How understanding spatial and temporal variation of ocean bottom temperature can significantly enhance the interpretation of DTS data from marine HV cables

Justin **DIX**, Etienne **ROCHAT**, Giuseppe **RIZZO**; Southampton University (UK), Omnisens SA, (Switzerland), EOSS, (Italy);
jkd@soton.ac.uk, etienne.rochat@omnisens.com, giuseppe.rizzo@prysmiangroup.com

ABSTRACT

Distributed Temperature Sensing is now widely accepted as a key component of conditional monitoring of submarine HV cables, underpinning Real-Time Thermal Ratings, Depth of Burial algorithms and monitoring of the ambient temperature of the cable environment. Crucial to the success of these monitoring packages is a validated measurement of the spatially and temporally varying ambient seabed temperature. This paper will demonstrate how the data can be extracted from operational cables and through comparison against independent ocean temperatures demonstrate their accuracy and precision.

KEYWORDS

Distributed Temperature Sensing; Ocean Bottom Temperature; Conditional Monitoring of marine HV cables

INTRODUCTION

Failing subsea power cables are one of the primary risks affecting offshore windfarm (OWF) development and operations. Although the exact published numbers are variable, one of the latest reviews suggests that, between 2010 and 2020, subsea cables (export and inter-array) represented the most frequent and expensive losses e.g. 30% of claims incurred and 50% of total claims spend over this period [1]. The actual causes of these failures are debated with numerous studies providing very different results, however, a 2018 assessment by the UK's offshore renewable energy catapult suggest that, between 2007 and 2018 in the UK offshore wind sector, the primary causes of failure were Electrical Faults (47%); Manufacturing & Installation (37%); External and Environment (13%) and Replacements (3% - [2]).

Using the more extensive records of the telecommunication cable industry [3] suggest that within the external and environmental category the actual causes of submarine cable failure can be further split in to 4 categories: fishing activity; anchor strikes; geohazards; and abrasion. The impact of these is predicated on the cable being at or near the seabed surface and so it is essential to have a good understanding of post-installation seabed mobility to identify or mitigate for cables becoming exposed and subsequently at risk from human agency or catastrophic natural processes. Therefore, approaches that are capable of real-time monitoring of cable exposure or over-burial are now considered critical to the successful lifetime operation of all marine High Voltage (HV) cables (windfarms and interconnectors). Consequently, approaches for real-time, cost-effective monitoring of cable exposure and over-burial are becoming a standard part of operational monitoring.

Similarly, through increased use of Real-Time Thermal Rating (RTTR – e.g. [4]) and the potential for thermal risk estimation to become a part of power transfer optimisation (e.g. [5]), the importance of accurate measurements of conductor temperature and an understanding of the processes that control conductor temperature variation is increasingly important. Finally, in some regions, the requirement to comply by the "2K rule" [e.g. [6]) has led to the need for understanding the ambient temperature at both cable depth and in the top 0.2 m of the seabed.

Distributed Temperature Sensing (DTS) has become a standard techniques for conditional monitoring of almost all marine HV cables, having developed from being purely a "fault detection" tool to underpinning all established RTTR algorithms; becoming a recognised approach towards real-time "depth of burial" calculations; having the potential to provide critical inputs into understanding the ambient thermal environment of the trenched environment; and ultimately being fed back into the actual cable design process.

Almost all these approaches are underpinned by application of components of either IEC-60287 or IEC-60853. Critical to these calculations is an accurate record of ambient temperature of the seabed, which in turn needs to be propagated to cable depth, typically through the application of Fourier's Law (e.g. [7]). Traditionally, for cable designs and conditional monitoring applications, ambient temperatures were typically set at between 10 and 15°C [8]. However, ocean bottom temperature can show significant spatial (local, regional, and global) and temporal (daily to seasonal) variation. For instance, Hernandez-Colin et al [9] have demonstrated the potential impact of including seasonally varying temperature profiles on optimising power transfer, whilst Erdmann et al [10] have shown the influence of daily fluctuations on exposed marine HV cable conductor temperatures. Similarly, Lux et al [11] and Van Oosterom et al [12], have highlighted the importance of accurately determining the ambient seabed temperature condition for accurate burial depth calculation.

This paper will demonstrate the potential of actually extracting ocean bottom temperature directly from distributed temperature data from the cable; demonstrate the sensitivity of these measurements to changing oceanographic conditions and propose approaches for calculating the field accuracy and precision of these DTS measurements relative to independent continuous ocean temperature measurements.

WELL MIXED VS STRATIFIED OCEAN ENVIRONMENTS

This paper reports DTS data from a series of sites in varying oceanographic conditions ranging from "well-mixed", where ocean bottom temperatures (OBTs) are equivalent to sea-surface temperatures (SSTs) throughout all seasons; to thermally stratified environments where a combination of the water depths, currents and other hydrodynamic factors result in the seabed being thermally stratified such that seabed temperatures are significantly different to sea surface temperatures.