Framework for an efficient screening of potential cable system concepts for modern HVDC interconnectors considering state of the art converter technology, overall losses and transfer capabilities

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ABSTRACT

At the inception of any HVDC interconnector, fundamental questions emerge about the most efficient concept for the cable system and HVDC configuration and technology. This paper summarizes the framework of a concept aiming a more efficient screening of the most suitable conductor cross-sections, voltage level, and insulation materials vis-à-vis the required transfer capability, distances and overall losses taking into account state of the art HVDC converter stations. Dedicated analytical models were developed integrating cable thermal analysis, total losses (converter station and cable losses) and required active power (rated power) at the AC side terminals of the inverter station.

KEYWORDS

HVDC interconnectors, losses, cable system optimization, XLPE and MIND, VSC.

INTRODUCTION

Intermittent generation entails multiple challenges in terms of the respective output integration and accommodation of flow.

Modern HVDC interconnectors are essential components of a multiple path, transnational power flow concepts fostering integration of renewables, network stability, grid performance and power security. The respective transfer capability can be instrumental for the stability, planning and operation of the interconnected grids.

During the last decades the North Sea basin has seen a proliferation of HVDC interconnections (constructed in different technologies) fostering massive cross border energy exchanges, grid stability and energy market demands.

New developments of the converter technology (especially the growing number of applications of the modern VSC technology) and HVDC cable systems have gradually strengthened the design options towards a more robust, efficient and project specific concept.

Specific models for cable systems operated at ±320 kV, ±400 kV and ±525kV were developed. The performance of cable systems with extruded insulation was investigated for all the three voltage levels. The analysis of mass-impregnated cables was limited to a voltage level of ±525kV.

HVDC applications in VSC technology became the majority of HVDC projects constructed all over the globe, but specifically as interconnectors and wind and renewable offshore connections in Europe, they contribute successfully to the change in the energy market, modern supply strategies and the aim to reduce the CO_2 emissions to a minimum.

During this period the development of the VCS converter technology (based on their IGBTs and similar semiconductor components) initiated the process implementing VSC based HVDC converter stations starting with Symmetrical Monopoles (SMP) with lower power rating moving to bipolar applications of up to 1.400 MW as Rigid Bipoles (RGB) and potentially beyond (2.000 MW and more) in the very near future.

During this time and in close coordination with the developments at the HVDC cable market (voltage levels of XLPE as well as MIND cables), HVDC converter stations have been built and developed from 320 kV up to 500 kV, currently being under construction for projects such as the bipolar Viking link and the NeuConnect interconnector, both RGB topologies.

HVDC CONVERTER STATION TOPOLOGIES

HVDC converter stations in VSC technology today are built as SMP and/or RGB transmission schemes depending on project specific conditions such as power rating, cable length, environmental conditions, grid code, system performance etc.

The SMP constitutes of a single set of VSC converters at each converter station connected by one pair of DC cables and no ground and/or metallic return options. No power transmission in case of a DC cable and/or a VSC converter failure.

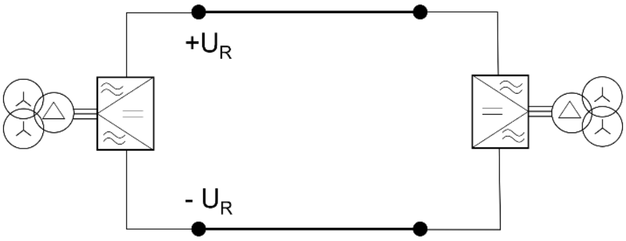

Fig. 1: Symmetric Monopole Configuration

The RGB constitutes of a double set of VSC converters at each converter station connected by one pair of DC cables providing certain metallic return options depending on the connections and switching opportunities on the DC side of the converters, offering up to 50% power transmission in case of a failure of one VSC converter.