Optimization of offshore wind farm power cable routing

Up to now methods to optimize cable route layout are only based on a flat seabed and do not take the seabed dynamics into account (Jenkins et al., 2013; Morelissen et al., 2003). The result of this approach is that power cable coverage is not guaranteed over wind farm design lifetime. Cable optimization is mainly executed based on shortest routes instead of cost reduction over the entire design lifespan. Therefore the aim of this research is to develop a Matlab based tool, which optimizes power cable route design based on expected morphological behaviour in the design lifetime of an offshore wind farm.

To find the optimized cable layout a tool is developed including the optimization under a flat, static and dynamic seabed. These three steps help to identify the impact of bedforms on cable positions. First, the cable layout is determined based on a flat and static seabed. Found layouts show large similarities with the original layout in terms of total length. Thereby, the original layout is used during the optimization under a dynamic seabed.

All connections in the original layout are optimized in vertical and horizontal direction. The aim for this step is to minimize weights of all connections. Cable weights are determined based on the cost function incorporating risk of failure and costs of failure, cables and monitoring.

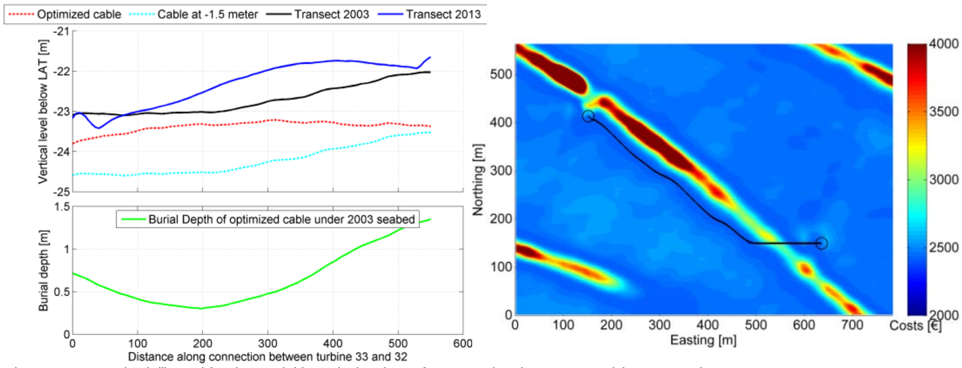

Figure 0.1: Vertical (l) and horizontal (r) optimization of connection between turbine 33 and 32

The red dotted line in Figure 0.1 (l) shows the optimized vertical cable position under the 2003 bed (black line) and 2013 bed (blue line). Figure 0.1 (r) displays the optimized horizontal cable position. Combining all optimized connections shows that all vertical optimizations lead to a decrease in costs. Results of the horizontal optimization depend on the fixed burial depth and bed level change. Combined with an option to include case-specific information, it can be assumed that the tool is general applicable.

Parameters used in the vertical and horizontal optimization were all fixed. To show the influence of the different parameters, a rough sensitivity analysis is executed. A parameter from all four cost function parts is analysed. Main conclusions are that the parameter magnitude, amount of turbines affected and dynamics of the crossed area form the greatest influence on total costs. Since the tool is designed to find the optimized cable layout over the wind farm design lifetime, also parameter sensitivity after survey prediction is analysed. Results show that survey prediction only has influence on parameter sensitivity during the horizontal optimization. In addition, only connections interfering with sand waves were affected.

The results of this research make a contribution towards renewable energy targets. With the aid of this tool, cable coverage can be guaranteed, reliability increases and project costs and risk of cable failure decreases.

Jenkins, A. M., Scutariu, M., & Smith, K. S. (2013). *Offshore wind farm inter-array cable layout.* Paper presented at the PowerTech (POWERTECH), 2013 IEEE Grenoble.

Morelissen, R., Hulscher, S. J. H. M., Knaapen, M. A. F., Németh, A. A., & Bijker, R. (2003). Mathematical modelling of sand wave migration and the interaction with pipelines. *Coastal Engineering, 48*(3), 197-209.

Tom Roetert

Graduation Date:
19 December 2014

Graduation committee:
University of Twente
Prof.dr. S.J.M.H. Hulscher
Dr.ir. B.W. Borsje

Deltares
Ir. R.W. Hasselaar