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Fuzzy prioritization approach for risks of wind turbine life cycle

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Abstract

Recently, wind force which is renewable energy resource has been used widely throughout the world. Wind turbines are system which firstly, converts the kinetic energy of the wind into mechanical energy secondly mechanical energy change into electrical energy. Starting from the design and development phase of wind turbines till the establishment of and operate this system, this process includes too many risks in terms of occupational health and safety. For this study, the life cycle phase used is taken from1: design, development, manufacture, transport, construction, operation associated infrastructure, maintenance, repowering/life extension, decommissioning and waste treatment and recycling. Design and development phase relates to measures to be taken, rather than contain risk. Also related to waste treatment and recycling phase we have a few information about that contains risk. For these reason in this study these two phase is neglect. In this study we aimed at gain a prioritization of risks which exist during the life cycle of wind turbine. Prioritization of risk is very important in terms of to determine which steps should be taken further measures. For prioritization of risk is employed fuzzy AHP α-cut analysis method.

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*Keywords:*wind turbine; fuzzy priorization; renewable energy;occupational safety.

1. Introduction

In recent years, wind force which is one of renewable energy resource has been used widely throughout the world, because renewable energy sources are cheaper, safer and more eco-friendly system than traditional energy system. Growth in the wind energy sector can be explained to a number of factors, including financial confidence,

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technological advancements, legislative support from local governments and increased public support and awareness. Wind turbines are system which firstly, converts the kinetic energy of the wind into mechanical energy secondly mechanical energy change into electrical energy. In its recently published research agenda the European Wind Energy Technology Platform (TP Wind) proposes an ambitious vision for Europe. In this vision, 300 GW of wind energy capacity will be implemented by 2030, representing 25 % of the EU's(European Union) electricity consumption[1]. Moreover, the TP Wind vision includes a sub objective on offshore wind energy, which it believes should represent 10 % of EU electricity consumption by 2030[1]. Though wind energy system is considered one of green energy system, starting from the design and development phase of wind turbines till the establishment of and operate this system, this process includes too many risks in terms of occupational health and safety[2.] Wind energy workers can be exposed to hazards that can result in fatalities and serious injuries during the various phases of a wind turbine life cycle. The objective of this study is determine of which phase or phases are the most dangerous phases. With gained results, we can demonstrate to the developing field for which step further measures should be taken. For this study, the life cycle phase used is taken from[1]design, development, manufacture, transport, construction, operation associated infrastructure, maintenance, repowering/life extension, decommissioning and waste treatment and recycling. Design and development phase relates to measures to be taken, rather than contain risk. Also related to waste treatment and recycling phase we have a few information about that contains risk. For these reason in this study these two phase is neglect. In this study we aimed at gain a prioritization of risks which exist during the life cycle of wind turbine. Prioritization of risk is very important in terms of to determine which steps should be taken further measures. For prioritization of risk is employed fuzzy AHP (Analytic Hierarch Process) method. Because of the wind energy sector is still relatively new, we have no directly relatedargumentaboutprioritization of risks which exist during the wind turbine life cycle in literature. Guerreroet al.[3]investigated risk prioritization of renewable energy facilities. In their study, Delphi, SWOT (Strength, Weaknesses, Opportunities, Threats) and AHP technique was used to prioritization of risks in solar photovoltaic facilities. Another researcher[4] used fuzzy FMEA (Failure Modes Effect Analysis) for prioritization of emergency department of hospitals. Kolios et al.were interest application of multi-criteria decision-making to risk prioritization in tidal energy developments[5].

2. Method

This paper proposes the use of fuzzy AHP method to prioritize the risk which exist during wind turbine life cycle. The AHP, introduced by[6] addresses how to determine the relative importance of a set of activities in a multi-criteria decision problem.The AHP is widely employed for solving multi-criteria decision-making problems in real life. But, AHP method is insufficient for circumstances which contains uncertainty. Because decision maker need to express their judgment more correctly, decision making in fuzzy environment is approach to overcome this challenges. Hence risks in terms of OHS is mostly uncertain, we decide to solve our problem using fuzzy AHP. Therefore in this study, fuzzy AHP α-cut analysis is used for prioritization of risks that exist during wind turbine life cycle. In literature there are many fuzzy AHP methods proposed by various authors. The earliest work in fuzzy AHP appeared in Van Laarhoven and Pedryczwhich compared fuzzy ratios described by triangular membership functions[7]. Mikhailov[8]proposed a fuzzy preference programming method to derive optimal crisp priorities, which are obtained from fuzzy pairwise comparison judgments based on α -cuts decomposition of the fuzzy judgments into a series of interval comparisons. In practical applications, the triangular form of the membership function is used most often for representing fuzzy numbers[9,10,11]. In the literature, fuzzy AHP, has been widely used in solving many complicated decision-making problems. For exampleDağdeviren et al.[12] used the fuzzy AHP and TOPSİS for weapon selection. Zyoud et al.[13]used fuzzy AHP integrated with fuzzy TOPSİS to gain A framework for water loss management in developing countries. Like this studies there are a lot of studies can be found in literature related fuzzy AHP[14,15,16].

3. Proposed Model

In this study Fuzzy AHP one of the multi criteria decision making method has been employed for prioritization of risks. As it can be seen in the literature there are a lot of fuzzy AHP methods that have been proposed by several authors[7,17,18].