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Towards zero carbon in a hot and humid subtropical climate

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Abstract

Hong Kong buildings account for 90% of total electricity consumption and over 60% of greenhouse gas emissions. Therefore buildings present both a challenge and an opportunity for reduction in energy use and greenhouse gas emissions. Net Zero Energy Building (NZEB) and Net Zero Carbon Building (NZCB) are recognised as feasible strategies to reduce energy use and carbon emissions leading to a more sustainable built environment. While there is a growing number of NZEBs and NZCBs in relatively cool or temperate climates, there are relatively few examples in the subtropical climate, and in a densely populated city such as Hong Kong.

This paper will examine the current progress towards a low carbon built environment in Hong Kong, zero energy/carbon design strategies and technologies applicable to building in a subtropical climate, and examines a case study of Hong Kong's first zero carbon building—ZCB. ZCB's energy and carbon performance, experiences and lessons learned, and future directions are discussed. The paper will conclude with the challenges and opportunities for wider adoption of NZEBs and NZCBs in the Hong Kong construction industry.

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1. Introduction

The built environment has a key role in climate change mitigation. There is an urgent need to minimise the impacts of construction sector activity on the natural environment and to develop low carbon cities [1], [2]. Having

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reached an unprecedented first ever-binding agreement to combat climate change at the Paris climate conference (COP21) in December 2015, 195 participating nations are committed to actions and investments toward a low carbon and resilient future. The Paris Climate Agreement aims to limit global warming to well below 2°C with a long-term goal of net zero emissions for this century [3]. Net Zero Energy Building (NZEB) and Net Zero Carbon Building (NZCB) are recognised as feasible strategies to reduce energy use and carbon emissions [4], [5], [6], [7].

There are relatively few examples of NZEBs and NZCBs in a subtropical climate and in high density cities. As the first of its kind in Hong Kong, Zero Carbon Building (ZCB) aims to achieve zero carbon emissions through balancing the energy consumed with the energy generated from renewable energy sources on an annual basis. Surplus renewable energy generated is used to offset the embodied carbon of its construction process and major construction materials. The design, construction, and operation of ZCB is innovative in its application in the hot and humid subtropical high density Hong Kong environment. However, more widespread adoption of zero energy/carbon building principles and technologies in the Hong Kong construction industry would rely on demonstrable evidence of energy use reduction and carbon reduction potential, as well as their transferability from small scale use to highrise applications. The aim of this paper is to present a case study overview of ZCB's energy and carbon performance, experiences and lessons learned to date, with a view to examining strategies applicable to a subtropical climate and the feasibility of applying NZEB and NZCB approaches in a highrise urban environment.

2. Towards a Low Carbon Built Environment

In line with an urgent international agenda to reduce carbon emissions, Hong Kong has pledged to reduce its carbon intensity by 50%-60% by 2020 [8]. The Hong Kong SAR Government has also launched an "Energy Saving Plan for Hong Kong's Built Environment (2015-2025)" [9], which outlines the Government's energy saving policy, strategy and targets. A target of this plan is to reduce Hong Kong's energy intensity by 40% by 2025 compared to the 2005 baseline. Policies and actions for carbon reduction are in place as part of Hong Kong's aim to become a low carbon liveable city.

The need to target climate change and abate greenhouse gas emissions has led to increasing awareness of the concepts of NZEB and NZCB among stakeholders in the Hong Kong construction industry as approaches to create a low carbon city. ZCB is an example of this shift in thinking. Recent times have also seen an increasing number of residential, commercial and institutional projects with BEAM and LEED Platinum ratings in Hong Kong. Examples include Welfare Road Residential Development, Hysan Place, Hang Sang Management College S H Ho Academic Building etc. [10]. More attention is also directed towards sustainable urban development in newly developed and existing developed districts. One example of a newly developed area is the Energizing Kowloon East development comprising a mix of government buildings, commercial areas, residential buildings, community facilities and open spaces with the integration of a district cooling system [11]. This development aims to be a new economically, environmentally and socially sustainable Central Business District in Hong Kong. These examples demonstrate Hong Kong's efforts to transition to a low carbon built environment.

3. NZEB/NZCB Strategies and Technologies for a Hot Humid Subtropical Climate

An evaluation of existing NZEBs and NZCBs shows that there are several main strategies to achieve net zero: (1) reducing energy demand through the use of low energy passive design measures; (2) increasing efficiency through using energy efficient building systems and technologies; and (3) using renewable energy sources to supply the remaining energy demand [12]. Different building types, countries, and local climatic conditions would affect energy conservation, the standards or values used to evaluate indoor environment quality, the types of renewable energy sources that could be adopted, as well as whether renewable energy is supplied onsite or offsite [13].

Hong Kong is characterised by a subtropical climate—hot humid summers and mild to cool winters [14]. The typical cooling season in Hong Kong is estimated at 2000 degree-hours, which differs quite significantly to London's 200 degree-hours for example. Meeting the cooling demand for buildings is therefore a significant

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