

Experience and Challenge of Cable connections of Offshore Wind Farms in German North Sea

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Starting in 2006 with the connection of Germany's first offshore wind park (OWP) alpha ventus, TenneT Offshore GmbH (former E.ON Netz Offshore and Transpower Offshore GmbH) implemented various connections of OWP to the German grid. As most of the OWP's are situated far away from the coast on the continental shelf of the North Sea and all the sea cables cross the UNESCO natural reserve Wadden Sea generating additional environmental restrictions, only three OWP's could be connected with HVAC. For the time of this publication four HVDC grid connection projects are in test operation and one HVDC cable connection has passed the final installation test and will start test operation soon.

- Alpha ventus - the first German offshore grid connection project
110kV AC, 60 MW, 60 km offshore and 6 km onshore, in continuous operation since spring 2009.
- BorWin1
150kV DC, 400 MW, 125 km offshore and 75 km onshore, in operation since May 2011.
- BorWin2, DolWin1 and HelWin1
 - HelWin1: 250 DC, 576 MW, 85 km offshore and 45 km onshore, in test operation with two OWP's connected
 - BorWin2: 300kV DC, 800 MW, 125 km offshore and 75 km onshore, test operation started recently with one OWP connected
 - DolWin1: 320kV, 800 MW, 75 km offshore and 95 km onshore, in test operation, two OWP's connected
- SylWin1
SylWin1: 320kV, 864 MW, 160 km offshore and 45 km onshore, final cable installation test passed, test operation starting soon

This paper will present an overview of the challenge and the experience with now three HVAC- and four HVDC-systems in operation:

- Cable design, manufacturing and testing
 - Increasing voltage levels and long cable routes with many joints onshore
 - After installation tests of long cable length with many joints
 - Monitoring of health status and preventative cable repair measures
- Cable laying and burial
 - Cable routes with cable laying activities of different projects in the same time window
 - Environmental restrictions like narrow time slots for cable laying activities
 - HDD (Horizontal Direct Drilling) with length more than 1300 m
 - UXO (Unexploded Ordnance) along sea cable routes
 - Laying methods to meet the burial depth requirements
- Environmental protection (locations system and temperature monitoring)
 - Observing the 2K-criteria in sight of changing OWP arrangements and upgrading of existing windmills
 - Cable location systems to monitor the cable position to verify the compliance with permissions