

# **LCA\_WIND\_DK: temporally, geographically and technologically-sensitive life cycle inventories for the Danish wind turbine fleet**

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The environmental performance of a wind turbine is usually calculated as the ratio of the life cycle impacts occurring during the manufacture, installation, maintenance and dismantling of the plant, to the electricity it produces during the use phase. The modelling of the life cycle inventory in each phase should ideally cover the temporal, geographical and technological dimensions of the product system under study. Assumptions are commonly used to simplify and handle variable aspects of the inventory. While this approach provides generic one-size-fit-all inventories, it may disregard important characteristics of the wind turbine leading to biased end-results. As these assumptions are prone to differ from one study to another, the results become hardly comparable. With more than 1,500 wind turbine models on the market and a high variability of sites and manufacture periods of the different installations, it makes the environmental assessment of wind turbine fleets a daunting task.

LCA\_WIND\_DK is an on-line tool that provides the environmental footprint of Danish wind turbines based on systematic individual cradle-to-grave life cycle inventories using manufacturer's data. The temporal context is considered through the evolution of the electricity mix used for manufacturing wind turbines as well as the evolution of recycled content in materials over time. The spatial dimension is also accounted with geographical parameters determining the amount of material required, such as the distance from shore and sea depth for offshore installations. Additionally, the supply chain is adapted to select the relevant origin of the material and energy suppliers. Finally, the approach considers the registered electricity production for past and present wind turbines and assesses the future production from site-specific weather re-analysis data and power curves.

Denmark, where wind power contributed to 45% of the gross annual electricity production in 2016, is a prominent choice to demonstrate the benefits of such comprehensive modelling based on spatial, technological and site specific LCAs. The approach generates a life cycle assessment for each of the 11,000 wind turbines that compose the Danish national fleet over the 1980-2030 period. The results, through the on-line tool, are showcased as a map, where the individual performance of each of the past, present and future wind turbines can be consulted, as well as the performance of the whole fleet at a given year.