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RESEARCH ARTICLE

Systematic framework for the efficient integration of wind technologies into buildings

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Abstract
The renewed interest that is being paid by architects, project developers and local governments to integrate wind turbines with buildings is mainly required a framework to unify much data, criteria and variables to ease the design process to many architects. Therefore, this paper introduces and elaborates the systematic framework towards the efficient integration of wind technologies into new building. Moreover, it evaluates the framework effectiveness by comparing the current status of wind technologies integration into a building with the suggested status if the framework is followed.

1. Introduction

The increasing threats of climate change, along with diminishing fossil fuel energy sources, and uncertainty over the security of energy supplies, underscore the increasing value of renewable energy technologies. According to the Intergovernmental Panel on Climate Change (IPCC), buildings are responsible for one-third of global energy-related CO_2 because of their dependency on fossil fuels (Urge-Vorsatz, 2007). As a result, it is imperative that; architects and engineers should find

Abbreviations: IPCC, Intergovernmental Panel on Climate Change; WTs, Wind Technologies; BIWT, Building Integrated Wind Technology; HAWTs, Horizontal Axis WTs; VAWTs, Vertical Axis WTs; WARP, Wind Amplified Rotor Platform; IBL, Internal Boundary Layer.

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building's design ways to decrease its amount of fossil fuels consumption. One of the ways is the integration of wind technologies (WTs) into the primary building design to produce energy where it is consumed.

Building Integrated Wind Technology (BIWT) is becoming increasingly common as a green building icon to achieve energy self-sufficient building. However, the integration of WTs into buildings has not reached its goal yet. The reason is the absence of a framework that helps the architects to achieve the efficient integration. Therefore, this paper aims to introduce this efficient integration framework, which includes four stages: (1) determining site suitability; (2) determining suitable integration methods; (3) determining suitable WTs; and (4) comparing energy production with consumption. Then, this systematic framework is applied on Strata SE1 building in London, UK and the results are used to compare the building's current status with other integration methods when applied to the case study in its conceptual design phase. The results of these four stages and their analyses were finally combined and synthesized in the case study building to evaluate the usability and effectiveness of the suggested systematic framework.

2. Building integrated wind technology

Building designers are showing an increasing interest in reducing the environmental impact of their buildings. Hence, the first step is to reduce energy demands and the second is to cover most of the remaining needs of building by renewable energies. One of the useful approaches being used is BIWT (Stankovic et al., 2009). In this context, WTs, which have many types, can integrate into buildings in many forms. Therefore, BIWT advantages, integrated-wind technology types, methods and problems associated with integrated-wind system are illustrated in Sections from 2.1 to 2.3.

2.1. What are the advantages of BIWT?

Wind energy systems are omnipresent, freely available, environmental friendly, and they are considered as promising power generating sources due to their availability and topological advantages for local power generations. As a result, BIWT is becoming interesting subject to research for

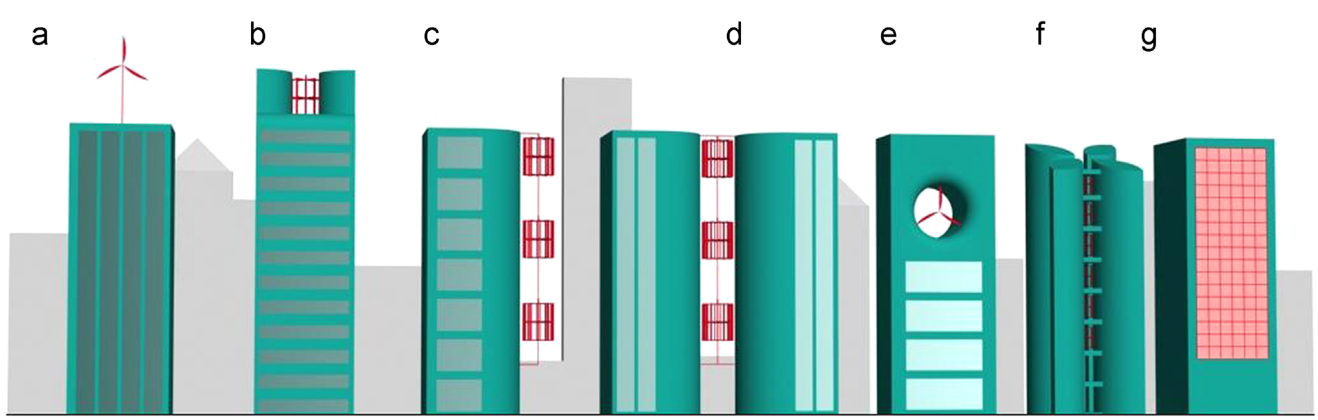

Fig. 1 The main methods of WTs integration into buildings: (a) on building roof; (b) concentrator on building roof; (c) on building side; (d) between twin buildings; (e) concentrator within a building façade; (f) combined concentrator within a building façade; and (g) as an external envelop of building. Source: the authors after (Dunster, 2006; Stankovic et al., 2009).

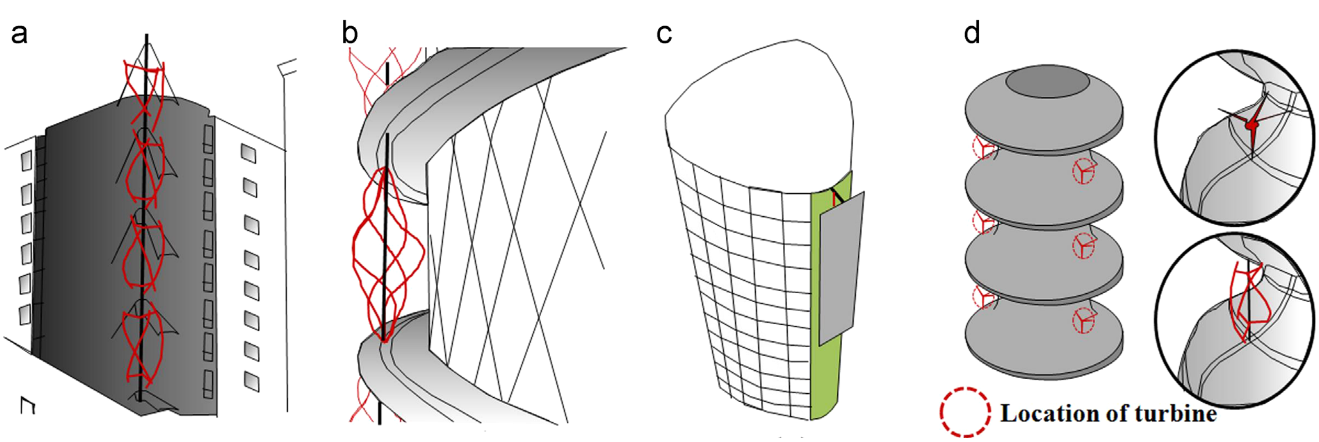

Fig. 2 The sub-methods of WTs integration on building side: (a) VAWTs integrated on the curved edge of the Kinetica building in UK; (b) VAWTs integrated on the curved side of a high-rise structure; (c) the Altechnica Aeolian Tower building-augmented system; and (d) the WARP system. Source: the authors after (Dutton et al., 2005; Pennsylvania State University, 2014; Sivakumar, 2012; Taylor, 2008; Weisbrich and Pucher, 1996).