POSITION PAPER

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Table of Contents

1. Background Material

LITERATURE USED:
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2. Scope and Considerations

For the roadmap offshore wind 2030 (routekaart windenergie op zee 2030) TenneT is tasked with the connection of several offshore wind farms up to 2030. The wind area's 'Hollandse kust West' and 'Ten Noorden van de Waddeneilanden' will be connected with TenneT's previously established and consulted standardized 700 MW grid connection concept. Due to its size and distance to shore, a new grid connection concept has been established for the wind area IJmuiden ver. The figure below shows a schematic cross-section of this new grid connection concept. Wind turbines are connected through medium voltage (66 kV) “inter-array” cables (in orange) to an offshore (HVDC) convertor station. Using 2 GW high voltage (525 kV) export cables the electricity is transported to shore. TenneT will be responsible for the offshore grid, from the onshore substation up to and including, the offshore substation. TenneT intends to create a new standard HVDC grid connection concept for both connections to IJmuiden ver and potential future wind farms.

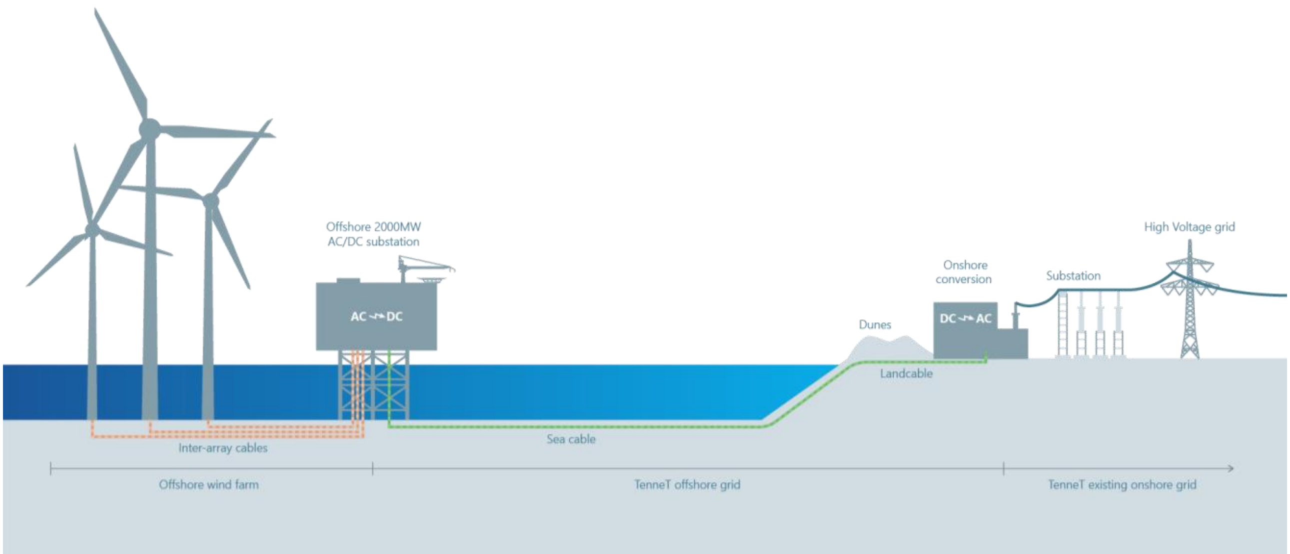

Figure 1 - HVDC grid connection concept

This paper describes how TenneT, as the offshore grid connection owner, proposes to deal with the fault-ride-through (FRT) performance of the overall offshore system.

3. Current Situation

HVDC Systems for the connection of offshore wind farms to the onshore grid are typically equipped with a dynamic braking system (DBS) to fulfil the FRT requirements at the onshore grid connection point (marked in red in figure 2). The reason is, that during a severe fault in the onshore grid the HVDC onshore station cannot inject power anymore. As the OWF is decoupled from the onshore grid by the DC circuit, it is not able to detect the onshore fault and is consequently not changing its operation point. This leads to a fast rise of the DC voltage which is limited to pre-defined value in order to protect the DC cable and the converter equipment.

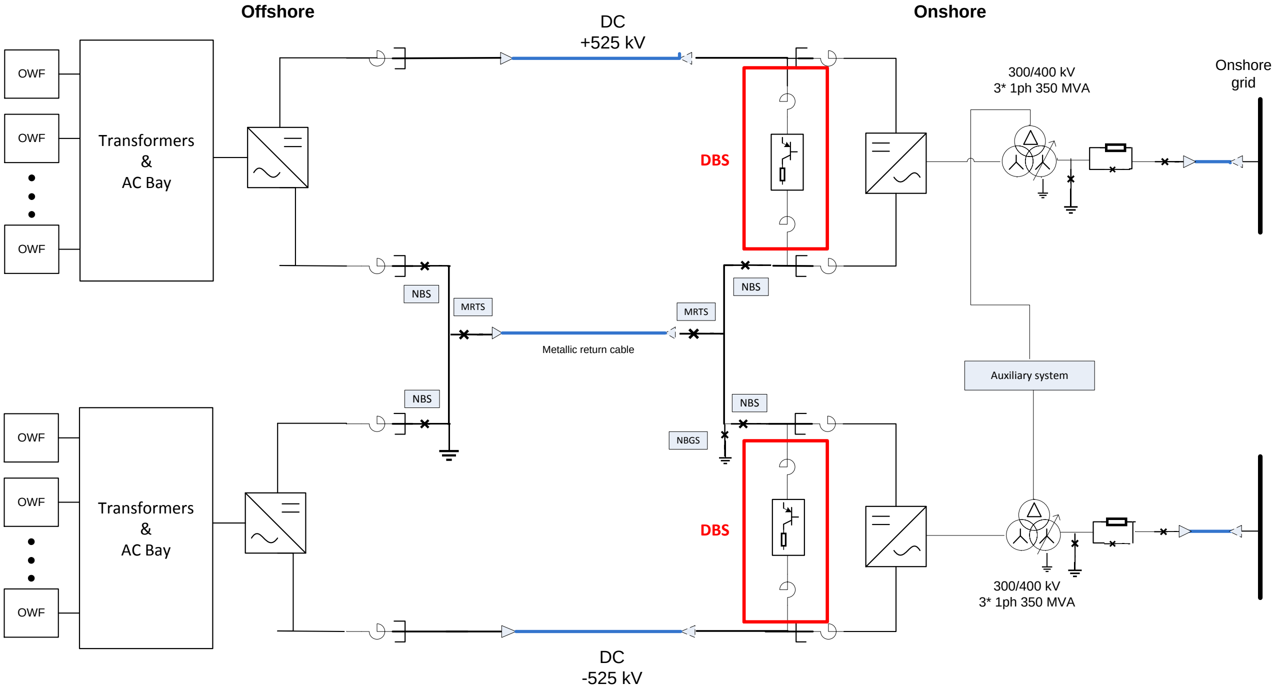

Figure 1: Generic SLD for Ijmuiden Ver with DBS

The advantages of this solution are related to the decoupling between the onshore and offshore side, the possibility for excessive active power dissipation (in case of special EPC functions) and to the fact that no disturbance is seen by the WTGs.

However, this solution comes at a cost due to the additional equipment, the extra land occupation and associated civil works required. The approximate cost of employing DBS at the onshore HVDC station of IJVER is estimated in the range of 10-20 M€, based on TenneT's experience.

Besides that, wind turbines are also typically equipped with a DBS (chopper) in order to fulfil the FRT requirements offshore. This DBS is only triggered in case of an offshore fault when the wind turbine is not able to feed its active power into the grid.

4. Future Solutions

TenneT intends to explore alternative and more cost-efficient solutions during the development stage of IJVER, that would provide similar FRT performance in order to comply with the grid code. The idea of utilising the inherent capability of the WTGs to dissipate excess energy in case of onshore faults will, therefore, be studied further.

On a preliminary basis, the following design options will be considered and studied in detail:

4.1 Option 1: Active power reduction by WTGs based on fast telecommunication

In case of a GCS without DBS on the land station, an obvious alternative design option would require the fast announcement of the onshore event to the WTGs, either by the onshore station based on the AC side measurements or by the offshore station upon sensing a DC voltage rise, in order to immediately reduce their power output.

However, this solution seems to require a very fast telecommunication system. The exact time window may also be dependent on the exact valve design of the onshore station, but it will in any case be short.

Even after achieving the fast telecommunication, the challenge would be to ensure the required reliability.

4.2 Option 2: Active power reduction by WTGs based on virtual offshore faults

Another alternative could lead to the creation of an artificial offshore grid fault by the offshore HVDC station (by controlling the offshore AC voltage) when sensing a DC voltage rise, in order to force the WTGs to enter a LVRT mode. In that way, the choppers of the WTGs would dissipate the surplus energy.

This solution seems to rely less (or not at all) on the speed of telecommunication between onshore and offshore.

A combination of option 1 (fast telecom) and option 2 (virtual offshore fault) is also an option.

5. Position TenneT

Above considerations lead TenneT to the following position:

TenneT intends to study alternative solutions for the FRT performance of the overall offshore system in case of onshore grid faults. This will include the dissipation of the surplus energy from the WTGs.

In case a proof of concept for a technical alternative with a lower cost (compared to the base case) could be achieved during the development stage of IJmuiden Ver, the OWF will be asked to support the onshore FRT behaviour of the HVDC system by use of the DBS inside the wind turbines.

TenneT invites the OWF developers to describe their power dissipation solutions in full detail, in order to be properly represented in the simulation work of the development stage of the offshore Grid Connection System.
