IMPLEMENTATION OF CABLE MODELS FOR STUDIES OF COMPATIBILITY OF ELECTRIC COMPONENTS IN WIND FARMS

Andrzej **HOLDYK**, Joachim **HOLBOELL,** Technical University of Denmark, Department of Electrical Engineering, Kgs. Lyngby, (Denmark), aho@elektro.dtu.dk, jh@elektro.dtu.dk

Asger **JENSEN**, Dong Energy, Fredericia, (Denmark), asgje@dongenergy.dk

ABSTRACT

Study of interactions between electric components in power systems is getting more important in the view of an increasing degree of systems' complexity and, as in the case of wind farms, risk of systematic (highly repeatable) design problems. So far there have not been many studies treating that problem in a sufficiently general way, trying to take into consideration different layouts of farms and different wind farm electric environments at the same time. This paper introduces a first step towards the concept of compatibility of electric components in wind farms by relating different cable models from an electromagnetic transients program to such studies.

KEYWORDS

Electric component interaction, electric component compatibility, wind farm, cable models

INTRODUCTION

An offshore wind farm (OWF) is usually characterized by the wind turbines placed in several radials, each consisting of the same number of turbines, submarine cables to connect the turbines to the transformer platform plus a number of park transformers on the platform and additional equipment. The distances between turbines in each radial and between radials are usually the same, as shown in Fig. 1.

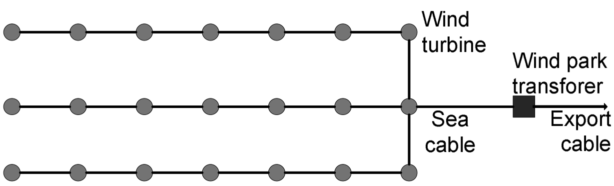

Fig. 1: Example of a typical offshore wind farm's layout principle

As the available space for OWF's is very often limited (e.g. by environmental or political regulations) their layouts might be become very compact. Moreover, future turbines of 6 - 7 MW limit the number of possible turbines per radial making a compact design in order not to cause problems with the voltage at the end of the radials, unless certain measures regarding cross section of the collection grid cables are taken. The consequence hereof is again a compact layout like a large number of identical radials surrounding the transformer platform.

Such complexity and modular layout raise the concern of harmful interaction between a wind farm's electrical components. In particular, some focus should be put on the regular pattern most farm configurations are characterized by, since these patterns involve the risk for resonances, consequences of which can lead to component failures.

Systematic studies are, therefore necessary in order to prevent these harmful combinations of components.

INTERACTION OF MAIN ELECTRIC COMPONENTS

A number of examples of harmful interaction between cable and transformer in transmission and distribution systems can be found in literature. [1] shows a case of a 120 MVA 150/50 kV power transformer being destroyed due to overvoltages causing damage to a winding's insulation. The flashover occurred between a phase winding and the transformer's core under energization of the unloaded transformer via a cable feeder. Investigations show that the cause of those overvoltages was a combination of resonance frequencies of the transformer and a cable. Amplification of high order harmonic voltages of voltage sourced converter by a series and parallel resonance due to a transformer-cable interaction is described in reference [2]. Gustavsen in [3] shows that for specific cases an unloaded transformer connected to a cable on the high voltage side can experience overvoltage as high as 43 p.u. Several international investigations, like performed by Cigré JWG A2-A3-B3.21 on electrical environment of transformers [4], recognised coincidence of natural frequencies of cables and transformers in connection with fast- and very fast-front transients as one of possible causes of transformer's failures.

Examples of harmful interplay of network components as shown above are taken from transmission and distribution networks. So far, no literature describing similar cases at offshore wind farms could be found. This can have two reasons: 1) such cases did not occur in collection grid of offshore wind farms so far or, 2) such cases occurred but were never described and published.

Nevertheless, it is essential to be aware of possible problems with the interaction of wind turbine components, and this has to be taken into account at an early stage in the planning phase. Otherwise, the risk for economic consequences of a systematic design problem is far too high.

High competitiveness of the current market forces manufacturers to highly optimize their products to obtain costs reduction. This optimization might also imply decreasing losses in the system and thus less damping, which can in turn shift the resonant frequencies of some components to few kilohertz region.

COMPATIBILITY

It was illustrated in the previous section that the use of some specific combinations of components subjected to a disturbance can result in a serious damage to the system;