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It is hoped that the spread of renewable energy will lead to the realization of sustainable society for NZE. What are some of the new environmental and biodiversity risks that will arise in the power sector as a result of the mass introduction of renewable energy?

To meet sustainability targets and increasing power demand, the Swedish government has announced plans to enable large scale expansion of offshore wind power production along the Baltic Sea coast. In 2021, Sweden produced less than 0.6 TWh of electricity from offshore wind. The new plans would allow construction of new offshore wind farms at a rate of 20-30 TWh per year targeting an annual production of 120 TWh.

The Baltic Sea is a large brackish body of water connected to the Atlantic Ocean through the narrow Danish straits, which provide the only influx of saline water. The surface salinity level varies from 8‰ in the south to 2‰ in the north. Below the halocline at about 60 meter depth salinity levels may reach 13‰. During winter the Baltic Sea will partially freeze. The eco-system consists of a mixture of marine and fresh-water species adapted to the current salinity level and environmental conditions. Any change could lead to ecological stress. The low natural biodiversity implies a risk that the ecosystem is more vulnerable to changes affecting a single species compared to marine areas of higher natural biodiversity such as the North Sea.

In May 2022, the Swedish Environmental Protection Agency published a synthesis report authored by a multiorganizational team [1]. The report describes impacts from offshore windfarms on marine wildlife in the Baltic Sea, assessing potential risks on benthic habitats, fish, marine mammals and seabirds during construction, operation and decommissioning. Of significance to the grid connection is sediment dispersal when preparing the seabed for high voltage cables. The connection will traverse shallow coastal areas that are important for biodiversity. The impact is highly dependent on seabed properties and marine organisms at that location and requires individual consideration project by project. Rare and sensitive natural benthic habitats should be avoided. Furthermore, the sediment dispersal may release toxins that have been previously accumulated in the seabed.

Other risks include noise during construction and operation that may disturb fish and marine mammals. Evolving technology with increasing voltage levels brings forward the topic of electromagnetic effects on marine wildlife, although existing research does not indicate any lasting negative effects on species in the Baltic Sea. Temporary or local negative effects may be balanced by the positive impact of reef effects. The risk that the reef effect could also benefit non-native species that would disrupt the sensitive ecosystem has to be monitored. The presence of wind farms may reduce other human activity in the area which is positive for the marine wildlife.

The cumulative effects must also be considered. A combination of minor disturbances in adjacent areas together with concurrent marine activities and climate change may create a larger disturbance that ultimately exceeds the tolerance level of a species. On the other hand, the reef effect may also become cumulative, improving the connectivity between different populations. Due to the uniqueness of the ecosystem in the Baltic Sea, it will be difficult to draw conclusions based on research from wind farms in other locations. It is important to make dedicated studies on offshore wind farms in the Baltic Sea as they are constructed so that risks can be monitored, and mitigation action be taken as necessary. Research is also needed to better understand the impact of floating transformer stations, or alternatively subsea transformer stations constructed below the halocline.

Manufacturers of equipment for offshore wind grid connection may support developers with tools and technical know-how to quantify possible disturbances such as noise, electromagnetic fields, and heat generation, ensuring that they are below agreed thresholds to not threaten biodiversity. This may include multi-physics numerical simulation, factory testing, harbour testing, and monitoring of pilot installations. Designing equipment for high reliability and with digital solutions that reduce the need for maintenance can lower the human disturbances close to the installation. Sustainable materials such as biodegradable insulation liquids should be used to mitigate risk in case of leakages.

A high pace of expansion of offshore wind is required for the energy transition. With appropriate technology it can be achieved without threating biodiversity in unique ecosystems such as the Baltic Sea.

[1] L. Bergström, M. C. Öhman, C. Berkström, M. Isæus, L. Kautsky, B. Koehler, A. Nyström Sandman, H. Ohlsson, R. Ottvall, H. Schack, M. Wahlberg, *"Effekter av havsbaserad vindkraft på marint liv – En syntesrapport om kunskapsläget 2021"* The Swedish Environmental Protection Agency, Report 7049, May 2022