Application of Fuzzy Analytic Hierarchy Process to Assess the Potential of Offshore Wind Energy in Taiwan

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ABSTRACT

In this paper, the Fuzzy Analytic Hierarchy Process is applied to obtain the importance sequence and finds out the key success factors of offshore wind energy for the selection of appropriate sites in Taiwan. The Fuzzy Analytic Hierarchy Process is applied to each factor to determine the weight of fuzziness of its attributes. Based on numerical results, it is found that the wind speed, typhoon, earthquake, distance to shoreline, land use and flight safety are the key success factors in the selection of appropriate sites of offshore wind farms in Taiwan.

KEY WORDS: Fuzzy analytic hierarchy process; offshore wind energy; typhoon; earthquake.

INTRODUCTION

For a rapidly industrializing island society like Taiwan, sustainable energy utilization faces a number of challenges at the start of the 21st century. In Taiwan, the energy supply principally depends on imported fossil fuels and uranium which together accounted for 97% of total energy supply in the past. Fluctuations in international energy prices and availability of imported energy supplies could deeply affect domestic socio-economic stability. In addition, the expanding use of fossil fuels due to economic development has resulted in rapidly increasing CO_2 emissions.

Renewable energies are regarded as a key factor in mitigating global climate change in the future. Among various renewable energy sources, wind energy in particular has achieved maturity in the energy market, and has experienced the greatest growth worldwide over the past few years. According to the assessment of the Intergovernmental Panel on Climate Change concerning wind energy potential, intermittent wind power on a large grid can contribute an estimated 15-20% of annual electricity production without special arrangements for storage, backup, or load management. Technical maturity of wind energy has allowed a number of countries to actively exploit this environmentally friendly energy source.

The application of wind energy throughout the world is growing dramatically. Over the past two decades, on-shore wind energy technology has been intensively studied. While on-shore wind technology becomes mature, offshore wind energy is at the beginning stage. Off-shore wind farms are different from on-shore installations for several reasons. Despite of the high costs compared with on-shore wind farms, off-shore applications allow an increased energy efficiency, due to the higher average wind speeds and the reduction of the sitting and environmental issues, particularly with regards to noise, visual constraints and space limitations, since off-shore wind farm are commonly built several kilometres away from the coast (Barthelmie et al. 1996; Lavagnini et al. 2003; Musial et al. 2006).

Taiwan is a small island which has very scarce energy and resources. Therefore, development of offshore wind energy has great potential, compare with other renewable energy in Taiwan. Wind energy is something that will have continuous supply and it reduces pollution onto the earth as well.

The Delphi method reflects the features of group decision making with multiple feedback and it has also been widespread (Dalkey and Helmer, 1963; Diao and Zhou, 1991; Yu, 1992). In this paper, the method is used to decide the assessment factors and the hierarchy by investigations from experts.

The Analytic Hierarchy Process (AHP) was developed by Saaty (1980) and is widely used for multi-criteria decision-making and has successfully been applied to many practical decision-making problems (Saaty, 1988). In spite of its popularity, this method has often been criticized for its inability to adequately handle the inherent uncertainty and imprecision associated with the mapping of the decision-maker's perception to exact numbers (Deng, 1999).

In the traditional formulation of the AHP, human's judgments are represented as exact (or crisp, according to the fuzzy logic terminology) numbers. However, in many practical cases the human preference model is uncertain. Thus, decision-makers might be reluctant or unable to assign exact numerical values to the comparison judgments. Therefore, a Fuzzy Analytic Hierarchy Process (Fuzzy AHP) is used on each factor to determine the weight of fuzziness of its attributes. This study is aimed at applying the Fuzzy AHP to find the importance sequence and obtain the key success factors for the selection of appropriate sites of offshore wind farms in Taiwan.