Gotland gets smart about wind

Bottlenecks in the distribution system can restrict the flow of electricity from wind turbines to consumers. A pioneering smart grid project under way in Gotland, Sweden, will address this issue and more, says Junior Isles

In May, Ventyx, an ABB company, joined an innovative initiative to create one of the world's smartest electricity networks – a project called Smart Grid Gotland (SGG). Ventyx is to provide a new distribution management system (DMS) that will encompass network control, demand response management, demand forecasting and business analytics to support the project, enabling large quantities of wind and other renewable and distributed energy sources to be integrated into the grid, while maintaining reliability and providing better operational performance.

Gotland is the largest island in the Baltic Sea, some 90 km from the Swedish mainland. Sweden plans to increase its renewable electricity production primarily through wind power, as generated on the island. The SGG project intends to upgrade the existing power system on the island to a true smart grid system that will, among other things, enable a greater use of renewable energy sources (RES) in Gotland's network and handle the balance between production and consumption.

SGG is a collaboration including ABB, Ventyx, Schneider Electric, the Royal Institute of Technology (KTH), Svenska Kraftnät (Swedish TSO), local energy company Gotland Energi AB (GEAB) and Vattenfall, which owns 75 per cent of GEAB.

The project, which is being managed by ABB and Vattenfall, was started in 2012 in response to the European Union's climate change target to reduce carbon emissions by 20 per cent by 2020. It is being partly financed by Swedish Energy Agency.

SGG basically has three elements. It will: address how to use the existing network to integrate more wind; improve the power quality within the network; and test customer demand response programmes.

Explaining the first of the project's goals, Mattias Wedberg, Project Manager with Ventyx said: "There is an HVDC link to the mainland but the network is weak and has reached the 195 MW limit of the amount of wind generation it can handle. We will be seeing how we can bring an extra 5 MW of wind into the system."

Most of the island's wind power is generated in the south. The bulk of the wind power generation is exported to Visby via a 70 kV AC line with an HDVC Light link in parallel to support increased transmission capacity when necessary. The southern HVDC Light station can be operated as a dynamic reactive power compensator to increase system stability. This function supports the smart grid and increases system stability when large amounts of renewable production are present.

The network in the south of Gotland is modern and SGG will mainly introduce increased measurement and control in the region to support more renewable energy generation. The south HVDC station voltage control will be connected to the system controller in Visby and a control for optimum voltage control is being implemented as part of the SGG initiative, further increasing network stability.

This, however, will first require basic investments to upgrade the existing 30 kV overhead lines to 70 kV. Some reinforcements to substations are also needed to handle the increased electricity production.

In the central region of the island the SGG project will see the upgrade of two 70 kV substations with new protection and control for increased availability and communication. The distribution grid will also be partly rebuilt using the latest grid technology for increased controllability allowing better supervision, higher reliability and improved communication with end consumers.

Gotland's network is weak in terms of both transmission and distribution, often experiencing power cuts. ABB, which joined the project in 2013, is looking at how to reduce the frequency of these outages.

As part of its work, ABB will be installing a new substation, rural grid equipment and a "zone concept" for the medium voltage network, where circuit breakers and protection equipment will be deployed in the field to reduce outage extent and quickly restore power. Schneider will install smart meters in homes to assist in detecting LV faults, which the ABB Ventyx DMS can read so engineers can be dispatched to fix a problem.

Wedberg explained: "Dividing the grid into many zones minimises the area where the problem is. We can then disconnect this area and backfeed from another substation. This means all the customers, except in the actual location of the problem, can still receive power. The use of this zone concept with our DMS means we can isolate and solve a problem without any intervention by an operator; so it becomes a self-healing network.

"For example if you are away and there is a power-cut in your home, you as a customer can be informed by the smart meter before you reach your home and the problem will probably be fixed even before you arrive. Our DMS is also connected to the smart meter so the operator will also know in real-time what has happened."

ABB is expected to deliver the equipment for this part of the project within the next six months.

The effect of a greater amount of solar power, which is expected in the future, is also being investigated. In an effort to find new ways of detecting and resolving anticipated power quality issues related to micro production, a 1000 m² ground-based photovoltaic plant began operation in October 2013 near Visby. The complex consists of three single-phase installations, each of 3.2 kW and one three-phase installation of 2 x 22.5 kW. The single-phase installations symbolise a house rooftop installation, while the three-phase installation represents the roof of a barn.

According to GEAB, the aim is to use the increasing amount of micro production in a more efficient way. Jenny Larsson, CEO of GEAB said: "The results of the installation will give us important input into how we can use micro production to reinforce the grid and thereby increase the power quality here on Gotland."

When renewables such as wind and solar are the main source of power generation, other means of increasing network stability apart from backup generating units may be necessary. Further, when the generation is intermittent it is important to manage situations when generation is high but load is low and vice versa.

The project partners had originally planned to purchase battery storage units to investigate how they could help wind integration, address power quality and allow the network to run in island mode. This part of the project, however, has now been put on hold. Instead the consortium will later rent units from the University of Uppsala, which is looking to purchase batteries for use on the island.

Although balancing power will be available from other areas of the grid at certain times, the SGG consortium believes it is also important to involve consumers. The ability to alter the consumption pattern of consumers enables the most efficient usage of the renewable generation.

Part of the SGG project therefore involves testing the technical solutions and market models that will allow consumer participation based on more dynamic price signals.

This aspect of the project has in fact been already running for about one year and the plan is to add more customers and new load devices. At the moment there is a pilot demand response solution with equipment in about 300 homes controlling heaters and water boilers. The partners are now hoping to add smart meters and equipment to perform functions such as recording energy consumption in real-time, assessing grid status and power quality, etc.

While industrial consumers are not yet participating, Wedberg says the partners are looking at companies that could have electric vehicles that can be charged at night.

Having just completed studies on the project, Wedberg says equipment will now start to be deployed in the field for testing and verification of the theoretical studies.

The world will be watching closely as SGG enters this important phase. Although there are a limited number of islands in Europe, it will attract wide international interest. Being on an island, significantly, it will enable the testing of individual components and entire systems together. Consequently, it is an important step towards a full-scale implementation of smart grids in Sweden.

"It is a full-scale project. It's like a miniature Sweden where you can test everything in real-life on a small island," noted Wedberg.

Certainly it is a very important project for both the project consortium and the industry. "This project has high focus in ABB and I think it is also one of the biggest R&D projects in Vattenfall," said Wedberg.

"There has been big interest worldwide. People involved in other smart grid projects want to visit us to see how we are doing and check-out our solutions to see how they can use them in their future projects. So it's really a great project."

The ability to alter the consumption pattern of consumers allows the most efficient use of renewable generation