Hornsea projects 1 and 2 – Design and Optimisation of the Cables for the World Largest Offshore Wind Farms

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ABSTRACT

In this paper experiences with the design, production, installation and commissioning of the world's two largest offshore wind farms are described.
These ground-breaking projects that until recently were thought impossible, push the limit of a cabled HVAC transmission system to almost 200 km in length.
Through extensive electrical system analysis and detailed project cable engineering the longest 220 kV cable connection to an offshore wind farm in the world was conceived and built.
This paper covers all aspects in relation to the export cable system from the onshore substation to the offshore substations including the array cable systems from the offshore substations to the wind turbines.

KEYWORDS

World's largest offshore wind farm, world's longest 220 kV cable connection to a wind farm.

INTRODUCTION

Large offshore wind farms are currently getting bigger and bigger, being built further and further from shore and come with shorter construction windows compared to previous wind farms. Even though the basic design of large offshore wind farms follows the state-of-the art known from older wind farms, the significant size and short execution time present huge challenges.

Hornsea Project One (HOW01) will be the largest offshore wind farm in the world. Once completed in 2020, it will produce enough energy to power over 1 million homes. With a capacity of 1.2 gigawatts (GW), Hornsea One will be the world's first offshore wind farm to exceed the 1 GW threshold in capacity. Following this the Hornsea Project Two (HOW02) will in 2022 surpass HOW01 as the world's largest offshore wind farm with a capacity of 1.4 GW meeting the electricity needs of a staggering 1.3 million UK homes per year.

Located off the cost of Yorkshire, England (Figure 1.), HOW01 and HOW02 will span huge areas of over 400 square kilometers each, which each is over five times the size of the city of Hull. The offshore wind farms will use 7 and 8 Mega Watt (MW) wind turbines respectively, with each one 190 meters tall – higher than the Gherkin building in London.

This paper will describe some of the challenges experienced during design and execution of the biggest wind farms in the world.

Figure 1 - Location of Hornsea Project One

ELECTRICAL SYSTEM CONSIDERATIONS

The high-level electrical design for the two offshore wind farms HOW01 and HOW02 is the same (Table 1). The Wind turbines (WTs), generating the active power, are connected to an offshore substation via the array cable system. At the offshore substations voltage is stepped-up to the transmission system level of 220kV by transformers. The generated power is exported through the export cables to the onshore substation. At the onshore substation the voltage is further increased to 400kV and connected to the two transmission interface points (TIP) at National Grid's Killingholme substation (Figure 2). The voltage profile along the export cable is optimized by including an offshore reactive compensation station. This also increase the active power transfer capability of the export cable.

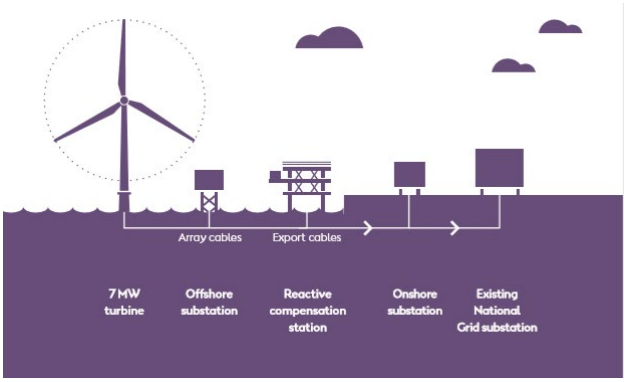

Figure 2 - HOW01 Design Layout

To obtain Grid Code compliance with the reactive power and voltage control requirements at the TIPs, three