable energy in HVAC operations. Additionally, home automation systems are defined and can optimize airflow by parameters like occupancy, temperature, humidity, pressure, air quality and ventilation.[20] The system monitors this data via sensors then a microprocessor device analyses it and forwards it to a control device.[21]

**17.** UN Environment Programme, *Building Energy Management Systems (BEMS) | Climate Technology Centre & Network, 11/08/2016*, https://www.ctc-n.org/technologies/building-energy-management-systems-bems..

**18.** AIBP Industry Platform, *How Smart Energy Management Systems Can Drive Transformation in ASEAN Countries Industry Platform*, https://iotbusiness-platform.com/insights/how-smart-energy-management-systems-can-drive-transformation-in-asean-countries/.

**19.** Angaindrankumar Gnanasagaran, "What makes smart cities tick?", *The ASEAN Post*, 25/12/2018.

**20.** Juing-huei Su, Chyi-shyong Lee, Wei-chen Wu, "The design and implementation of a low-cost and programmable home automation module", *IEEE Transactions on Consumer Electronics*, Vol. 52, No. 4, 2006, 1239–1244; A. Alheraish, "Design and implementation of home automation system", *IEEE Transactions on Consumer Electronics*, Vol. 50, No. 4, 2004, 1087–1092.

**21.** Su, Lee, Wu, *The design and implementation of a low-cost and programmable home automation module; Alheraish, Design and implementation of home automation system.*

Typical home automation has a set of sensors, an actuator, a control panel and a main-board with a microcontroller, moreover there is communication protocol between these components of the system.[22] The performance of home automation systems can be enhanced by using data loggers. A data logger is a data collecting and saving tool which allows for further analysis of related environmental changes. Data loggers are capable of recording time stamped data from a data source, a home automation system, and saving them into a data storage server or an internal memory.[23] Therefore, it is possible to add a data logger component to an existing home automation system. The data collected by the data logger can then be analysed for the desired goal, such as energy efficiency, health, or optimal ventilation system function.[24]

## Towards Smart Buildings and Better Quality of Life in Phnom Penh

Due to the hot and humid tropical climate in Southeast Asian countries, a relatively large share of energy consumption is attributed to air conditioning used to maintain occupant thermal comfort. Reducing building energy consumption while maintaining comfort is a regional societal challenge tied to sustainable urban development and QoL maintenance in the region.

QoL in Phnom Penh is the focus of the Build4People research project and the relation of comfort to building energy use is one of the project's core considerations.[25] For that, basic indoor environmental parameters (temperature, humidity, CO2-concentration) in residential buildings are continuously monitored with wireless data loggers over a six-month period. Moreover, weather data is gathered from the National Centre for Environmental Information website and from the project's weather stations.

More specifically a series of surveys and studies are conducted in Phnom Penh within the project in order to try to answer how indoor environmental quality can be evaluated, measured and enhanced, both on the user and building level in the specific context of Phnom Penh.[26] Comprehensive indoor environmental data and occupant behaviour information are collected, analysed and used as a basis for subsequent simulation studies. The whole survey campaign consists of four main parts: preliminary household survey, building audit and long-term monitoring, detailed on-site survey and thermal comfort survey with occupants. The collected data are analysed, processed and prepared for following research and development of climate-adapted building strategies.

The purpose of this measurement campaign is to gain a basic understanding of the residential usage, building thermal behaviour, function, energy consumption, and perceived quality of life in Phnom Penh's urban regions. By identifying the link between occupant behaviour, building controls, energy-related consumption patterns and buildings thermal behaviour, innovations for building technology adoption in the building sector can be suggested and evaluated.[27]

The results of these combined campaigns can then be used to evaluate the impact of the use of different building materials, design techniques and user behaviour to the Indoor Environmental Quality (IEQ) in residential buildings and to possible energy savings. For existing buildings, building audits and records are critical for understanding what needs to be done, and when, to improve efficiency, intelligence and the occupants QoL. By following a series of core steps (understanding, measurement, enhancement), these outcomes can be used to promote and support the development of sustainable and smart building codes, guidelines and policies.

The first step towards any kind of smart intervention is the understanding of the current status of the building stock and how it can be optimised. Apart from helping us to gain this understanding, the use of specific data loggers could be also considered as a step towards smart devices in building monitoring, since the user can have access to the information in real time and make adjustments towards improving air quality, thermal comfort and energy use. The overall campaign could be used as a preparatory stage for a smart building design strategy by the city of Phnom Penh and could be aligned with the governments drafted plans to transform key Cambodian cities, with Phnom Penh amongst them, into smart cities, aiming at establishing an inclusive ASEAN smart cities network.[28]

Long-term measurements of the indoor environmental conditions should be used to identify solutions other than those revealed by the audit's data. This already qualifies as an entry level smart technology, especially if the equipment is connected to the Wi-Fi and other platforms providing real time information. The impact of the various components of the building depends a lot on the local conditions, thus the fundamental principles of smart buildings will differ in the various climates, meaning that the specific climate conditions of Phnom Penh should be taken into consideration.

It is also evident that some of the available technologies might currently not be economically feasible and that the local market capacities might not be enough to implement such solutions. In order to take into account these technologies and the predicted changes, the methodology of a technology roadmap can be employed. Such a roadmap documents the current context and drafts the desired future performance, then develops a pathway from the current situation towards the intended future performance.[29] Therefore, a roadmap for smart buildings can be made using the data acquired in the earlier processes by identifying current and emerging technologies as well as other advancements that can assist in achieving the desired future scenarios.[30]

## Benefits of Smart Buildings

If smart-building solutions are applied in commercial and residential buildings,

22. Alheraish, *Design and implementation of home automation system.*

23. ONSET, *Data Logger Basics | Onset Data Loggers*, https://www.onsetcomp.com/content/data-logger-basics/

24. ONSET, Data Logger Basics | *Onset Data Loggers*

25. M. Waibel, A. Blöbaum, Matthies, E., Schwede,D., Messerschmidt, R., Mund, J.P., Katzschner, L., Jayaweera, R.,Becker, A., Karagianni, C., McKenna, A., Lambrecht, O., Rivera, M., &Kupski, S., "Enhancing Quality of Life through Sustainable Urban Transformation in Cambodia: Introduction to the Build4People Project", 2020

26. Ibid.

27. Timuçin Harputlugil, Pieter de Wilde, "The interaction between humans and buildings for energy efficiency: A critical review", *Energy Research & Social Science*, Vol. 71, 2021, 101828; Yousef Al horr, Mohammed Arif, Martha Katafygiotou, Ahmed Mazroei, Amit Kaushik, Esam Elsarrag, "Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature", *International Journal of Sustainable Built Environment*, Vol. 5, No. 1, 2016, 1–11

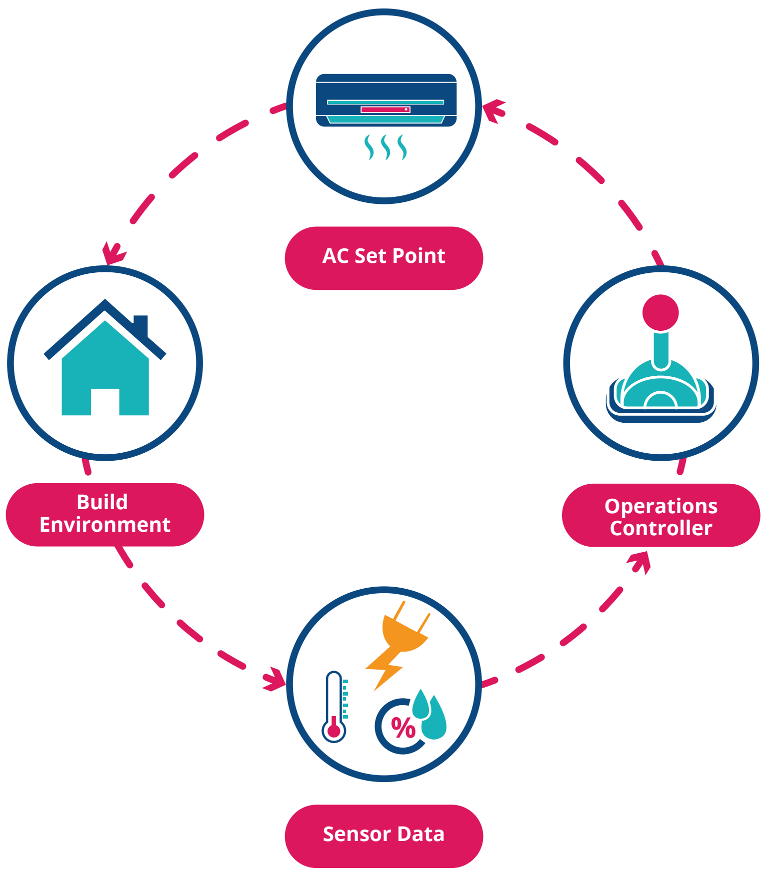
28. Sommana Yan, "Cambodia to Adapt Smart City Management Model from Singapore", *Construction & Property News*, 13/07/2021

29. Schwede D., "Road-Mapping for a Zero-Carbon Building Stock in Developed and Developing Countries", in: *Zero-Energy Buildings - New Approaches and Technologies*, Jesús Alberto Pulido Arcas, Carlos Rubio-Bellido, Alexis Pérez-Fargallo and Ivan Oropeza-Perez (eds.), IntechOpen, 2020

30. Hannah Kosow, Robert Gaßner, Lorenz Erdmann, *Methoden der Zukunfts- und Szenarioanalyse, Überblick, Bewertung und Auswahlkriterien*, Berlin, IZT, 2008

they can make them safer and healthier. Safer due to the improved fire, security and other emergency procedures that can be tracked instantly and healthier due to the technology's ability to monitor and control the indoor environmental conditions. Smart technologies can monitor factors such as air quality and water quality and can notify the users instantly when value thresholds are surpassed. For instance, an automated system can increase ventilation when the $CO_2$ levels increase above a set level in a room.

Automated operations can be employed in residential buildings to regulate energy usage in accordance with user demand and to instantly inform inhabitants about their energy use. Energy efficiency improvements result in lower emissions and less demand for resources. For instance, turning AC units off later at night when people are sleeping and/or controlling AC to necessary temperatures based on adaptive comfort models, can save energy and promote better sleep.[31] Moreover, residents can change energy use behaviour according to the provided information while the system can apply certain comfort settings for the residents based on the prevailing climatic conditions (Image 2).




**Energy-Efficient Thermal Comfort Control in Smart Buildings**

**31.** Sheikh Ahmad Zaki, Mohamad Faizal Rosli, Hom Bahadur Rijal, Farah Nurhanis Hassan Sadzli, Aya Hagishima, Fitri Yakub, "Effectiveness of a Cool Bed Linen for Thermal Comfort and Sleep Quality in Air-Conditioned Bedroom under Hot-Humid Climate", Sustainability, Vol. 13, No. 16, 2021, 9099

A prevalent problem in residential buildings in countries like Cambodia or Vietnam is the low air quality, where poor, inefficient HVAC systems are used to cool rooms. Furthermore, due to a lack of awareness of natural ventilation, many people open windows while operating their air conditioning units, thus wasting energy. If the functioning of the AC, window openings, and mechanical ventilation are connected, smart technology can assist in resolving the issue between the supply of fresh air and the AC. For example, simple sensors on windows and doors can be used to lock AC operation, or ventilation can be managed to maintain $CO_2$ and humidity levels below necessary thresholds via natural but controlled air exchange if the windows or ventilation apertures are fitted with motorized shutters.

Cambodian buildings are exposed to a lot of sunlight, 8 hours per day of intense sunlight to be specific. Without thoughtfully planned open spaces or natural air movement included into urban design, this contributes to overheating and the excessive usage of air conditioning equipment. One of the most widely used strategies to avoid solar radiation in buildings is to provide appropriate shading. On the other hand, external shading devices might be compromised by storms during the rainy season (especially in high rise buildings). In this situation, smart control can be used to make the most of external shade devices and safeguard them from wind sensor damage.

Another application of smart technology with obvious benefits is the coordination of household energy consumers, such as washing machines or electric water heaters, with renewable energy supply from Photovoltaic (PV) systems installed on the roof. Thereby the benefit of renewable energy applications is maximized and the demand for battery storage is reduced.

## Conclusion

For buildings to be considered smart, they must first be sustainable and energy-efficient. Policy makers and frontrunners should push for subsidised energy efficiency and building retrofit schemes, as well as smart technologies such as smart meters.

For such schemes and technologies to work, the lack of good quality data, caused by poor data acquisition and sharing practices, needs to be addressed as soon as possible. Data should be first acquired and then become openly accessible so they can be linked to other useful datasets. In order for buildings to be smart and for their energy use to be aligned to the grid, such data needs to be accessible in real time, of course with maintained privacy at all times. User-building and energy interactions should be carefully considered when new technologies are integrated into buildings. This integration should happen gradually, starting with simple technologies where the user can have an understanding of the interaction and where there is feedback between the building and its users. Furthermore, the concerns of homeowners will be alleviated if they can see the benefits and use of their data, so raising public awareness should be put on the first line of a data acquisition campaign.

Reducing energy demand and decarbonising buildings and energy systems is a complex problem with a range of socio-economic and technological aspects. Smart sensors and energy monitoring coupled with user input can help provide solutions for different kinds of inefficient building or user behaviours. The analysis of the acquired data can help identify and provide solutions for balancing demand and supply. In turn, It can reduce our overall reliance on fossil fuels, and lead to the promotion of more environmentally friendly energy sources. Smart technologies can reduce emissions with additional health-related benefits.

In conclusion, smart technologies can reduce emissions with additional health-related benefits. The potential is enormous and should be explored in all aspects, particularly in climatic zones requiring year-round cooling - such as Cambodia.

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### VIRAK HAN

Virak Han is a dean of faculty of civil engineering at the Institute of Technology of Cambodia. His research interest is related to construction materials and structural efficiency. Optimization of mix compositions in mortar and the prediction of strength development of concrete were the research works for his Ph. D degree. After his graduation, he took part in different research with foreign partner universities for topics relative to local context for the sake of construction fields in Cambodia.

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