Coordinated control of wind power plants in offshore HVDC grids

During the recent years, there has been a significant penetration of offshore wind power into the power system and this trend is expected to continue in the future. The North Sea in Europe has higher potential for offshore wind power; therefore, the North Seas Countries' Offshore Grid initiative was formed among nine North Sea countries. They agreed on closer energy cooperation to enable development of an efficient and economic offshore grid infrastructure for advantages, interconnectors based on the voltage source converter based high voltage DC (HVDC) transmission system is being used to exchange power between different countries, and different synchronous areas. It is very likely that they will then be combined with offshore wind power plant (OWPP) connections in the North Sea, transforming it in a multi terminal DC (MTDC) grid and, therefore, in a fully meshed offshore DC grid in near future. However, increased penetration of offshore wind power into the power system poses several challenges to its security. This thesis deals with two main research challenges, (1) Develop, and analyze the coordinated control strategies for AC voltage and reactive power control in the cluster of OWPPs connected to common offshore HVDC station, (2). Develop, analyze, and test the control strategies for ancillary services from OWPPs to the AC grid, mainly fast primary frequency control from OWPPs. Moreover, the impact of wind speed on the frequency control from OWPPs is also studied in this thesis. The main results of this research work show that the OWPPs in the HVDC grid can participate in fast primary frequency control of the power system by using the proposed frequency control methods. Also, wind speed has a significant impact on the frequency control, particularly at below rated wind speeds. The proposed methods for AC voltage and reactive power control can improve the steady state and dynamic AC voltage profile of the offshore AC grid with cluster of OWPPs connected to common HVDC station, while minimizing the active power losses in the offshore AC grid. The research work is carried at the Technical University of Denmark (DTU) in the Department of Wind Energy and it is funded by the People Programme (Marie Curie Actions) of the EU FP7/2007-2013/ under REA grants agreement no. 317221, project title MEDOW.