Evaluation Model of Offshore Wind Turbine Structures Based on Entropy-TOPSIS Method

Miaojun Sun
PowerChina Huadong Engineering Corporation Limited, Zhejiang Engineering Research Center of Marine Geotechnical Investigation Technology and Equipment, Hangzhou, Zhejiang, China

Yujing Chen, Zhiji Zhou, Min Zhang*
Shandong Provincial Key Lab of Ocean Engineering, Ocean University of China, Qingdao, Shandong, China

ABSTRACT

In order to maximize the economic benefits under the premise of ensuring the safety and reliability of the offshore wind turbine structures, a scientific and reasonable evaluation system is established to determine the optimal scheme of offshore wind power units in this paper. Multiple evaluation indicators are selected from the aspects of the economy, the performances of offshore wind turbine structures and impacts on environment, to construct an evaluation index system. To determine the optimal scheme, a comprehensive evaluation model for offshore wind turbine structures based on entropy Entropy-TOPSIS method is developed. Two different types of offshore wind turbines, of which one is a semi-submersible floating support structure and the other is a jacket support structure, both with NREL 5MW wind turbine, are taken as examples for case study. The results indicate the validation of evaluation model.

KEY WORDS: Entropy-TOPSIS method; offshore wind turbines; evaluation model; decision-making.

INTRODUCTION

Nowadays, energy is the main driving force for the economic development of all countries in the world. With the continuous growth of population and the demand of economic development, the consumption of has been increasing. However, a series of environmental problems caused by the excessive exploitation and use of fossil energy have become one of the main reasons restricting the healthy and sustainable development of the country. As the energy consumption kept increasing, in order to ensure sustainable development, the transition from traditional fossil energy to clean energy has become a global consensus. Renewable energy, represented by wind power, has been developed rapidly all over the world. Compared with onshore wind power, offshore wind power is preferred due to the abundance of wind resources and vast exploitable marine space. Global offshore wind energy in 2021 had a record year for deployment with 17,398 MW of new projects commissioned. This growth was largely attributed to China, which commissioned 13,790 MW (Musial et al., 2022). Offshore wind power projects are more difficult to design, build and operate than onshore ones. Because the offshore wind power structures are kept in service under a complex marine environment, it is not only affected by wind, wave, current and other loads, but also produces the coupling effect with the environment. Therefore, the requirements for stability and strength of offshore wind turbine structures are quite challenging. As a result, offshore wind power projects often have high costs for construction, installation and maintenance. As the installed capacity of offshore wind turbines becomes larger, improving efficiency of construction and reducing cost has great significance for offshore wind power projects. To further open up the offshore wind market, it is necessary to think about how to maximize the economy while ensuring the safety and reliability of the structures. In order to determine the optimal scheme, this paper establishes a more reasonable and comprehensive offshore wind turbine structures evaluation system based on the research of offshore wind power project evaluation. In this paper, several evaluation indexes are selected to construct an evaluation index system for offshore wind turbine structures from three aspects: economy, performances of offshore wind turbine structures and impacts on environment. A comprehensive evaluation model for offshore wind turbine structures is established based on Entropy-TOPSIS method. The entropy weight method was used to determine the index weight, and TOPSIS method was applied to calculate the relative proximity between each scheme and the ideal solution. The 5MW-OC4 semisubmersible floating wind turbine and OC4 jacket offshore wind turbine are taken as examples to verify the effectiveness of the evaluation model.

OFFSHORE WIND TURBINES SUPPORT STRUCTURES

Offshore wind turbines support structures are mainly divided into fixed and floating types. There are various forms of fixed offshore wind turbine support structures, including gravity, monopile, jacket and so on, as shown in Fig. 1. Fixed support structures have the main advantages of their more established design, manufacturing, installation and operational processes available from previous experiences in offshore structures. They are suitable for water depths of up to 50m, and infrastructure costs will increase as water depths increase, severely affecting their economic competitiveness.