Study on VSC HVDC Modeling and Control Strategies for Wind Power Integration

Recently, more and more offshore wind farms have been integrated into the power systems. In the next years, these offshore power plants are going to be rated at higher capacities and located in larger distances from the coast. This results in greater interest in the transmission technologies, which are available for the grid connection of the offshore wind farms. In this report various transmission systems are presented. Precisely, the HVAC systems, which have dominated up until now in the power transfer sector, are briefly analysed, by providing their advantages, as well as the bottlenecks that occur in their applications. The main focus is given in the HVDC transmission systems, since they do not exhibit these disadvantages, whereas they additionally present beneficial attributes. This is the reason for which the applications of HVDC systems have been increased in the latest years. A brief description of different application cases is provided in the introduction of this report, while the rest chapters deal with the use of the HVDC technology for the grid connection of offshore wind farms. The main structure of the HVDC system is analysed, by describing the role and operation of its main components. Especially the converter configurations, the devices for reactive power compensation, the filter systems and the DC breakers are presented in details. The presence of different components, with different characteristics, leads to alternative system structures. Therefore, a comparison between the different structures is performed, regarding power losses, costs, equipment aspects and control capabilities. It is concluded that the VSC-HVDC system exhibits the most advantageous features for the grid connection of offshore wind farms. In addition, various topologies of the HVDC converter stations are analysed. Furthermore, the control schemes and strategies of the VSC are described in details. The capabilities of the VSC-HVDC technology, provided by its control system, are analysed. These attributes give the opportunity to the VSC-HVDC transmission system to provide grid support. They imply also benefits for the design of the wind turbines, as well as for the operation of the TSOs. Special focus is given on control strategies for fulfilling requirements concerning LVRT and frequency regulation. The corresponding technical rules, included in grid codes, are provided and the relevant structures and methods are described. Finally, more specific requirements are given for the grid connection of offshore wind farms through HVDC systems. These rules derived from the combination of grid codes for the integration of offshore wind farms and grid codes for the operation of HVDC transmission systems, connecting power plants to the AC network.

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