Economic analysis of the wind energy generation: overview and current perspectives

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Abstract. The transition to a low-carbon economy necessarily involves the implementation of large-scale electricity generation from Renewable Energy (RE) sources [1], which now account for around 30% of electricity generation in the world [2]. In this context, developing countries will play a key role as they present the best environmental conditions for generating electricity through RE sources and have the highest rate of growth in demand for electricity [3]. Wind and solar generation have consolidated their predominance in current investments so that electricity from RE sources is now the cheapest power option in most regions of the world [4]. Given the current high fossil fuel prices, renewable electricity has become even more competitive [5]. RE sources are fast becoming the cornerstone of the global electricity sector. In a carbon-neutral economy scenario for 2050, the share of RE sources in electricity generation will correspond to approximately 90%, with almost 70% of electricity being from wind and solar photovoltaic energy. However, several countries will face limitations to their solar photovoltaic energy generation potential due to land area restrictions [6]. In this way, wind energy will gain even more relevance in some countries, such as European ones, which will have to implement other sources of clean energy [7]. Due to the complexity and high capital costs involved in large-scale wind power generation projects, the economic analysis of these investments becomes fundamental, indicating the need to use management and risk analysis tools to reduce the possible impacts for investors [8]. Indeed, finding a suitable investment strategy is central to determining success in wind farm investments. Identifying the main characteristics in the previous studies, such as the technology adopted, the region or country studied, and the methods and financial criteria adopted in the studies, can serve as guidelines for researchers, investors, and other stakeholders interested in this type of technology. This reinforces the relevance of a review study, allowing the provision of methods that supports the financial valuation of investments in wind projects. Thus, this study provides the state-of-the-art in literature on the economic feasibility of wind energy generation through a Systematic Literature Review (SLR) following PRISMA statement [9]. SLR is a process consisting systematically of three steps: (i) input (or review planning), (ii) processing (or conducting research), and (iii) output (or report and dissemination). The search strings used in the WoS database resulted in 373 articles (between review and research articles). In the processing step, the inclusion and exclusion filters were carried out by the authors sequentially, ensuring the quality of the final set of articles throughout this refinement process. Finally, this process resulted in a final sample of 317 articles, which were analyzed using quantitative and qualitative approaches to drive the last step of the model for conducting an SLR (summarizing the evidence and interpreting the findings). Due to the large number of selected works, a wide range of countries were identified, with China, US, Spain, UK, and Brazil standing out for the number of works. However, in recent

years, works on wind generation involving Middle Eastern countries have become very frequent, gaining relevance. Although well established in the literature on economic feasibility analysis, some economic performance measures such as Net Present Value (NPV), Internal Rate of Return (IRR), Discounted Payback and Annual Gross Margin do not appear as relevant measures in the selected sample. Other parameters for defining discount rates such as Weighted Average Capital Cost (WACC) and Capital Asset Pricing Model (CAPM) also do not appear among the most relevant terms. This fact may indicate a gap in the literature to be explored. It was also identified that there is an increasing trend in the number of publications on wind energy in the world, demonstrating its growing relevance. In recent years, research involving investment in offshore wind energy has gained prominence, with a significant increase in the number of publications on this topic. Studies involving more technical aspects of the electrical system that jointly analyze aspects of the economic viability of the projects appear in a smaller number in the selected sample. Finally, if we consider the centrality of the terms "models" and "optimization", then the mathematical modeling of financial responses and the quality and reliability of the network and its optimization in multi-objective models emerges as a possible point to be further explored in the literature that involves the economic analysis of the generation of wind energy.

Keywords: feasibility analysis, investment, financial assessment.

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