Review of Offshore Cable Reliability Metrics

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ABSTRACT

A review of published reliability data was undertaken in order to populate a database which is presented in this paper. This data focusses on a number of connection types including both AC and DC connections across a number of cable ratings and configurations. From this database it is confirmed that reliability figures currently being used across the literature generally conform to those currently being experienced in the offshore wind industry. However it is established that failure rates taken from some reports are not accurate as the technology and environments these are calculated from are typically different from those used in offshore wind farm connections. This information is collated and converted into reliability metrics in order for comparisons to be made.

INTRODUCTION

With the increasing number of offshore wind farms as well as other renewable energy sources, such as wave and tidal, the need for greater subsea cable reliability is ever increasing. One of the most important challenges that are met is that of cable installation. There are many complex aspects of the processes before, during and after installation many of which can lead to significant failures if not managed correctly.

If literature is examined it can be seen that reliability figures and failure data from offshore cables is sparse. As a result of this a number of authors have had to estimate failure rates. Some literature has been found to have used data from CIGRE reports which as shown in this research is not as reliable as would be assumed.

There is a need for cable failure statistics to be made available. With this interested parties such as wind farm developers, prospective OFTO asset investors and 3rd parties involved in due diligence and maintenance services could perform detailed reliability analysis as well as analyse the costs associated with a prospective failure. This could not only allow for better installation practice, leading to reduced outages and greater revenue but also help achieve cost reduction targets set by both the UK and EU governments related to climate change and renewable energy.

LITERATURE

In order to populate the database a number of papers and reports which focussed on reliability analysis and offshore cables were reviewed [1-8]. The reliability figures used were then converted from a number of different formats to be represented as failures / year in order to allow for comparison between different cable lengths and ratings.

Technology	Cable Rating	Failure rate (failures/year)	Year	Reference
HVDC	320 kV	Best: 0.00001107	2015	[1]
		Middle: 0.00002213		
		Worst: 0.0003689		
HVAC	60 – 500 kV	0.000000101	2012	[2-4]
HVDC	60 – 500 kV	0.000000163		
EHVAC	700 – 800 kV	Single Circuit: 0.3	2010	[5]
		Double Circuit: 0.03		
HVDC	600 – 650 kV	Single Pole: 0.4		
		Double Pole: 0.03		
HVAC	132 kV 3 Core	0.25	2007	[6]
	220 kV 3 Core	0.46		
	400 kV 3 Core	0.67		
	275 kV Single Core	0.15		
	400 kV Single Core	0.22		
MVAC	30 kV	Feeder Cable: 0.003	2006	[7]
		Tower – Tower Cable: 0.0125		
		Tower Cable: 0.1875		
M/HVAC	33 – 150 kV	Submarine: 0.00000467	2006	[8]
		Inter-Array: 0.0000323		

PUBLICALLY AVAILABLE

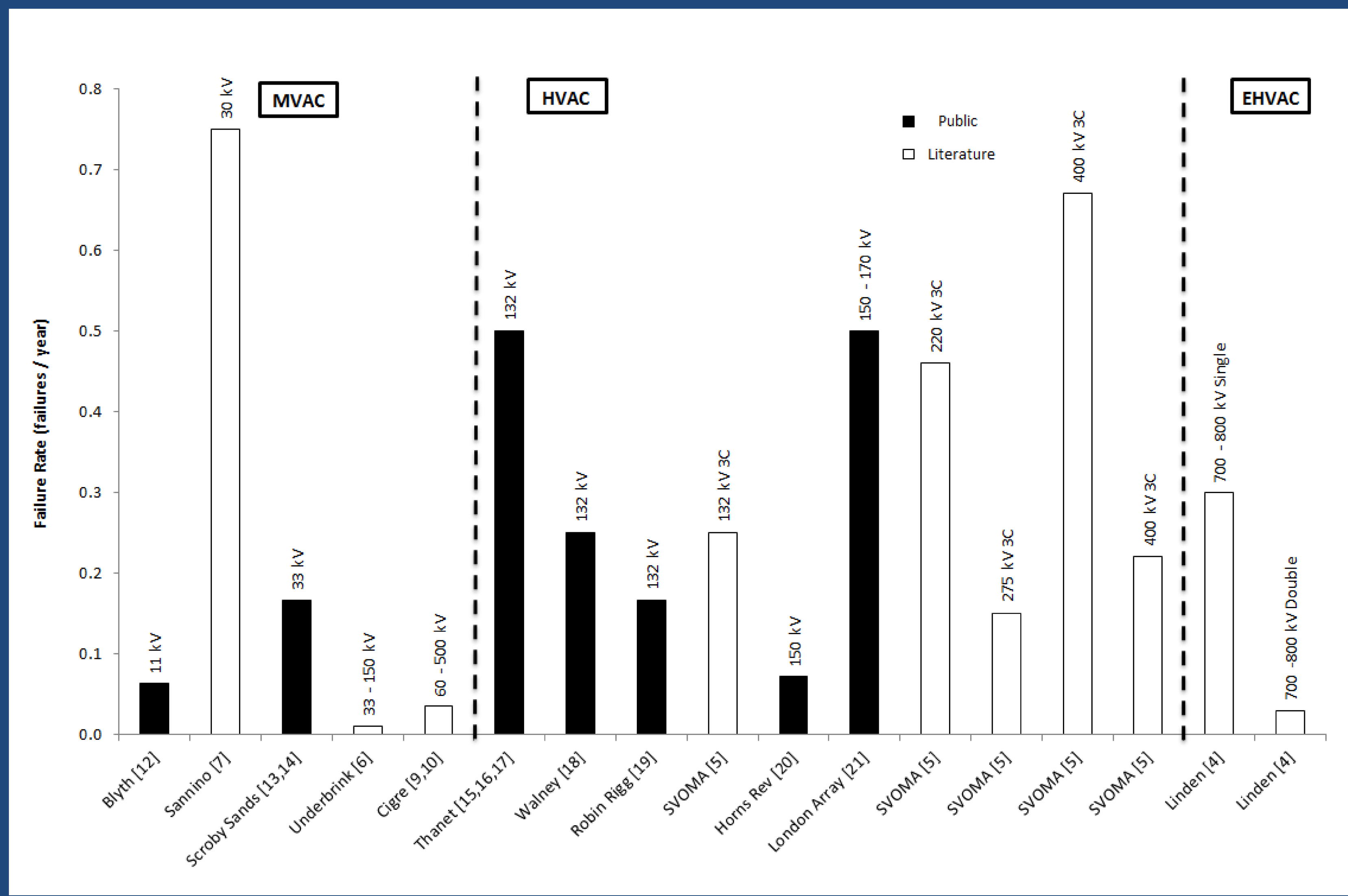
In order to populate this database publically available data on offshore cable failures was then investigated, revealing failure data that did not appear to be present throughout the literature. This information was collated through investigation of news articles, Notice to Mariners and SeaFish reports.

4C Offshore | BBC NEWS | ofgem Making a positive difference for energy consumers | ADMIRALTY Maritime Products & Services | THE TIMES | SEAFISH the authority on seafood | WINDPOWER OFFSHORE

Technology	Cable Rating	Failure rate (failures/year)	Year	Reference
MVAC	11 kV	0.0625	2000 – 2016	Blyth
MVAC	33 kV	0.167	2004 – 2016	Scroby Sands
HVAC	132 kV	0.5	2010 – 2016	Thanet
HVAC	132 kV	0.25	2012 – 2016	Walney
HVAC	132 kV	0.167	2010 - 2016	Robin Rigg
HVAC	150 kV	0.0714	2002 – 2016	Horns Rev
HVAC	150 – 170 kV	0.5	2012 – 2016	London Array
HVAC	220 – 245 kV	1	2013 – 2016	Anholt
HVAC	132 kV	1	2015 – 2016	Walney 2
HVAC	132 kV	3	2015 – 2016	Gwynt Y Mor

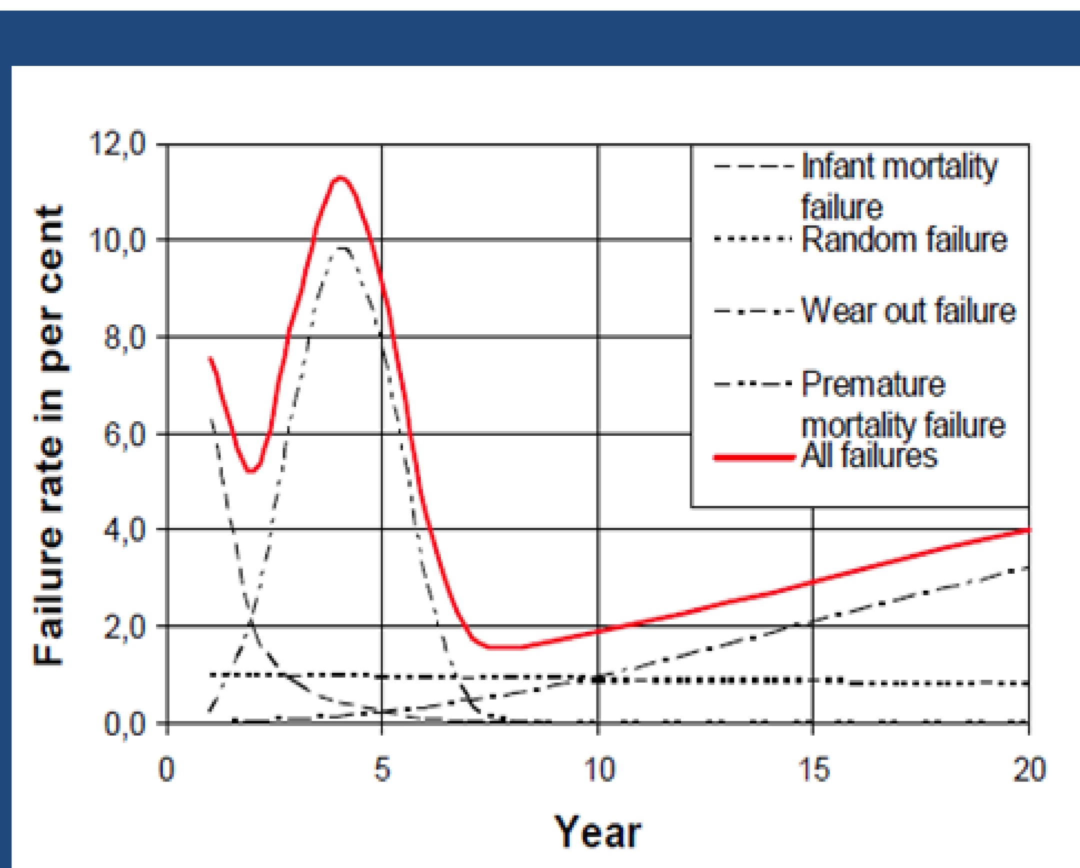
COMPARISON OF RESULTS

It can be seen that when comparing the failure rates, especially in the HVAC range, the figures estimated generally conform to those being experienced offshore. However this is minus the data collated from sites which are early in their life cycle such as Gwynt Y Mor in which 3 failures have been experienced in the first year of operation as well as in the installation period.



EARLY LIFE FAILURES

An explanation for a high rate of failure in new installations, such as Gwynt Y Mor, can be found in [9]. In this Steisdal and Madsen investigate reliability of offshore wind components. The authors take a conventional bathtub curve and determine that in practice the bathtub curve is not always applicable. The paper discusses infant mortality, random failures, wear out failures and premature mortality failures in order to plot the overall failure curve for offshore wind components.



CIGRE DATA

Reports that were often cited by other literature were those completed by CIGRE working groups, namely B1.10 and B1.21 [3,4]. Whilst the data taken from these reports covers a large range of cable ratings the derived failure rates appear to be much smaller than all of the failure rates observed from operational wind farm export cables. This is most likely due to the type of cables that were analysed for these reports. In many cases the cables analysed in these reports were interconnectors, spanning hundreds of miles and in deep water. Given the differences in the assets being analysed, it is unsurprising to see the reliability metrics diverging. As such it is wise to use caution when using these figures in the analysis of offshore windfarm cables.

CONCLUSIONS

- The work completed presents a comparison between the failure rate data presented throughout literature
- Comparison of literature and Publically available data shows that some estimates are accurate whilst others deviate
- Data from all sources, especially the widely cited CIGRE reports should be used with caution when deriving failure rate data for offshore wind farms
- There is a need for greater transparency within the industry with regards to reliability and failure rates, especially with regards to offshore cable failures

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