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A model proposal for locating wind turbines

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Abstract

Total energy demand has increased all around the world in recent years, as a result of growing population and industrialization. Most of the existing sources to generate energy are fossil fuels and it is known that fossil fuels are scarce. In order to satisfy increasing energy demand, searches for new energy generation sources have been conducted and these searches are ended with the proposal of generation of energy by using renewable sources. Decision makers are facing with some important decision problems related to energy generation from renewable sources. In the scope of this study, site selection problem which is one of the most important problems related to renewable energy is considered. Site selection decision consists of many alternatives and many conflicting decision criteria. Due to the hesitance of decision makers in criteria evaluation, a decision making approach based on hesitant fuzzy sets is proposed for solution of the problem. Weights of evaluation criteria for locating wind turbines are obtained by using the proposed decision making approach.

*Keywords:*Hesitant fuzzy sets; decision making; site selection; renewable energy; wind energy

1. Introduction

In daily life activities, different types of energy are needed by people. People need energy for heating, cooking, using electric devices, transportation, etc. Lack of energy in these areas causes reduction in life quality, and makes citizens unhappy. Energy is also one of the most important inputs of production.Due to the contribution of production to the country's economy, production inputs should be supplied. Hence, governments should feel

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responsible tosatisfy energy demand. This responsibility tells that energy policies take an important rolein government policies.

Energy policies are vital for countries. Rapid changes in energy prices or supply and demand characteristics of energy can lead countries into crisis. So, energy systems should be developed in a reliable manner and should be independent from other countries.

Developing a sustainable energy system with renewable sources consists of some problems. Some of major problemsrelated to renewable sources are prioritization of sources, selection of appropriate sources, determination of plant location and generation capacity, etc. For each problem that mentioned above decision makers should consider a number of conflicting environmental, social, economic and technical criteria related to source type. Considering the number of alternative types of energy generation technologies could lead decision makers to model these problems by using multiple criteria decision making (MCDM) techniques.

In the scope of this study, wind turbine site selection problem is considered. Due to the number of site selection criteria and alternative locations, problem is modeled as a MCDM problem. In the literature, studies on wind turbine site selection is widely seen. Some of these studies are given in Table 1 as follows:

Table 1. Some studies in the literature related to wind turbine site selection and multiple criteria decision making

Method
COPRAS – F[1]
GIS – OWA[2,3]
Fuzzy VIKOR – AHP[4]
GIS – ELECTRE TRI[5]
FAHP[6]
Multi Criteria Spatial Methodology[7]
GIS – AHP – OWA[8]
GIS – Fuzzy Logic[9]
Multi Attribute Choquet Integral[10]
Multi Criteria Spatial Decision Support[11, 12]
FANP – BOCR[13]
Ideal Matter – Element Extension Method[14]
ELECTRE II[15]
GIS – ELECTRE III, GIS – ELECTRE TRI, GIS – SMAA TRI[16]
GIS – AHP[17,18,19, 20,21]

There are too many site selection criteria in given studies. These criteria are summarized in Table 2. Site selection parameters are determined by considering practical issues in Turkey and the criteria in the studies given in Table 2. Decision makers' opinions are collected and location for wind turbine is selected. The rest of the paper organized as follows: In the second part, the proposed decision making methodology for wind turbine site selection is explained. Application of site selection based on the proposed methodology is presented in the third part. This paper concluded in the fourth part by giving results and search directions for further studies.

2. Methodology

Problems with multiple alternatives and multiple conflicting criteria are identified as MCDM problems. MCDM problems can be constructed in a hierarchical structure in order to divide the main problem into small sub-problems. By this way, solving the problem can be easier.

In this study, the MCDM algorithm based on hesitant fuzzy linguistic term sets (HFLTS) proposed by Yavuz et al. [22] is used. This algorithm provides the ability to handle hesitancy of decision makers in evaluation. The hierarchical structure and using fuzzy representations makes it possible for this algorithm to handle complex MCDM problems. The steps of Yavuz et al.'s algorithm are given in Fig. 1 as follows. Since our study doesn't consist of evaluation of alternatives, we didn't apply algorithm's steps related to alternatives, we use this model for weighting site selection criteria.