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NEON research

TU Delft

Life cycle assessment of a soft-wing airborne wind energy system and its application within an off-grid hybrid power plant configuration

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The European Commission's roadmap for transitioning towards a fully renewable energy system includes ambitious goals to install 60 GW of offshore wind energy by 2030 and 300 GW by 2050[1]. This accelerated capacity scale-up will entail a massive consumption of raw materials to manufacture the required wind turbines, including the foundations and installation infrastructure. One of the key advantages of airborne wind energy (AWE) is the low material demand of the technology, which should not only lead to a further reduced carbon footprint of renewable electricity but also to a reduced environmental impact [2].

The goal of the present research is to assess the environmental performance of a commercially developed 100 kW soft-kite AWE system by quantifying its global warming potential (GWP100) and material intensity. The presently pursued target market for soft-wing AWE systems in the 100-500kW range is for off-grid remote areas – coupled with solar PV and batteries, primarily for displacing diesel generators. The starting point of the research is an earlier sizing study for this type of novel kite-powered hybrid power plant (HPP) [3], expanding this now by a life-cycle analysis of mainly the AWE component. The research is conducted as a graduation project at TU Delft within the larger scope of the doctoral training network NEON, funded by the Dutch Research Council NWO.

To quantify the hypothesized environmental benefit of AWE systems, a comparative LCA study of a hybrid power plant configuration with and without AWE will also be performed. The LCA will use the methodology as provided in ISO 14040 and 14044 [4][5]. The LCI modelling framework used is an attributional LCA with system boundaries from cradle-to-grave. The functional unit is: 'Annual electricity production of 450 MWh, generated by an airborne wind energy system'. Activity browser and EcoInvent are used as the LCA modelling software and database respectively. The research will also aim to provide better insight into whether recycling kite and tether materials is beneficial in the overall environmental impact of the system. Initial findings show that the ground station contributes the most to environmental impact despite the kite and tether requiring the most replacements over the 25 year lifetime.

References:

[1] International Renewable Energy Agency (IRENA): Offshore Renewables–An Action Agenda for Deployment. Technical Report, Abu Dhabi, United Arab Emirates, 2021.

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[3] S. Reuchlin, R. Joshi, R. Schmehl: Sizing of Hybrid Power Systems for Off-Grid Applications Using Airborne Wind Energy. Energies 16, 4036, 2023. https://doi.org/10.3390/en16104036

[4] ISO 14004: Environmental management systems – General guide- lines on principles, systems and supporting techniques

[5] ISO 14040: Environmental Management – Life Cycle Assessment – Principles and Framework