Wind farms: higher voltage, lower costs

HV wind farms can now dispense with an entire platform

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GIS RENEWABLES WIND

Today's offshore wind farms use medium voltage systems. However, a higher voltage design is more attractive at every stage, from layout to operation through to long-term costs – provided a number of challenges are overcome.

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Governments worldwide are promoting renewable energies. But if they really want to achieve sustainable development, then solutions to environmental problems have to make economic and social sense, too. Wind farms are part of strategies for renewables, but expanding their contribution significantly will mean reconciling the often conflicting interests of policy makers, investors, clients, citizens, and the energy industry itself.
Offshore wind farms can meet many of the objections to onshore projects, especially new offshore designs that exploit the advantages of moving from today's favoured solution using medium voltage 33 kV technologies to high voltage 66 kV designs.

1__Double the voltage, half the current

Doubling the voltage to 66 kV means the current is halved. Robert Lüscher, Manager of Gas-Insulated Substation (GIS) Development at Alstom Grid, outlines the advantages of the new approach in terms of design, cost and reliability. For a start, more strings of wind turbines can be linked to the substation busbar. Energy from a larger area can be handled by a single platform for a given 'power density' - the generation capacity installed in a given area.

This advantage will grow as platforms move farther offshore and if their cost increases.

The 33 kV voltage level generally used offshore was determined by the availability of switchgear and transformers that could fit into the wind turbine. However, equipment that already exists for the onshore market can now be adapted for integration into the latest generation of 5 MW offshore installations, allowing the use of 66 kV AC designs.

« We could even dream of a single centralised 66 kV/245 kV AC to ±320 kV/DC platform »

Lüscher explains that a future increase of wind farms rating above 500 MW can be technically and economically achieved by applying 66 kV. The increase in power of the wind turbine generators will reinforce these benefits. The main advantage can be seen in the central AC collector platform, where the 66 kV equipment would have a major advantage in comparison to traditional 33 kV equipment in terms of maximum transmitted power and size. "We could even dream of a single centralised 66 kV/245 kV AC to ±320 kV/DC platform - converter station, collecting the power of multiple wind clusters."

Moreover, the technology does not have to be designed from scratch; several practical solutions exist. Lüscher, whose role is to help integrate and customise GIS in offshore platforms and turbines, points out that GIS switchgear has already been integrated into offshore platforms for some years now, and higher voltage equipment could be integrated into offshore installations in a number of ways – in the tower itself, on top of the monopile, or in the jacket substructure. Some significant resizing may be needed to allow the tight integration into a wind turbine tower, since 33 kV cubicles are smaller than 66 kV GIS bays. Alstom Grid's optimised type F35-72.5 kV gas-insulated substation was considered as a perfect candidate for this project. However, close cooperation with the skilled people of Alstom Renewable Power was needed to make the GIS fit. At least 15 different layouts of the GIS were intensively studied to find a solution that matches all the technical requirements and also accommodates all possible wind farm collector system configurations. On the other hand, a 66 kV switchyard requires fewer bays overall on a central 500 MW-rated collector platform, so the 66 kV equipment in fact needs less space than the commonly used solution in 33 kV.

Future 66 kV-rated GIS equipment could be designed completely SF_6-free and therefore contribute a major step to the Alstom Clean Grid programme.

2__The benefits of dispensing with a platform

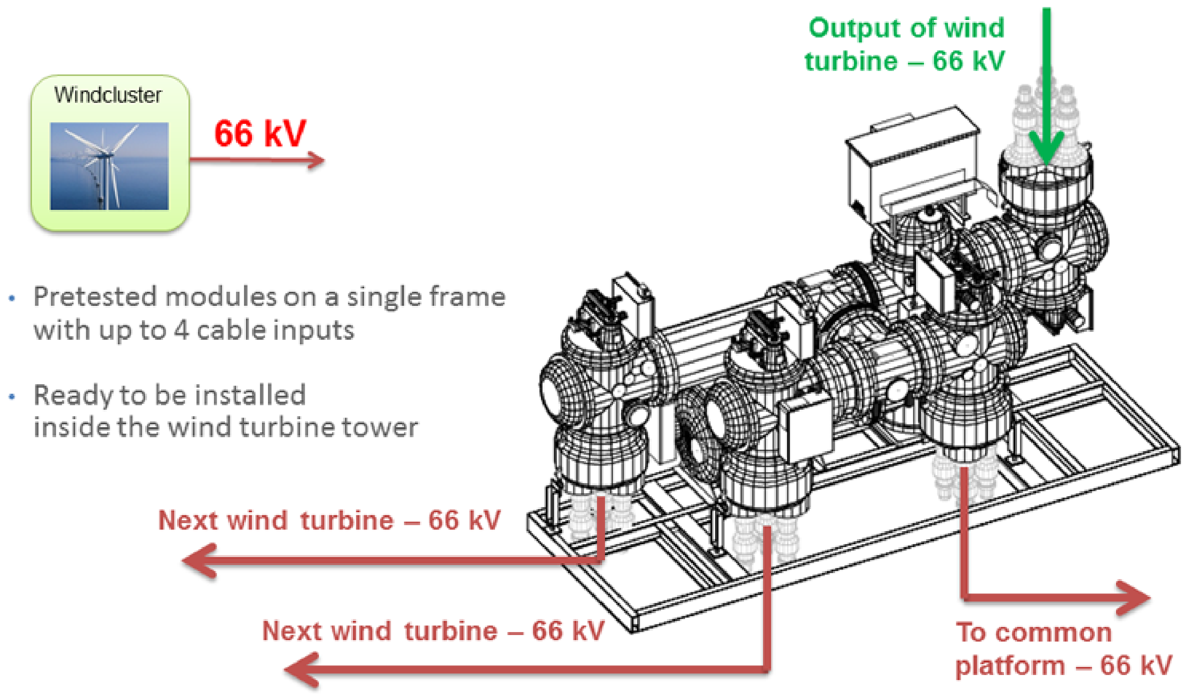
Removing the extra platform needed for the 33 kV design has a number of advantages, not least avoiding the cost and difficulty of accessing remote platforms in rough conditions. The two platforms may be up to 50 km apart, and a range of factors can affect the performance of the cable linking them, apart from the purely mechanical stresses and accidents that any equipment on the sea bed is exposed to. For example, the cables need to compensate reactive power, the power that exists in an AC circuit when the current and voltage are not in phase.

Operating at 66 kV means making extra efforts to ensure the equipment can withstand various over-voltages, notably the temporary over-voltages (TOV) that can occur when operating conditions suddenly change, and the switching over-voltages that happen within the first 20 ms after switching events, such as energising the cables.

With some studies suggesting that switching to 66 kV could double transmittable power, Lüscher argues that as well as needing fewer substations, the technology has other significant advantages. “We should be able to work with larger arrays, with more turbines in each array. In any case energy transport is more efficient at 66 kV, so system losses are cut.”

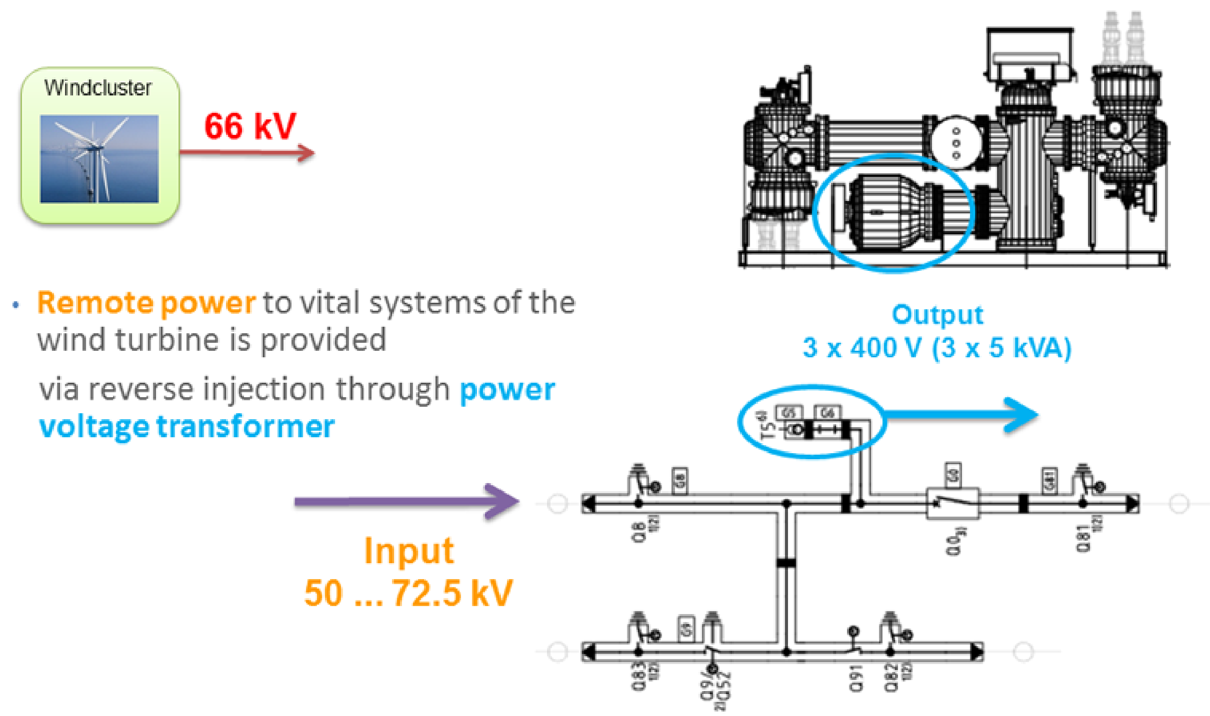
The concept is now being commercially offered with the Haliade™ 150-6 MW wind turbine developed by Alstom Renewable Power. The integration of the GIS into the wind turbine is based on pretested modules on a single frame with up to three cable feeders plus protection to the main transformer, ready to be installed in the wind turbine tower.

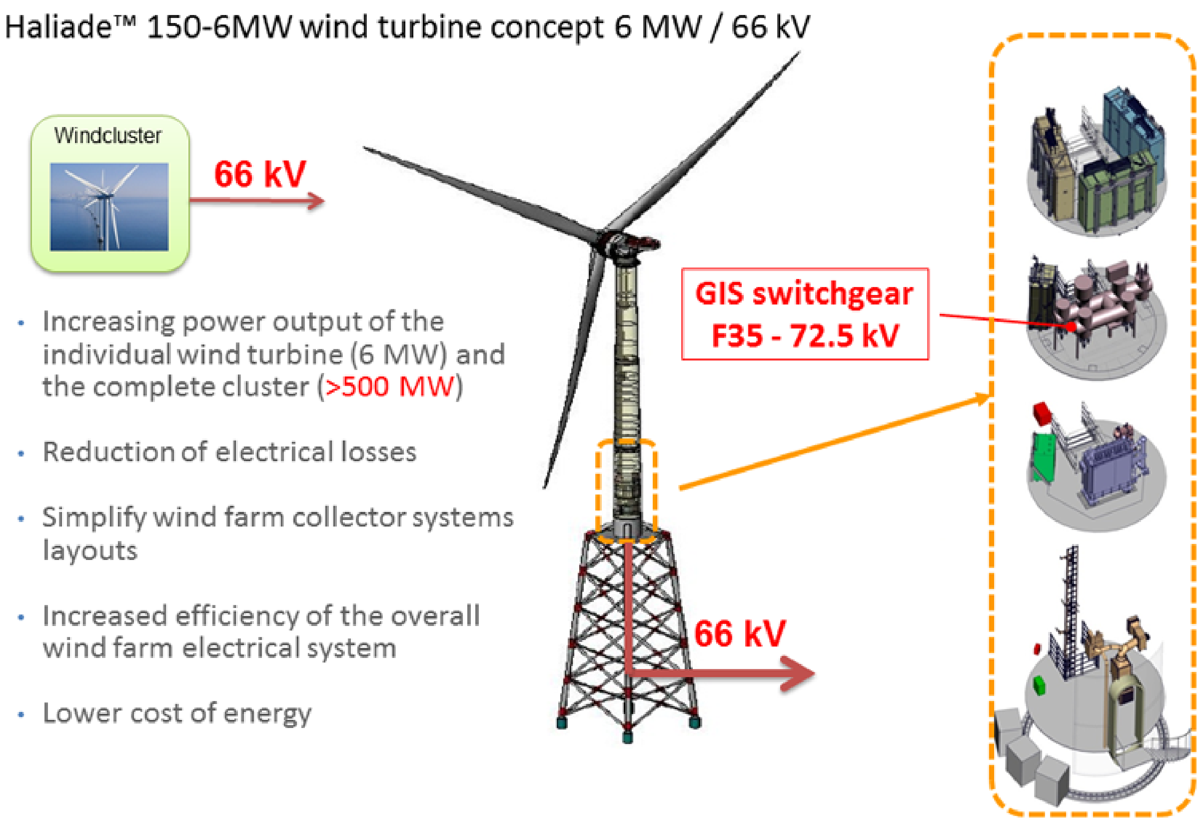
GIS integration in wind turbine



Remote power to vital systems of the wind turbine is provided via reverse injection through a power voltage transformer.

Remote power for start-up of wind turbine

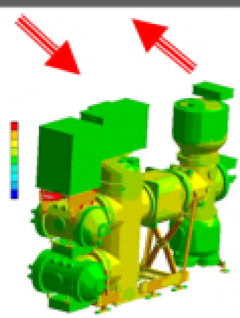




3__ Environmental and standards challenges

Lüscher describes the multiple challenges the various teams had to overcome in adapting and inventing solutions. “Exposure to the highly saline marine environment is one problem, of course. Then there are the high shocks and accelerations the equipment has to resist at every stage from construction, transport, installation and commissioning on site, and last but not least some of the most violent weather in the world.”


F35-GIS bay on „shaking –table“



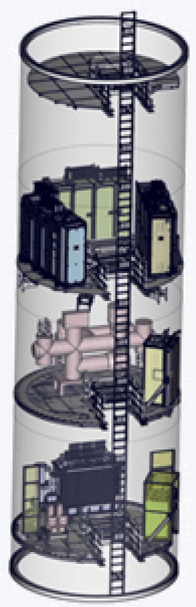
One difficulty was the lack of specific standards for such a pioneering application in offshore conditions. The team used similarities in the earthquake-withstand capability for the design and obtained good correlation of test results with the simulation.

Lüscher points out that there is a high chance that the new higher voltage concept becomes a major contribution to making energy systems greener. “It’s helping provide energy more reliably, at lower cost and with a lower environmental footprint.” In other words, it makes economic, environmental and social sense. There are multiple conventions covering the aspect of raising the system voltage and their potential impacts; the trend is going that way.

4 __Higher, bigger, farther

Ramon Piñana: Head of Electrical Systems in the Alstom Wind R&D department.

Integrating such high voltage level equipment into an existing wind turbine design means facing several challenges. When voltage increases, equipment size does as well. And this is



not limited to switchgear – the wind turbine power transformer and cables also get bigger. Space inside the tower or transition piece is very tight; moreover, its circular shape does not facilitate easy integration of a square-shaped GIS. The tower door was another limiting factor and as such a design driver of this HV equipment. To overcome this problem, two activities were needed; first, reduce the GIS footprint as much as possible by removing any accessory or feature no longer needed in wind turbines. Efforts to shorten length, reduce width and cutting corners were made to find a suitable size.

Other requirements considered during the adaptation work were linked to operation and maintenance needs. As size increases, so does the weight. This means finding new methods and tools to deal with such large systems in the event of on-site reparation or complete system replacement, such as bigger beams and special cranes to deal with the new weight.

Stringent vibration requirements were also a must-have feature to incorporate into the design. Vibrations may come not only from normal operation of the wind turbine or constant splashing of sea waves against the tower foundations, but can also occur during transport between the tower assembly plant and the site, when the equipment can experience severe accelerations. The people at Alstom Grid were able to come up with an optimal solution thanks to their expertise and know-how acquired during years of similar demands such as those of seismic-sensitive sites.

The new offshore wind solution adapting the Haliade™ 150-6 MW offshore turbine to a voltage level of 72.5 kV will help cut electrical losses, simplify wind farm collector system layouts, reduce the cost of cable layout during execution and potentially also allow the use of smaller cable sections – and therefore reduce the cost of energy.

Although further design details will be needed since this component is usually tailor-made for a specific site or project, we can now already say that Alstom is ready to offer this solution to the market.

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