Conception of a Medium Voltage Power Converter for Offshore wind turbines up to 10MW

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Abstract
During the last two decades, very demanding environmental agreements, signed by developed countries (especially Europeans), have led to a fast development and exponential increase in the number of installations of wind turbines all across the continent. This rapid pace of development has led to the erection of a wind turbine wherever feasible in terms of wind availability and has left no good enough onshore sites for newly designed wind turbines. The unpredictable regulatory framework in most of the countries has favored that the wind turbine manufacturers and operators focused more on extending the lifetime and capabilities of the existing wind turbines rather than substituting them by newly-designed and more efficient ones. As a consequence of this, the authorities laid their eyes on the sea where better wind conditions are to be expected, thus increasing the potential energy harvest. Additionally, being willing to increase the predictability of the energy production, the European governments boosted pilot projects to develop offshore windfarms and encouraged wind turbine manufacturers to develop new models specifically aimed for offshore conditions. In offshore windfarms, the cost of new wind capacity has been reduced by 60% from 2010 levels (IEA-RET, March 2017), leading to the current trend of increasing the power rating of the wind turbine as much as feasible. This increase in power and the increase in the maintenance costs derived from offshore sites (long time to repair) have led to multiple redundancy requirements across the offshore wind turbines especially affecting the power converter and the control equipment.

Objectives
Ten years ago, Ingeteam decided to develop a new power converter product range aimed for the foreseeable offshore wind turbines. The main objectives were:

- Effects of the different factors on the Annual Energy Production (AEP).
- Process to design and certify a power converter for offshore wind applications.

Methods
CONCEPTION STAGE
in this stage, several analysis were performed such as:
- Converter voltage rating selection
- Converter topology selection
- Semiconductor selection
- Redundancy and modularity
- Impact of different factors on Levelized Cost of Energy (LCOE)
Three different semiconductor types are available for MV converters such as HV-IGBT, IEGT and IGCTs. HV-IGBT modules were selected due to the following factors:
- They are widely used in industry.
- They allow to build very compact and lightweight field replaceable power modules,
- The losses on the device are low (high efficiency),
- There are several suppliers all across the world

DESIGN AND COMPONENT VALIDATION STAGE
Individual testing of each key component:
- IGCTs
- Gate drivers
- Capacitors in specific test bench
- Heatsinks
- Busbars.
- Power stack.
- Converter.

DESIGN VALIDATION AND GL CERTIFICATION STAGE
IP, Vibrations and certification tests in lab

Results
After all the studies and analysis carried on during the conception stage, the characteristics of the optimal power converter were raised. Especially important results were obtained from the studies about the impact on the AEP of the different characteristics of the power converter.
These yielded to the optimal solution composed of two conversion lines (two converters in parallel) as it combines a reduced parts number (increasing reliability) and the modularity, as one conversion line can be kept in operation when the other has failed. In order to reach the target power (10MW) with only two converters in parallel, the design needed to be in the medium voltage (MV) range.

Conclusions
Even though that some key players in wind industry are developing their 8+MW offshore wind turbines with a low voltage conversion stage, the studies done show that the medium voltage range can be a competitive alternative for these massive wind turbines. The cost of the converter is higher in the MV range, but the increase in overall efficiency, reduction of the cost of the cables and increase in reliability due to the lower part number, pays off the initial over cost in a short period of time.
Additionally, the reduced probability to fail, which directly implies a reduction of the maintenance tasks, leads to a further cost reduction during the whole lifetime of the wind turbine.

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