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«Infrastructure and Construction Project Management»

Postgraduate Diploma Thesis

Circular Economy Methodologies: Their Contribution to Waste Management in Wind Energy Infrastructure Projects

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Abstract

The transition of the European Union (EU) into a zero-emissions energy system, according to the "Agenda 2030", heavily relies on wind energy. In the next five years, a 140 GW increase of the installed wind power is expected, while simultaneously, 50% of existing wind turbines will reach their End-of-Life (EoL), contributing to a large waste increase. Despite emissions absence while operating, wind turbines not only pollute the environment during manufacturing and after disposal, but they also intensify the supply chain risk as they escalate the dependency on critical raw materials imported by other countries. This thesis examines how circular economy and Life Cycle Assessment (LCA) are able to contribute to the reduction of these impacts. After extensive research of circular economy methodologies, EU norms and wind turbines' technologies, two key components of wind turbines are investigated. Blades, whose composite materials can substitute some of concrete's raw materials (up to 16% CO2 decrease) and NdFeB permanent magnets, for which innovative recycling solutions are now available (up to 78% drop in environmental impacts). However, permanent magnets are more sensitive regarding their environmental burden and supply chain security. Thus, this thesis focuses on their recycling and specifically on the comparative LCA study of two different wind turbine technologies. Particularly on a permanent magnets generator (DDPMSG) and an electrically excited one (DDEESG or DDSG). The research yielded that despite including permanent magnets, DDPMSG has 22% less impact than DDSG in the case of virgin raw materials usage. Moreover, the integration of recycled materials leads to an approximate 70% alleviation of the ecological consequences for both types. This way, the research validates the effectiveness of applying circular economy methodologies at diminishing the environmental consequences of NdFeB magnets and wind turbines, while simultaneously mitigating their supply chain risk. This thesis concludes that following this direction will facilitate the EU's progress towards achieving the Sustainable Development Goals.

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