Life Cycle Assessment of Floating Offshore Airborne Wind Energy Systems

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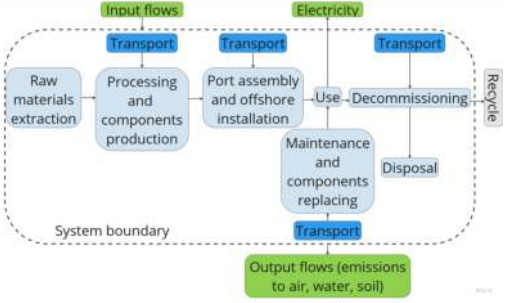
Airborne Wind Energy (AWE) appears to be a promising option for green energy production, in terms of efficiency and also land use, especially if Offshore Airborne Wind Energy (OAWE) systems are considered. However, systematic studies on the environmental impact and sustainability of such a technology are still rather rare in the literature. The research presented in this contribution, developed jointly by Politecnico di Milano and Politecnico di Torino, aims to design an OAWE system and exploit the design of the different components to come up with a life cycle inventory and perform a Life Cycle Assessment (LCA) of a hypothetical offshore wind farm. The farm includes 500 OAWE systems and is located in the Mediterranean Sea, about 60 kilometers off the western Sicilian coast. The LCA methodology, applied in this work to assess the environmental sustainability, is defined in the ISO standards 14040 [1] and 14044 [2].

The goals of the LCA are determining the potential environmental impacts of the OAWE and the life cycle hotspots as well as compare it with a study on an Offshore Horizontal Axis Wind Turbines (OHAWT) farm in the same location. The functional unit of the study is 1 GWh of electricity generated by the offshore farm and delivered to the grid. The system boundary is illustrated in the scheme on the right: natural resources as energy and raw materials taken from the environment and emissions to air, soil and water are both taken into account to quantify the environmental burdens. The majority of inventory data rely on the components design, conducted from scratch; also, an iterative approach is applied on the choice of the floating platform materials and the design phase to pursue lower environmental impacts. Likewise, sensitivity analyses are done on the two wing options (flexible and rigid) and on different alternatives for the end of life phase.

The investigated impact categories align with the EU environmental footprint (EF) 3.0 [3], a life cycle impact assessment (LCIA) method which covers 16 impact categories, divided in 3 main groups: environment, human health and resource consumption.



Schematic representation of the system boundary, own illustration

References:

[1] ISO 14040:2006+A1:2020: Environmental management-Life cycle assessment-Principles and Frameworks (2021)

[2] ISO 14044:2006+A2:2020: Environmental management-Life cycle assessment-Requirements and Guidelines (2021)

[3] European Commission and Joint Research Centre, Schau, E., Castellani, V., Fazio, S., Diaconu, E., Sala, S., Zampori, L., Secchi, M.: Supporting information to the characterisation factors of recommended EF Life Cycle Impact Assessment methods : new methods and differences with ILCD. Publications Office (2018)