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Case Study for Impact of D-String® on Levelized Cost of Energy for Offshore Wind Turbine Blades

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The rapid growth of the offshore wind industry has led to a considerable increase in the size of offshore wind turbine blades. Loading of these has become an important factor, particularly edgewise loads resulting from gravitational forces. These loads imply development of longitudinal cracking on the trailing edge, with a significant impact on maintenance cost. As a result, several devices are in development with the goal of stiffening the blades. This paper aims to analyze the potential impact of such a device on the levelized cost of energy using a discrete event simulator. A case study is made using the NORCOWE reference wind farm.

INTRODUCTION

With the rapid growth of the offshore wind industry over the past two decades and the implicit growth in the size of wind turbines, operation and maintenance (O&M) has become a major focal point in the attempt to lower the cost of wind energy to market competitive prices. Generally, O&M operations account for an estimated 25%–30% of the levelized cost of energy (LCoE) (Engels et al., 2009). This leads to a high impact on the LCoE, where the contribution from the blades is estimated (depending on the study) to range between 13% and 22%. Table 1 shows a cost distribution over the LCoE of the various components (Engels et al., 2009).

Aside from perfecting maintenance strategies and optimizing the placement of maintenance effort, several research projects and industry development are focusing on improving the structural performance of the wind turbine blades in an attempt to lower failure frequencies. One such example is the D-String® concept (Bladena, 2016), developed to stop edgewise crack development on the trailing edge for existing and future installed wind turbines. As shown in Fig. 1 (Nissim, 2013), this type of failure can account for up to 35% of blade defects, thus having a considerable impact on maintenance costs.

This paper aims to present a methodology for analyzing the O&M consequences and to illustrate the potential impact on the LCoE from implementing D-String® devices by performing a case study on an offshore wind farm based on the NORCOWE reference wind farm (Bak et al., 2016). A maintenance model is set up, using condition-based maintenance for blades and corrective maintenance for the rest of the components in the wind turbines. A degradation model is set up for the blades, where the failure frequency output is dependent, among other factors, on the installation of the D-String® device. A Markov-type model is used for the probabilistic modeling, and a discrete event simulator is used to estimate the cost of energy with and without installing the devices.

Rated power	MM29 2	DOWEC 6	NREL 1.5	Risø 2.5	MM8 2	WEH 1.5
Tower	26.3	25.0	11.0	21.0	11.0	18.7
Blades	22.2	14.4	16.0	22.0	13.0	19.5
Hub	1.4	7.6	7.0	3.0	7.0	2.7
Main bearing	1.2	2.4	1.3			
Shaft	1.9		2.2	5.0	5.0	4.5
Nacelle frame	2.8	1.4	7.0	13.0	10.0	11.5
Gearbox	12.9	13.1	16.4	15.0	11.0	13.3
Generator	3.4	6.1	10.6	9.0	7.0	8.0
Yaw system	1.3	2.0	1.3	5.0		4.5
Pitch system	2.7	10.3	3.9	5.0	16.0	
Power conversion	5.0	2.0	10.9			
Nacelle cover	1.4	0.7	4.0			
Brake	1.3	0.7	0.3	2.0		1.8
Cables	1.0	1.9				
Misc	11.9	12.4	1.6		20.0	15.5

Table 1 Cost distribution on the LCoE of different studies

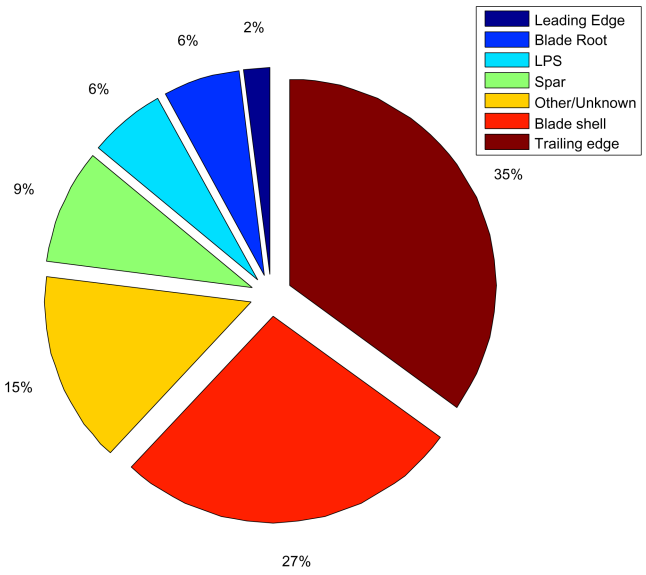

Fig. 1 Blade defects

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