ABB STATCOMs help fulfill the Grid Code of the Westermost Rough offshore wind farm, UK
The shift towards distributed renewable electricity generation results in new challenges to the power grid. Grid Codes have been amended to reflect these additional challenges. From a Grid Code perspective, onshore and offshore Wind Power Plants (WPP) consisting of many Wind Turbine Generators (WTG) are seen as one system comparable to a conventional power plant.

Grid Code requirements have to be fulfilled for these WPPs. Due to limitations in WTG capability and limitations in cable export capability additional dynamic reactive compensation is required to meet Grid Code demands.
Westermost Rough Wind Farm
The Westermost Rough Offshore Wind Farm has been developed by DONG Energy and been divested recently to an Offshore Transmission Owner (OFTO). The wind farm is situated 8 kilometers (km) off the Yorkshire coast, north of Hull and contains 35 wind turbine generators, each rated at 6 megawatt (MW), covering a total area of 35 km² and providing enough electricity to power around 180,000 homes. It came on line in July 2014.

A 33 kilovolt (kV) inter-array cabling system collects the power generated by the wind turbines and transmits it into an offshore substation, where the voltage is stepped-up from 33 kV to 150 kV. Two cable export circuits connect the offshore substation to the onshore substation. The export submarine cables from the offshore substation have their landfall north of Tunstall. From there, about 15 km of underground cables reach the onshore grid entry point. The Westermost Rough offshore wind farm is a showcase requiring additional dynamic reactive power support to maintain grid code compliance at its onshore grid connection point. The project helps fulfill the UK’s commitment to reducing CO₂ emissions and contributes towards the UK achieving its targets of electricity generation from renewable energy sources.

Challenge
The continuous increase of installed wind power has forced the transmission system operators to tighten their grid connection rules – also known as Grid Codes – in order to continuously secure grid stability and power quality as power sources are changing from centralized conventional power plants to distributed new renewable energy sources. A showcase is the United Kingdom (UK) with its fast growing wind power penetration in the country’s power generation balance. Many onshore and offshore WPPs have been developed in the past and more are to be developed in the upcoming years. Especially offshore wind is becoming more and more of interest. In contrast to onshore wind, offshore wind generation is facing some additional challenges.

In terms of dynamic reactive power capability at the grid connection point the WTG capability is not the only issue but moreover, the distance to shore and the limitation in reactive power transfer are a challenge.

Solution
The lack of dynamic reactive power capability at the onshore grid connection point requires some source of additional dynamic reactive power at the onshore end of the WPP, where it is connected to the grid. For the Westermost Rough offshore wind farm ABB installed a dynamic reactive compensation (DRC) plant at the onshore substation with connection to special tertiary windings of the two WPP supergrid transformers. The DRC plant consists of two ±25 megavolt-ampere reactive (Mvar) PCS 6000 STATCOMs, one 50 Mvar mechanically switched shunt reactor (MSR) and a containerized medium-voltage switchgear together with auxiliary power generation, stabilization, distribution and a local DRC SCADA.
As the WTGs have certain dynamic reactive power capability but due to the long distance to the onshore grid connection point this capability is limited, it is economically attractive to combine the remaining capability of the wind turbines with the additional capability of a STATCOM. Long AC export cables connecting the WPP to shore are a considerable source of capacitive reactive power that is required to be compensated. With the MSR additional inductive reactive power can be absorbed from the DRC plant in order to compensate most of the export cable capacitance in steady state. Required dynamic adjustment of the reactive power at the PCC will be provided with the STATCOMs and WTGs.

**PCS 6000 STATCOM**
The PCS 6000 uses advanced IGCT technology (Integrated Gate Commutated Thyristor) that has been developed by ABB from a proven gate turn-off thyristor (GTO) semiconductor background. The IGCT modules including gate drivers, sensors and other supporting infrastructure are mounted on a common water-cooled heat sink as a power electronic building block (PEBB). This PEBB construction is the basis for a wide range of applications to be covered with the PCS 6000 modular converter system.

With the DRC plant, ABB offered a holistic solution based on a combination of PCS 6000 STATCOM with container housing and an MSR. ABB’s solution (excluding civil works) furthermore included STATCOM step-up transformers, STATCOM external water/air heat exchangers, MV and LV cables, protection, engineering, installation, commissioning and acceptance testing of the entire DRC plant.
ABB technology

ABB's compact PCS 6000 STATCOM represents an important leap in high power technology, particularly in terms of technical performance and economic operation. The PCS 6000 is particularly competitive in terms of footprint, installation time and on-site efforts. Furthermore the high efficiency and low need for maintenance lead to low operational costs.

The high power static frequency converter is designed for applications of up to 38 MVA per unit. Higher powers can be achieved by paralleling multiple PCS 6000 STATCOM units. Owing to maximum flexibility, the solution may be applied to a wide range of applications. These include wind farms, utilities with weak grids or fluctuating reactive loads, as well as industrial applications.

More than 20 ABB STATCOMs operate around the world and in various UK wind farms and provide more than 500 Mvar to help strengthen the country's electrical grid.

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**Main technical data**

<table>
<thead>
<tr>
<th>DRC plant rating</th>
<th>-100...+50 Mvar</th>
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<tbody>
<tr>
<td>STATCOM rating</td>
<td>±50.0 Mvar (2x ±25.0 Mvar)</td>
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<td>Number of STATCOMs</td>
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<td>MSR type</td>
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<tr>
<td>400 VAC stabilization type</td>
<td>ABB PCS100 AVC</td>
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</tbody>
</table>
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