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Investigation on the thermal and power performance of vacuum BIPV glazing and its optimization potential in high-rise buildings

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Due to the significant cost reduction of solar photovoltaic (PV) modules and aggravating environmental problems in the urban environment, more and more solar PV curtain walls, especially in commercial buildings, have been developed throughout the world. However, the poor thermal and sound insulation performances were usually observed in traditional solar PV curtain walls, which in turn seriously hinder their large-scale use. Although solar photovoltaic (PV) curtain walls can generate electrical power in situ, they also increase the cooling load and heating load of buildings significantly due to their high solar heat gain coefficient (SHGC) and U-Value. However, vacuum glazing, which has excellent thermal and sound insulation performance, can effectively solve the above issues for PV curtain walls. In this study, a novel high-efficient energy-saving vacuum BIPV (building integrated photovoltaic) curtain wall, which combines photovoltaic curtain wall and vacuum glazing technologies, was developed and investigated. This vacuum BIPV curtain wall can not only generate electricity in situ, but also significantly reduce the heat transfer through the building envelope due to its improved thermal insulation performance. The thermal and power performance of the vacuum PV glazing were investigated by experiments and numerical simulations. A prototype of the vacuum BIPV curtain wall was set up for a short-term outdoor testing campaign to demonstrate its thermal and power performance under typical weather conditions of Hong Kong. A comprehensive energy model was then developed to predict the dynamic power and thermal performance of the vacuum BIPV curtain wall to evaluate its annual energy saving potential compared to other advanced window technologies used in buildings in Hong Kong. Based on the simulation model, an optimum design of the vacuum BIPV curtain wall was proposed. In addition, the annual energy-saving potential for a typical high-rise commercial building with the application of miscellaneous BIPV products was estimated using the typical meteorological year weather data. BIPV characteristics were jointly optimized with other architectural parameters and the net building energy demand can be decreased by up to 60% compared with a benchmark office building in Hong Kong. The target of near-zero energy high-rise building can therefore be further approached by this integrated design optimization process. Finally, a design guideline of the advanced BIPV technology was proposed to guide its future large-scale application and commercialization.

Biography

Xi Chen has 8-year experience in building simulation, renewable applications, HVAC design and microclimate studies. He published 17 papers in peer-reviewed international journals and coauthored a book in the green building area. He has also participated in more than 30 green building projects as a certified BEAM Professional and conducted massive investigation into green building rating tools over the world. Prof. Hongxing Yang is now leading the Renewable Energy Research Group of The Hong Kong Polytechnic University. His research interests cover R&D topics in renewable energy applications and energy saving in buildings including solar cell materials, solar photovoltaic integration in buildings, wind power, hybrid solar-wind power, solar cooling and ground-coupled heat pump technologies. He has over 300 academic papers and 6 professional books published including more than 160 SCI journal papers published.

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