Energy Reports 11 (2024) 179–196

Contents lists available at ScienceDirect

Energy Reports

journal homepage: www.elsevier.com/locate/egyr

Research paper

Multi-factorial methodology for Wind Power Plant repowering optimization: A Spanish case study

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ARTICLE INFO

Keywords:
Wind Power Plants (WPP)
Repowering
Multi-Criteria Decision Making (MCDM)
Optimal planning

ABSTRACT

Due to the climate change, there have been changes in the rhythm of nature over the last decades. In addition, there has been an increasing social consciousness regarding decarbonization and emissions, promoting governments new policies and economic support measures for renewable integration. In this scenario, the participation of the onshore and offshore wind sectors play a crucial role, expecting that more than 6000 GW will be globally installed in 2050. In parallel, the useful life of other wind power plants is coming to their end. Therefore, some countries will face in the coming years the decision of repowering, decommissioning, installing new turbines, or a combination of them. In general, the areas with the greatest wind potential are already occupied by relatively old wind turbines. Subsequently, a complex group of factors influences on the most appropriate solution decision-making, involving climatic, technological, environmental, social or economic aspects. This paper proposes an optimized methodology based on multi-criteria decision-making to estimate the most appropriate solution for extending the useful-life of wind power plants. An initial group of 26 factors were identified, corresponding to seven categories: technical, geographic, socio-environmental, location, economic, political and climate. The methodology is divided into three stages: (*i*) data, (*ii*) alternatives, and (*iii*) optimization. It was assessed with a Spanish onshore wind power plant connected to the grid. From the initial data and factors, 11 alternatives were designed based on a selection of 10 most relevant factors. The results provide an optimal solution, combining both repowering and installation of new wind turbines. From the results, this methodology would allow reducing the LCOE of the new wind plants installed in the European Union by more than 50%.

1. Introduction

The useful life of Wind Power Plants (WPPs) is usually expected to be 20–25 years (Xu et al., 2018; Nielsen and Sørensen, 2021). By considering that this resource has been integrating in power systems since 2001, a relevant number of Wind Turbines (WTs) are currently close to the end of their useful life (Njiri et al., 2019). Among the potential solutions, different authors point out three realistic alternatives: life extension, repowering, or decommissioning (Piel et al., 2019). However, there is not only one correct and unique answer among such potential alternatives (Pakenham et al., 2021), and these end-of-life strategies should be evaluated by considering different issues. According to the specific literature, a comparative assessment between repowering and decommissioning based on a techno-economic analysis model was proposed in Jadali et al. (2021). Serri et al. (2018) evaluated techno-economic sustainability in several repowering scenarios located in Italy. Santos-Alamillos et al. (2017) applied the mean variance Markowitz portfolio optimization theory to explore repowering actions in the Spanish power system. Technical analysis were discussed in Karoui et al. (2019), focused on studying the impact on the power grid of new WT performances under faults, in comparison to old WTs. Offshore platforms were studied by Safaei et al. (2019), proposing a methodology to estimate the best topology and optimal repowering time based on major performance metrics such as lifetime, cost, and reliability distribution. Szumilas-Kowalczyk et al. (2020) affirmed that

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https://doi.org/10.1016/j.egyr.2023.11.044
Received 29 March 2023; Received in revised form 22 November 2023; Accepted 22 November 2023