Optimization of tidal stream turbine arrays

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Background

With climate change effects becoming more severe, sufficient measures must be taken to mitigate these effects. One of the proposed measures by the European Green Deal is that of increasing the share of renewable energy sources in the energy mix.[1] With this mix consisting for the most part in the Netherlands of unpredictable and intermittent sources, like solar and wind power, tidal energy seems to be a good addition to the system for grid stability due to its predictability of both timing and amount.[2] Tidal energy is available in several ways, mainly with the use of barrages or stream. Whereas the first one is more impactful on the environment due to its need for extensive infrastructure and change in tidal ranges in the surrounding area. Tidal stream turbines, however, have less impact due to its size and less disturbance to the flow. Tidal stream has only been implemented on a small scale in the Netherlands, mainly because it is considered to have a low energy density of the tides.[3] Since this is the case for many areas around the world, technological advancement and optimisation can contribute to making this technology more effective and economically viable around the world.

Figure 1: Tidal stream turbines, Source: https://www.power-technology.com/news/50mw-tidal-stream-uk-contracts-for-difference/

Problem statement

Whereas tidal stream energy has been investigated, the lay-out of the arrays within a park in a low density tidal area is not fully optimised yet. The following things should be considered in its optimisation: the influence of different layouts on the effect of the turbines on the stream itself and on the turbines behind, the capacity, component fatigue, packing density, load assessment, lifetime and cost-effectiveness of the parks. Optimising these factors could help bring the levelized cost of electricity of tidal stream energy to a competitive level, making it a more attractive option for the energy market and supporting the transition to a renewable energy system in the Netherlands.

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[1] EEA. Climate change mitigation: reducing emissions. Nov. 2024. URL: https://www.eea.europa.eu/en/topics/in- depth/climate- change- mitigation- reducing- emissions?activeTab=e3e6b879-fef4-4a88-9436-5f0064698270

[2] CBS. Nearly half the electricity produced in the Netherlands is now renewable. Mar. 2024. URL: https://www.cbs.nl/en-gb/news/2024/10/nearly-half-the-electricity-produced-in-the-netherlands-is-now-renewable

[3] Alday, M., & Lavidas, G. (2023). Assessing the Tidal Stream Resource for energy extraction in The Netherlands. Renewable Energy, 220, 119683. https://doi.org/10.1016/j.renene.2023.119683