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Wind energy applications for Taiwan buildings: What are the challenges and strategies for small wind energy systems exploitation?

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ABSTRACT

Global warming, fossil fuel diminishing, climate change disaster and along with more energy demand underscore the increasing value of renewable energy implementation. Energy is an important factor for countries to achieve sustainable development. Therefore, government need to actively seek renewable energy technology innovations, assess for optimization of resource inputs and strategize to proceed with effective energy strategic planning. Wind is an alternative clean source of energy compared to fossil fuel. Taiwan is highly vulnerable in energy security, but geographic conditions for the development of wind energy applications have created a considerable advantage. However, the total installed small wind energy capacity is far less than might be expected. Consequently, this study proceeds to explore the main resistance and key factors that affect small wind energy systems application in Taiwan. Through the evaluation decision-making system model and expert groups giving evaluation values and feedback, the study found the main influences factors, and propose strategies for energy development in future to improve the quality and quantity of renewable energy applications and energy competitiveness, also provides countries access to applications of wind energy technology assessment and forecasts in the future.

Contents

Abbreviations: 3E, Economic development and Energy exploiting and Environmental protection; AWEA, American Wind Energy Association; BEMOEA, Bureau of Energy under the Ministry of Economic Affairs; BEMS, Building Energy Management System; BIWT, Building Integrated Wind Turbines; BNP, Best Non-fuzzy Performance; CCL, Climate Change Levy; FDM, Fuzzy Delphi method; GW, gigawatt; GWEC, Global Wind Energy Council; H0, Null hypothesis; H1, Alternative hypothesis; IEA, International Energy Agency; kW, kilowatt; LCBP, Low Carbon Buildings Program; LWT, Large Wind Turbines; MOEA, Ministry of Economic Affairs; MW, megawatt; NREL, National Renewable Energy Laboratory; PV, Photovoltaic; R&D, Research and Development; RD&D, Research and Development and Demonstration; RDD&D, Research and Development and Demonstration and deployment; RE, Renewable Energy; RES, Renewable Energy Source; RETs, Renewable Energy Technologies; RO, Renewable Obligation; ROI, Return On Investment; SPSS, Statistical Package for Social Science; SWT, Small Wind Turbines; TSWA, Taiwan Small & Medium Wind Turbine Association; VAT, Value-Added Tax; WWEA, World Wind Energy Association

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1. Introduction

Climate change, global warming, and the recent nuclear plant disasters warn the earth about having a safe, reliable and economically sounded source of energy. Currently, the demand for fossil fuel is increasing, but its price is increasing sharply. It goes without saying that carbon emission must be decreased too. Utilization of renewable energy resources like wind is viable way towards a clean environment, sustainable and secure energy future in the world. The world is confronted with pressing environmental problems and ever-increasing energy demands, so high-efficiency alternative energy technology must be developed. Worldwide attention is being given to green energy, especially wind energy [1]. According to the statistical survey by REN21 in 2014, 144 countries have set renewable energy-related policy targets [2]. Many countries are devoted to various types of renewable energy technologies (RETs) to promote research, development, demonstration and deployment (RDD&D). Therefore, RETs have become an important field of industrial competition internationally. In Taiwan the green energy industry is also included in the development of key industries [3].

Renewable energy (RE) market growth and development with the government subsidy appeared paradigm shift, prompting RETs continuous innovation and break through, accelerate the global application and development of RE. According to the 2014 International Energy Agency (IEA) statistical survey, renewable energy generated power accounts for 23% of global power generation (4892 TWh), of which wind energy accounts for 3.4% (166.328 TWh) [4]. Wind energy is the fastest growing renewable energy power generation technology in the world. Wind power generation increased 16-fold from 2000 to 2012, showing it to be a promising energy source in the future, and making it the first choice of green energy technology implemented in various countries [5]. However, the main objective of Taiwan's renewable energy policy is to promote more diversified applications in Taiwan. In accordance with the Bureau of Energy under the Ministry of Economic Affairs (BEMOEA) "Energy White Paper", "Challenge 2008: National Development Plan" indicated that the key project of renewable energy development and application in the future was wind energy. Taiwan is a very densely populated island, so the application of wind energy is mainly combined with buildings [6–8]. This becomes the supporting background of this study.

Wind energy application is divided into large wind turbines (LWT) and small wind turbines (SWT). The large wind turbine (MW class) is mainly applied to concentrated power generation to replace large-scale power plants, but it requires an open area with a large and already operational wind farm, and so is limited by the exploitable land area [9]. In contrast, the small wind turbine (below 10 kW) is mainly for a self-sufficient power supply, the buyers being average consumers or families. It is characterized by adaptation to local conditions and now has extensive applications; the U.S., U.K. and China are the major markets [5]. In recent years, the small wind turbine industry has received more attention, and its use has been extended to residential construction power systems, commercial building power systems and metropolitan areas [10]. Taiwan is a small territory with a large population and abundant wind resources. The wind energy density potential is excellent as the average wind speed is 7–9 m/sec. Nevertheless, the total installed small wind energy systems capacity is far less than might be expected. These become the major support motivations of this study. Thus, the aim of this study is to evaluate the challenges and strategy as regards the application of small wind energy systems in Taiwan.

Sustainable energy development policies contribute to the application and popularization of renewable energy, and the Bureau of Energy under the Ministry of Economic Affairs (BEMOEA) encourages the adoption and implementation of various techniques and incentive measures. The 2014 statistics of the Bureau of Energy shows that Taiwan's total installed capacity of wind power was only 614.2 MW, accounting for only 0.10% of total installed capacity of renewable energy, and supplying 276,000 families [11]. According to the Taiwan Small & Medium Wind Turbine Association (TSWA) statistics on the performance of small wind turbine systems in 2013, the number of cumulative installed units was only 1374, with a total cumulative installed capacity of only 440 KW [12]. The 2013 statistics of the Global Wind Energy Council (GWEC) shows increases in installed units, of 92700 (48.9 MW) in China, 7303 (19.0 MW) in the U.S. and 3068 (21.8 MW) in the U.K. [5] Clearly, there is a considerable gap between the countries which are pioneers in wind energy and Taiwan. It is important that small wind energy system applications be developed and popularized in Taiwan.

In order to explore and seek the main resistance and key factors influencing small wind energy applications and development, this study is composed of three parts:

(1) *Establishment of assessment factor variables:* through literature review and systems engineering analysis the research can retrieve factor variables that affect small wind energy applications;
(2) *Establishment of an evaluation decision-making system:* the evaluation values and feedback from the Fuzzy Delphi Expert Questionnaires and expert decision-making groups (industry, government, research and academic) is used to find key influence levels and factors in Taiwan;
(3) *Draw up wind energy development strategy proposals for the future:* according to the results of the study, wind energy development strategies were proposed for the future.

The results of this study are expected to improve and enhance the quality and quantity of RE applications and the competitiveness of national energy. Moreover, the study findings will help to provide references for relevant environmental and energy systems concerning deployment and technological aspects of R&D, as well as provide developing and underdeveloped countries' applications of wind energy technology assessment and forecasting for the future.

2. Current status and trends of wind energy applications globally

Utilization of renewable energy resources like wind is viable way towards a clean environment, sustainable and secure energy future in the world. The fastest growing renewable energy source