Advances in the Application and use of DTS Monitoring For Cable Systems

Oliver **CWIKOWSKI**, Adam **SIMMONDS** Ørsted Wind Power, (UK), OLINC@orsted.com, XADSI@orsted.com
Ida **STOUSTRUP,** Aris **KARAOLANIS**, Francisco **RODRIGUEZ**, Kim Lund **SORENSON**, Ørsted Wind Power, (Denmark), IDAST@orsted.com, KARRI@orsted.com, FRAGR@orsted.com, KIMSO@rosted.com

ABSTRACT

Offshore wind generation is becoming a globalised industry. Innovation and operational efficiency are essential areas for improvement to help bring down the costs of green energy generation. Cable monitoring solutions offer the opportunity to improve the operation of windfarms and advance cable design methods. This paper presents recent industrial activities on using Distributed Temperature Sensors (DTS) to support in both of these areas.

KEYWORDS

Cable Monitoring; Distributed Temperature Sensors (DTS); Cable Modelling; Validation; Operational Guidance

INTRODUCTION

Cable monitoring solutions offer significant opportunities to improve both the availability of offshore windfarms and design assumptions. There are many technologies on the market offering different insights [1,2,3]. Distributed Temperature Sensors (DTSs) is one technology which is frequently used in cable systems [4].

At present, a DTS' primary function is to provide the asset Operator with a temperature alarm, which allows abnormal thermal conditions to be identified; allowing a failure to be prevented by the partial curtailment of generation. This is typically used on assets which are expected to operate close to their maximum temperatures or use a rating methodology other than a continuous current calculation.

The same data which is used to generate alarms can also be used for thermal design validation. The validation of a cable's thermal design, although complex, offers a significant opportunity for learning and optimization of the cable asset design and by extension the windfarm as whole.

During design, assumptions have to be made for the thermal resistances, volumetric heat capacities, installation soil configuration, soil ambient temperatures and burial depths [5]. DTS offers the opportunity to test the assumptions using in-service monitoring and identify if there are learnings which can be adopted into industry practice.

For large windfarms, the total cable lengths as well as variations in installation conditions result in the need for digital design tools to be used to perform the calculations, simply due to the volume of data and scale of the problem.

This paper first provides general guidance on integrating DTS systems into offshore windfarms, as well as some learnings from deploying these systems.

The second part of this paper then presents validation results for 260 km of export cable from two different cable systems; showing the relative difference between what the design equations predict the Fibre Optic Cable (FOC) temperatures to be, compared to the DTS measurements. This is presented alongside with as-built information regarding burial depth, soil properties, and trenching tools. The preliminary results and their implications are then discussed, with suggested areas for future study.

DTS OVERVIEW

The type of DTS system which is used in this work is well described in [2].

OPERATIONAL GUIDANCE

This section provides some general guidance for integrating DTS into an offshore windfarm.

DTS Alerts

The DTS systems used for offshore windfarms have the ability to provide alerts to the windfarm's Substation Control System (SCS). As the DTS contains significant compute power, separated from the measurement system, alarms can be flexibly designed to alert the Operator to a range of conditions. Typical alerts used in practice are:

1. High Temperature Alarm – Conductor temperature will likely exceed its maximum operating limit and partial generation curtailment is recommended.
2. Temperature Warning – The cable is experiencing a higher temperature than expected but is still within a safe operating level. This can alert asset managers to developing thermal problems ahead of a failure/ partial curtailment.
3. DTS System Malfunction – This alerts the user that the DTS is not able to provide alarms or data. For sites where there are known thermal issues, this can provide the operator with essential information to ensure asset integrity.

Additional alarms can be provided if required, but these are the general alarms which are sent from the DTS to the SCS.

The DTS alarms then need to be appropriately classified in the SCS to ensure that the alarms reach the right level of operator; i.e. does the alarm just appear on the local SCS Human Machine Interface (HMI) or will this also be automatically escalated to the regional operator. High class alarms will require immediate action, whereas lower class alarms can be tolerated or simply used for asset management purposes.

The highest-class alarms are the ones which typically require immediate action by the Operator. It is generally recommended that Temperature Alarms are set to this highest level, as these conditions, while rare, could result in damage to the cable system.

Temperature Warnings can be attributed to a lower-class level. No immediate action is required for this warning as