Guest editorial: Global energy transformation for combating climate change in the built environment: challenges and opportunities in developing countries

Globally, buildings account for 30–40% of total energy consumption (Peng *et al.*, 2019; Dong *et al.*, 2021) and are responsible for about one-third of greenhouse gas (GHG) emissions (Lam *et al.*, 2014; Fenner *et al.*, 2020). The use of conventional energy, mainly from fossil-fuel-based energy generation systems (Flammini *et al.*, 2021), continue to be the major energy supply to buildings, thereby contributing significantly to global warming and climate change. With the signing of the Paris Agreement that sets out a global framework to avoid dangerous climate change by limiting global warming to well below 2 C and pursuing efforts to limit it to 1.5 C (Gunfaus and Waisman, 2021), it has become necessary to explore low-carbon energy transformation pathways in all sectors for climate change mitigation and adaptation (Zhao *et al.*, 2021; Linton *et al.*, 2021).

In the built environment, energy consumption is influenced by a number of factors including building design and materials used for the construction (Opoku *et al.*, 2020), the occupancy rate, the type and efficiency of the appliances used in the building, as well as the behavior of the occupants using the building (Ahadzie *et al.*, 2020). Researchers, practitioners and policy makers across the globe are therefore exploring opportunities to improve efficiency of energy systems, energy consumption behavior, smart technologies, carbon sink materials for building construction, etc. in order to reduce building energy consumption and emissions (Arrigoni *et al.*, 2017).

Integration of renewable energy in buildings also brings opportunity to diversify building energy supply to low-carbon pathway, thereby reducing energy-related emissions during the operational phase of the building (Wang *et al.*, 2021). Renewable energy for running HVAC systems which are the major energy consuming equipment in buildings has therefore been explored to reduce building energy consumption and emissions (Opoku *et al.*, 2018).

Over the past decades, a lot of research have been conducted worldwide to explore the possible solutions for combating climate change in the built environment due to its negative impact on humanity and socio-economic development (Fathy *et al.*, 2021; Nhep *et al.*, 2021). Global energy transformation that prescribes sustainable energy supply with low-carbon renewable energy generation pathways coupled with energy efficiency presents opportunity for decarbonization and contributing to the target of limiting global warming to well below 2 C. While there are clear policies, technology innovations, initiatives and programs to realize some of these global targets in developed countries, not much is known for developing countries. From available literature, there are scanty information on specific technology innovations and programs, particularly in Africa, that support global energy transformation targets.

The aim of this special issue is therefore to understand the cutting-edge research and technologies being implemented in developing countries to achieve clean, affordable and

International Journal of Building Pathology and Adaptation
Vol. 40 No. 2, 2022
pp. 161-164

2398-4708
DOI 10.1108/IJBPA-04-2022-156

sustainable energy for the built environment. In addition, efficient technologies that deliver effective thermal cooling of buildings in a sustainable manner to enhance significant energy efficiency improvements and reductions in GHG emissions to address SDG 13 are priority for this Special Issue.

International contributions to this special issue address the range and depth of current research on very interesting topics including smart technologies and energy efficiency, mechanical cooling and energy efficiency practices, indigenous technologies and community actions, renewable energy development for the built environment and energy consumption behavior in sub-Saharan economies. Research studies presented in this special issue with case studies from countries like South Africa, Ghana, Burkina Faso, Nigeria and Uganda present the generality of the challenges and opportunities in energy transformation for combating climate change in the built environment in developing countries, especially in Africa. The following section presents highlights from the seven papers published in this special issue.

Drawing on systematic review of the literature (SLR), aided by the PRISMA guiding principle, Simpeh *et al.* (2021) reviewed the status and current trends of energy consumption associated with HVAC systems with the aim of interrogating energy efficiency practices for improving HVAC energy consumption in buildings. The authors developed an integrated optimization conceptual framework, highlighting energy efficiency options that may complement HVAC systems operations in buildings.

The study presented by Ouedraogo *et al.* (2021) discussed the major challenges faced by West African countries in finding comfortable housing because of climate change and population growth. They proposed an adaptive model which relies on a combination of parameters such as the operative temperature, the new effective temperature and the basic parameters of thermal comfort. The decision-making tool proposed in their study based on bio-climatic concept through a long-term comfort index, allows building stakeholders to design, assess and improve the thermal environment of buildings better and easily, compared to conventional approaches.

Agyekum *et al.* (2021) presented a study on factors limiting the adoption of hemp as an alternative sustainable material for green building delivery in Ghana. They established that lack of awareness on the opportunities of low-embodied carbon building materials, like hemp, for green building delivery is the major factor for their adoption.

In the work of Jegede *et al.* (2021), they demonstrated the optimization of an existing residential building in a tropical climate using indigenous materials. The indigenous materials were used as alternative to conventional building envelopes to achieve thermal comfort and affordable housing in the city of Abuja, Nigeria. Using energy plus simulation tool in DesignBuilder, they demonstrated that the use of indigenous materials in buildings in Nigeria substantially reduced the annual operative temperature by 8%, thereby increasing the predicted three months of thermal comfort in the base case to nine months annually, resulting in about one-third reduction in the annual CO_2 emissions, cooling loads and construction costs.

Ekung *et al.* (2021) presented a study on green cost premium (GCP) for attaining energy-efficiency rating in Nigeria's hot-humid residential buildings. Their study provided cost benchmarks for navigating cost planning and budgetary decisions during energy-efficient designs (ED) of buildings. They demonstrated that potential GCPs and their payback periods are actually less than feared and that less than 5 and 21% extra funding would be required to achieve 1 to 4-star and 5-star energy-efficiency ratings involving passive design interventions and photovoltaic systems.

The study by Frimpong *et al.* (2021) presented a new and simple model for the prediction of unregulated energy usage in buildings. A method for determining a set of optimum values of power and usage periods of unregulated energy loads (UEL) required by the model was

developed. Their study showed that non-dominated sorting genetic algorithm II (NSGA-II) for predicting the energy consumption of UELs in offices is highly accurate and suitable for adoption by energy modelers, building designers and building regulatory agencies.

Finally, the study of Elasu *et al.* (2021) explored the economic and socio-demographic factors that influence households' decisions on the type of fuel used for cooking in urban areas in Uganda. Their study established that kitchen type, dwelling type and the type of apartment tenure significantly influence the choice of household cooking fuel decisions.

The seven papers presented in this special issue provide a valuable contribution to the discourse on climate change-resilient nexus by highlighting the challenges and opportunities in the global energy transformation for combating climate change in the built environment, particularly in developing countries.

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