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Environmental And Techno-Economic Analysis of Pyrolysis of Wind Turbine Blade Waste

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Abstract

Wind turbine blade waste (WTB) pose a significant challenge to wind energy sustainability, as they are often buried in landfills with numerous environmental and health problems and resource waste. Recently, thermochemical treatment using pyrolysis has proven highly efficient in recycling WTB into fibres and energy. This research aims to investigate the environmental and economic performance of this technology. The analysis included the pre-treatment (milling) and post-treatment (screening, washing, and oxidation) of WTB. The environmental analysis was conducted using Life-cycle assessment (LCA) approach based on ISO 14040 and 14,044 global standards. Techno-economic assessment (TEA) was conducted based on the concept of building a complete recycling pyrolysis plant with a capacity of 7,000 ton/year, and the analysis was conducted on samples with different fibres compositions of WTB (glass and carbon fibres). The TEA analysis was performed based on three financial indicators: net present value, internal rate of return, and discounted payback period. The technical inventory data used in LCA and TCA analysis were collected from the results of practical experiments conducted using a small-scale pyrolysis plant, then scaled up to the specified capacity. The results showed that the technology used is very ambitious and has great environmental potential, especially in the case of carbon fibre due to its large footprint. The economic analysis also showed great profit potential, especially in the case of carbon, and the possibility of achieving a break-even point within a few years with a profit of (> € 500 million). Based on these results, pyrolysis provides a promising, environmentally friendly solution with competitive and economic performance that can be subsequently generalized in WTB recycling.

Keywords: wind turbine blades waste; pyrolysis; techno-economic analysis; Life-cycle assessment.