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Towards zero energy school building designs in Hong Kong

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Abstract

The energy saving and electricity production schemes for a school building in hot and humid climate were studied by a building energy package eQUEST. High-performance building envelops, energy-efficient air-conditioning systems and lighting fixtures were employed to save energy consumption and building integrated photovoltaic (BIPV) panels were adopted to meet the energy needs. The annual electricity demand was 300 MWh, and 97.5% of it can be supplied by the vertical BIPV facades. Further PV installations on the roof can generate more electricity to balance the energy use. The results show that school block is possible to achieve the zero building energy consumption.

Keywords: Energy simulation; School Building; Zero energy building; Renewable energy

1. Introduction

Buildings account for 40% of worldwide energy consumption [1] and one-third of greenhouse gas emission [2]. Designing zero energy buildings (ZEB) has therefore become an international aim [3]. The general design strategies for a ZEB involve the minimization of energy use through energy-efficient measures and the renewable energy (RE) productions to meet the minimal energy needs. School buildings represent a significant part of building stock [4]. Currently, there are 572 primary schools and 506 secondary schools in Hong Kong (HK). With short school hours and long vacations periods, school buildings have potential to be ZEB with proper energy saving designs. To achieve zero energy, it is essential to accurately estimate the energy demands and PV energy production based on the readily accessible energy saving techniques and the available PV installation spaces on the building envelop.

Building-energy simulation programs are appropriate design tools to depict the trade-off between various design alternatives. The annual and monthly building energy requirements and renewable energy generations can be modeled by comprehensive computer simulations. Recently, the HK government has

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issued several compulsory and voluntary building-energy codes [5] which accept computer simulations to illustrate compliance. This paper presents the energy saving designs of a school building, simulates the energy expenditures and discusses the findings and design implications.

2. Computer simulation approach

Energy performance of a building depends on the subtle interactions of many building features and building-services systems. Computer-based building-energy simulations are valuable design aid in giving a comprehensive picture of the building's energy-behavior and the trade-off alternatives in detail. The simulation tool employed in the study is the eQUEST building energy program [6] which builds on the well-validated DOE-2.2simulation program and contributes to various worldwide green building crediting schemes such as LEED and BEAM Plus.

The eQUEST package conducts hour-by-hour calculation, using 8,760 hourly records of measured weather data to analyze the heating and cooling loads, and calculates the energy consumptions. The meteorology, however, may vary year-by-year. The typical meteorological year (TMY) of Hong Kong developed using 30 years of reliable measured data [7] representing the typical year-round local climate was adopted for the building energy performance analysis.

3. Reference school building

The institutional building is a 6-story-school with total floor area of around 7,000 m². It has 30 classrooms in total, 2 computer rooms, 3 staff offices, a library, a lecture hall, a study room, a visual art room and several shops. Figure 1 presents the typical layout plan for the building. Table 1 lists out the occupant densities, fresh airflow rate and equipment densities for different areas according to the ASHRAE Standard 62.1-2007 [8], Hong Kong BEAM [9] and ASHRAE Handbook [10]. With an efficiency of 100 lm/m^2, the T5 fluorescent lamps can keep the power density of classroom (500 lux), staff office (300 lux) and assembly hall (200 lux) lower than the Standards [11]. High frequency daylight-linked dimming controls were used to reduce the lighting energy use [12, 13].

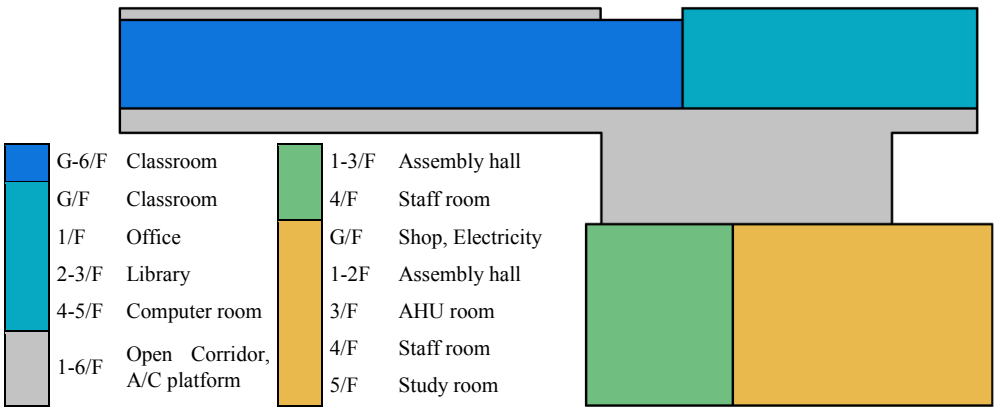

Fig. 1. The layout plan of building