Dynamic Thermoelectric Modelling of Oil-filled Power Transformers for Optimization of Offshore Windfarm Export Systems

Oil-filled power transformers are some of the most critical components of the electrical export system for Offshore Wind Power Plants (OWPPs). During contingency situations, dynamic loading of the export transformers becomes essential for debottlenecking and optimization of OWPPs, which is elaborated using a case study of Anholt offshore windfarm export system power transformers. Power transformers can be dynamically loaded if the temporal development of temperatures is known, especially Top-Oil (TOT) and Hot-Spot (HST) temperatures. Since the fibre-optic sensors for direct HST measurements are unavailable and the associated costs are high, these temperatures must be estimated using thermoelectric models based on differential-equations for real-time dynamic loading operation of transformers. The renowned and industry-wide accepted thermal model of IEEE loading guide C57.91 is presented in this paper, along with the recently established but well proven model by Susa et al. Both these models are validated using the instantaneous TOT measurements for one of the 140 MVA, 225kV/33 kV transformers in the Danish Anholt windfarm for the entire 2017 period. The model that is found to perform better is then used for HST calculation for the transformer and the thermal aging of its paper insulation is assessed based on its loading and ambient conditions history for 2017. Furthermore, the thermal utilization and insulation loss-of-life (LOL) based on HST variation of the Anholt windfarm transformer is assessed for increased wind energy generation for 1 year. This is done by upscaling the actual instantaneous load of the test transformer for the entire period of 2017. The upscaling factor 'W' is varied over the range of 1.0 to 1.6 pu with the actual instantaneous wind generation in 2017 at Anholt as base. The results are then used to provide insights into transformer dimensioning for offshore windfarm applications and to assess whether the transformer allows further wind energy integration in the existing export system for the Anholt offshore windfarm.

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